Internal Laptop Combo Antenna for Celluar/WLAN Dual-Network Operations

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***Abstract* — Two internal antennas for cellular (GSM/DCS) and WLAN dual-network operations are combined in an arrangement with optimized isolation for laptop computer applications. The two antennas are formed into a combo antenna and can be mounted at the top edge of the supporting metal frame of the display of a laptop computer as internal antennas. The impedance and isolation characteristics of the proposed cellular/WLAN combo antenna with various possible arrangements are studied, and optimized isolation for frequencies over the GSM (890 ~ 960 MHz), DCS (1710 ~ 1880 MHz), and WLAN bands (2400 ~ 2484/5150 ~ 5350/5725 ~ 5825 MHz) is analyzed.**

***Key words* — Mobile antennas, GSM/DCS antennas, WLAN antennas, combo antennas, internal laptop antennas**

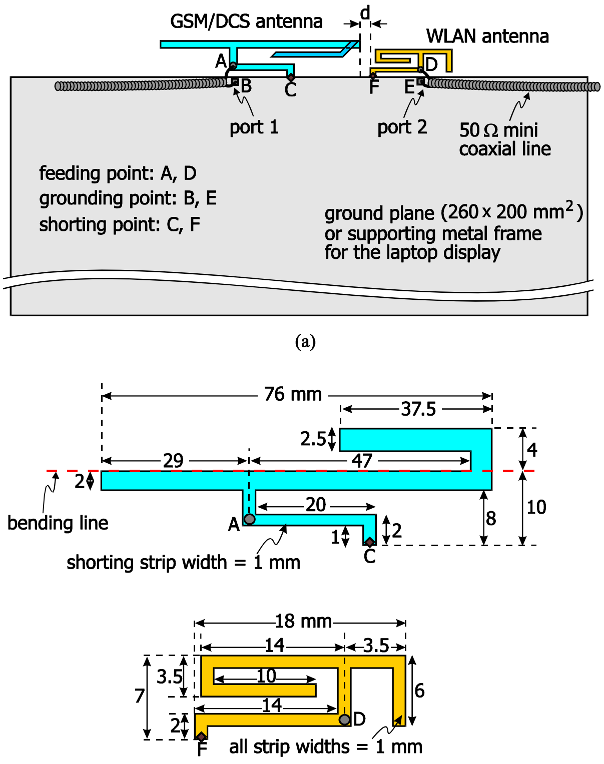
I. Introduction

Due to recent successful deployment of the hot spots for WLAN (wireless local area network) communications, it is widely recognized that the integration of WLAN and cellular networks can provide wireless users with seamless data services. For this kind of cellular/WLAN dual-network application, it is usually demanded that a mobile device be equipped with two separate antennas for GSM/DCS (global system for mobile communication /digital communication system) and 2.4/5.2/5.8 GHz WLAN operations [1]. However, due to the limited space available in a mobile device, how to combine the two antennas in an arrangement with optimized isolation becomes a challenging and important task.

In this paper we present a study of combining two internal antennas into a combo antenna for GSM/DCS and WLAN operations for laptop computer applications. The two antennas are modified from dual-band shorted T-shape monopoles [2-5], and both show low-profile and compact configurations, allowing them to be embedded within the narrow spacing (usually about 10 mm) between the display and casing of a laptop computer. Possible arrangements of the proposed cellular/WLAN dual-network combo antenna are studied, and the impedance and isolation characteristics of the combo antenna over the operating bands are analyzed.

II. Proposed Antenna Design

Figure 1(a) shows the configuration of the proposed internal laptop combo antenna for celluar/WLAN dual-network operations. The combo antenna comprises a GSM/DCS antenna for cellular operation and a WLAN antenna for operation in the 2.4 GHz band (2400 ~ 2484 MHz) and 5.2/5.8 GHz band (5150 ~ 5350/5725 ~ 5825 MHz). The two antennas are mounted at the top edge of a ground plane (size 260 × 200 mm^2 in this study), which is considered as the supporting metal frame of the display of a laptop computer. For the GSM/DCS antenna, it is a shorted T-shape monopole with two different radiating strips, both operated as quarter-wavelength resonant structures. The shorter radiating strip controls a resonant mode for DCS operation at about 1800 MHz. For the longer radiating strip, it can generate a resonant mode for GSM operation at about 900 MHz. Note that the longer radiating strip is folded to achieve a compact structure for the GSM/DCS antenna to be easily embedded within the narrow space between the display and casing of the laptop computer; in this case the total length of the antenna is 76 mm only.



(b)

Fig. 1(a) Configuration of the proposed internal laptop combo antenna for celluar/WLAN dual-network operations. (b) Detailed dimensions of the celluar and WLAN antennas.

For the WLAN antenna, a shorted T-shape monopole with two folded radiating strips is used, and the total antenna length is 18 mm only. The two folded radiating strips are also operated as quarter-wavelength resonant structures, with the longer and shorter ones controlling the 2.4 and 5.2/5.8 GHz bands, respectively. Details of the dimensions of the GSM/DCS and WLAN antennas are given in Figure 1(b); these design dimensions are obtained by following the design considerations presented in [2-5].

Also note that the GSM/DCS antenna is short-circuited to the top edge of the ground plane using an inverted-L shorting strip, so is the WLAN antenna. In addition, this shorting strip is arranged to be in-between the antenna's longer radiating strip and the ground plane. This arrangement makes the shorter radiating arm retains an effectively large distance to the ground plane, thereby making possible a wider impedance bandwidth for the DCS band for the GSM/DCS antenna and for the 5.2/5.8 GHz band for the WLAN antenna.

Based on the configurations of the GSM/DCS and WLAN antennas shown in Figure 1(b), there are four possible arrangements (see Case 1 to Case 4 in Figure 2) to combine the two antennas into a combo antenna, and the distance between the two antennas is denoted as *d*. It is expected that the isolation between the two antennas will be dependent on the different arrangements of the two antennas and the distance *d* between the two antennas as well [6, 7]. The related results will be analyzed in the next section.

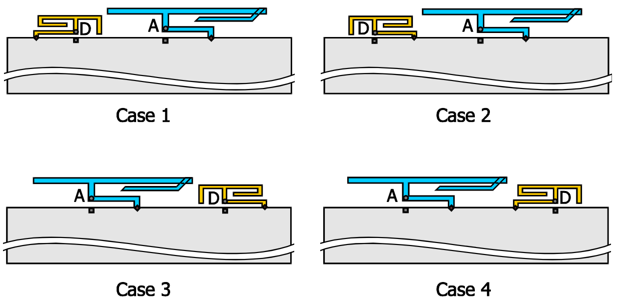


Fig. 2 Possible arrangements (Cases 1 to 4) of the celluar/ WLAN dual-network combo antenna; the configuration shown in Fig. 1(a) is for Case 4 arrangement.

III. Experimental Results and Discussion

The two antennas with the four possible arrangements shown in Figure 2 are studied. Since it is noted that the shorting strips of the two antennas in Case 4 arrangement face to each other back-to-back (that is, their shorting points face to each other), the isolation between the two antennas is expected to be optimized [6, 7]. For this expectation, the proposed combo antenna with Case 4 arrangement is first constructed and tested. The measured and simulated *S* parameters for this arrangement with d = 6 mm are shown in Figure 3. First note that the simulated results in this study are all obtained using Ansoft simulation software HFSS (high frequency structure simulator), and good agreement between the measurement and simulation is obtained.

As seen in Figure 3(a) for the GSM/DCS antenna excited with port 2 (the WLAN antenna) terminated to 50 Ω load, two separate resonant modes covering the GSM and DCS bands are obtained. The operating frequencies over the GSM and DCS bands are all with good impedance matching (S_{11} less than -10 dB). For the isolation (S_{21}) between the two antennas, it is seen that the maximum measured S_{21} is as low as -27 dB over the GSM band and -24 dB over the DCS band, which are well suited for practical applications. For the results shown in Figure 3(b) for the WLAN antenna excited with port 1 (the GSM/DCS antenna) terminated to 50 Ω load, two wide operating bandwidths with S_{11} less than -10 dB covering the 2.4 and 5.2/5.8 GHz bands are seen. For the operating frequencies over the bands, the measured maximum S_{21} is, respectively, about -19 dB and -24 dB over the 2.4 GHz and 5.2/5.8 GHz bands, which are also acceptable for practical applications.

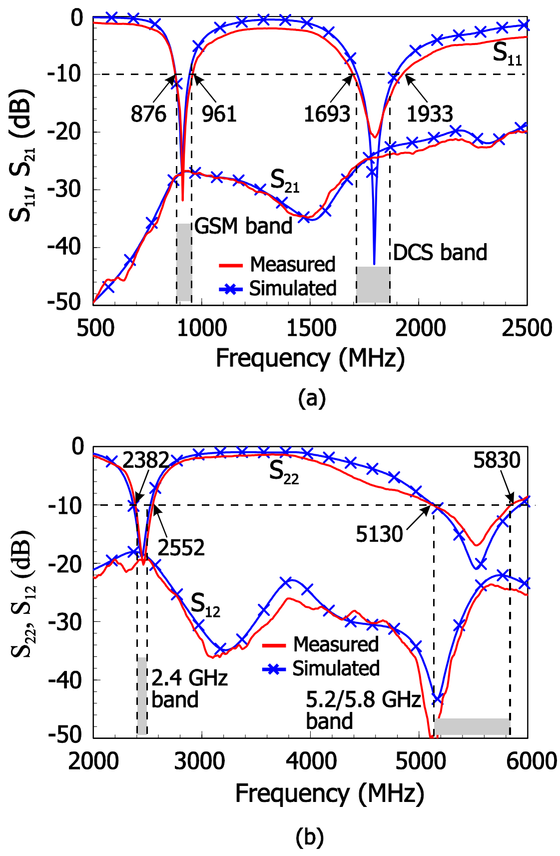


Fig. 3 Measured and simulated *S* parameters for the proposed combo antenna with Case 4 arrangement; d = 6 mm. (a) The GSM/DCS antenna excited with port 2 terminated to 50 Ω load. (b) The WLAN antenna excited with port 1 terminated to 50 Ω load.

For comparing the performances of the proposed combo antenna with various arrangements, a simulation study is conducted. Figure 4 shows the simulated S_{11} and S_{22} for different arrangements of Cases 1 to 4 with the same spacing of d = 6 mm. From the results in Figure 4(a), it is seen that the obtained bandwidths for the lower band at about 900 MHz are about the same. On the other hand, the obtained bandwidths for the upper band at

about 1800 MHz are varied. The bandwidths for Cases 3 and 4 are seen to be larger than those for Cases 1 and 2. This behavior is largerly because the shorter radiating strips of the GSM/DCS antenna are extended away from the WLAN antenna, thus smaller coupling effects are expected, which leads to almost no variations in the bandwidths obtained. For the impedance matching of the WLAN antenna [see Figure 4(b)], the variations in the 5.2/5.8 GHz band are seen to be relatively large, compared to those in the 2.4 GHz band. However, except for Case 3, the obtained bandwidths generally cover the 5.2/5.8 GHz band.

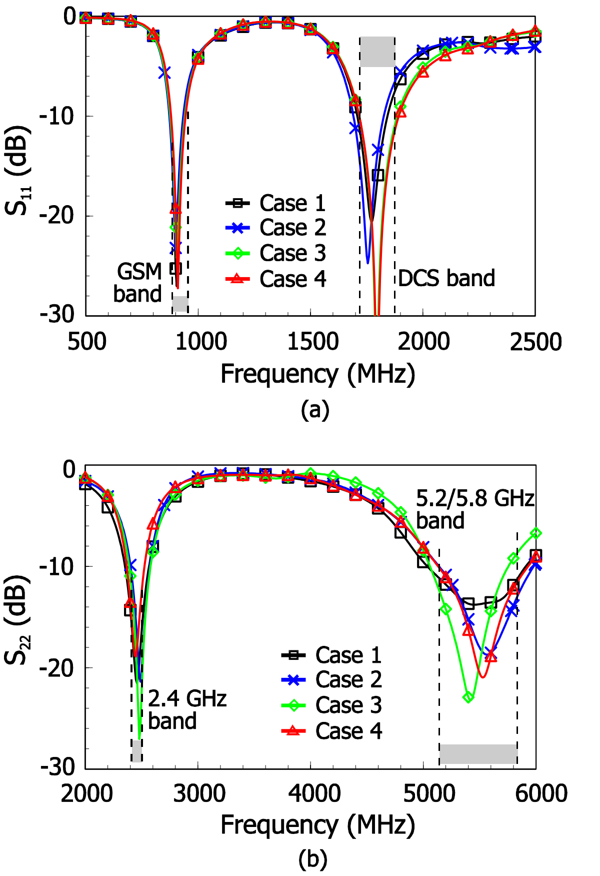


Fig. 4 Simulated (a) S_{11} and (b) S_{22} for the proposed combo antenna with different arrangements (Cases 1 to 4); $d = 6$ mm.

Figure 5 shows the corresponding simulated S_{21} and S_{12} for different arrangements of Cases 1 to 4 studied in Figure 4. Among the various arrangements, Case 4 shows the minimum S_{21} over the GSM and DCS bands and the minimum S_{12} over the 2.4 GHz and 5.2/5.8 GHz bands. This characteristic agrees with the expectation that the isolation of the two antennas in the proposed combo antenna is expected to be optimized, when the shorting strips of the two antennas are arranged to face each other back-to-back [6, 7].

The performances of the proposed combo antenna as a function of the spacing d are also studied. Figure 6 shows the simulated S_{11} and S_{22} for the proposed combo antenna with Case 4 arrangement as a function of d. As seen in Figure 6(a) for the GSM/DCS antenna, almost no variations in the impedance matching are seen for d varied from 0 to 10 mm. On the other hand, for the

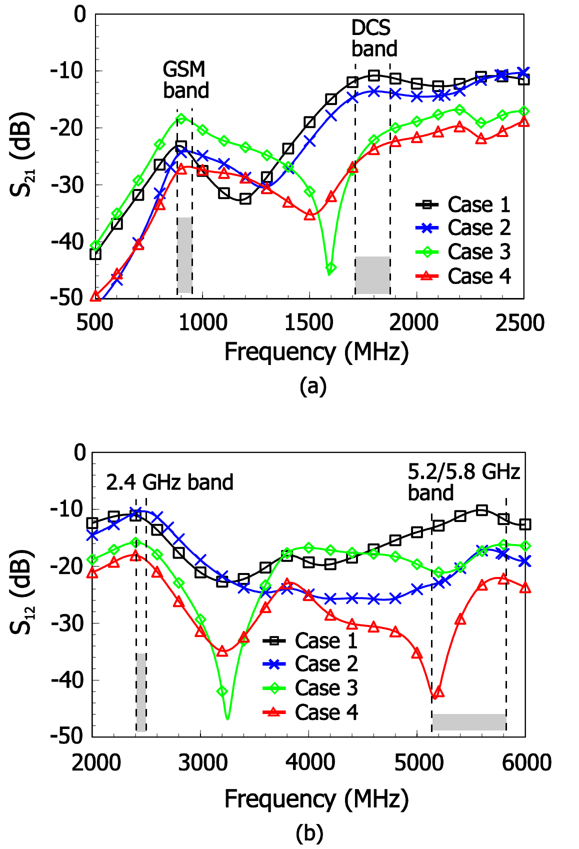


Fig. 5 Simulated (a) S_{21} and (b) S_{12} for the proposed combo antenna with different arrangements (Cases 1 to 4); $d = 6$ mm.

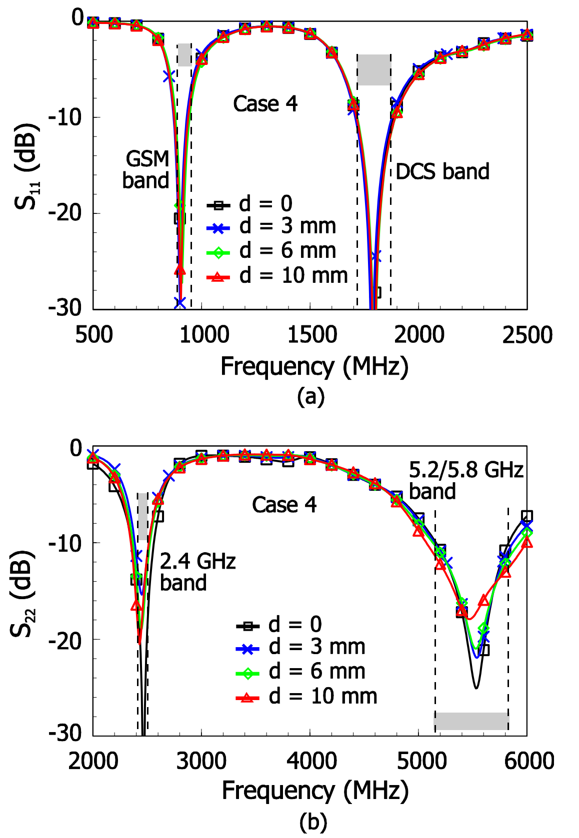
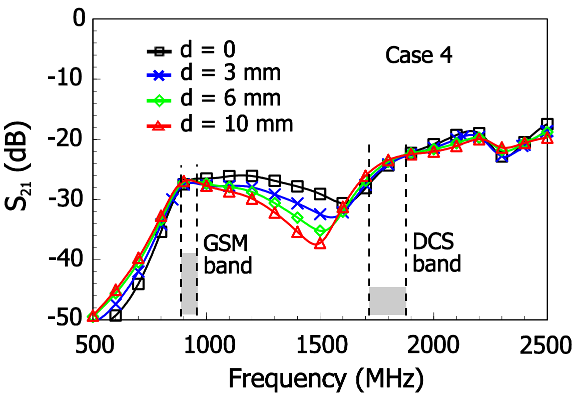


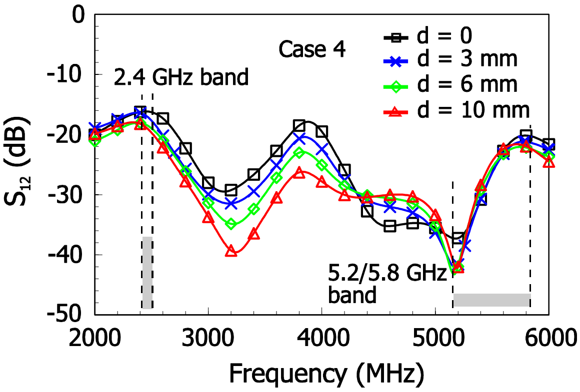
Fig. 6 Simulated (a) S_{11} and (b) S_{22} for the proposed combo antenna with Case 4 arrangement as a function of d. Other parameters are the same as given in Fig. 1.

results of the WLAN antenna shown in Figure 6(b), some variations are seen. There are some slight shiftings of the center frequency of the lower band at about 2.4 GHz. However, the obtained impedance bandwidths are about the same. For the upper band at about 5.5 GHz, the obtained impedance bandwidths are generally increased with an increase in *d*. Howver, even with d = 0, the obtained bandwidth can still cover the 5.2/5.8 GHz band.

Figure 7 shows the corresponding simulated S_{21} and S_{12} for Case 4 arrangement studied in Figure 6. For frequencies over the GSM and DCS bands in Figure 7(a), very slight variations in S_{21} are seen, and it can be concluded that S_{21} is almost not affected by the spacing *d* between the two antennas. On the other hand, over the 2.4 GHz band in Figure 7(b), S_{21} can be decreased by about 3 dB by increasing *d* from 0 to 10 mm. As for the 5.2/5.8 GHz band, although there are also some variations, the maximum S_{21} is all less than -20 dB for *d* varied from 0 to 10 mm.



(a)



(b)

Fig. 7 Simulated (a) S_{21} and (b) S_{12} for the proposed combo antenna with Case 4 arrangement as a function of *d*. Other parameters are the same as given in Fig. 1.

IV. Conclusion

A combo antenna comprising one GSM/DCS antenna and one WLAN antenna for cellular/WLAN dual-network operation for a laptop computer has been proposed and studied. With the use of the shorted T-shape monopole for both of the GSM/DCS and WLAN antennas, the proposed combo antenna shows a low profile and is thus very promising to be embedded inside the casing of the laptop computer as an internal antenna. The impedance and isolation characteristics of various possible arrangements of the GSM and WLAN antennas in the proposed combo antenna have also been analyzed. Results indicate that optimized isolation for frequencies over the operating bands can be obtained when the shorting strips of the GSM/DCS and WLAN antennas are arranged to face each other back-to-back (Case 4 arrangement in this study). On the other hand, relatively small variations in the impedance matching of the GSM/DCS and WLAN antennas have been observed for various arrangements of the combo antenna. Effects of the spacing between the two antennas have also been analyzed. However, results indicate that the effects on the performances of the combo antenna due to the variations in the spacing are relatively small, compared to the effects due to the various arrangements of the GSM/DCS and WLAN antennas in the proposed combo antenna.

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