2. W.C. Jakes, Microwave mobile communications, IEEE Press, New York, 1974.
3. A. Fluerasu, A. Sibille, Y. Corre, Y. Lostanlen, L. Houel, and E. Hamman, A measurement campaign of spatial, angular, and polarization diversity reception of DVB-T, COST 273 Management Committee Meeting, TD (05) 019. Bologna, Italy, January 20–21, 2005.
4. B. Poussot, J.-M. Laheurte, L. Cirio, O. Picon, D. Delcroix, L. Dussopt, Diversity measurements of a reconfigurable antenna with switched polarizations and patterns, IEEE Trans Antennas Propag 56 (2008), 31–38.

INTERNAL WWAN ANTENNA FOR THE CLAMSHELL MOBILE PHONE WITH VARIOUS CHASSIS SHAPES

Kin-Lu Wong, Cheng-Tse Lee, and Chao-An Lyu
Department of Electrical Engineering, National Sun Yat-sen University, Kaohsiung 80424, Taiwan; Corresponding author: wongkl@ema.ee.nsysu.edu.tw

Received 19 November 2009

ABSTRACT: *Stable performances of an internal WWAN antenna applied in the clamshell mobile phone with various chassis shapes are obtained. Six different states including five possible operating states and one closed state (idle condition) of the clamshell mobile phone, wherein the chassis shapes (main ground and upper ground) vary greatly, are studied. The WWAN antenna is mounted at the bottom of the main ground, and there are three connecting positions between the main ground and the upper ground. For each operating states, the upper ground is connected to the main ground at one of the three connecting positions. At each position, a band-stop circuit formed by two parallel LC chip elements is embedded, which is designed to excite a parallel resonance at around 900 MHz and hence leads to very high impedance seen into the upper ground in the 900 MHz band. This greatly decreases the excited surface currents on the upper ground, making the presence of the upper ground to have very small effects on the performances of the WWAN antenna mounted at the bottom of the main ground. At around 1900 MHz, owing to its shorter wavelength, the surface currents on the upper ground excited by the WWAN antenna on the main ground are small. Thus, over both the 900- and 1900-MHz bands, the various orientations of the upper ground to the main ground cause small effects on the WWAN antenna embedded therein. Details of the obtained results are presented.* © 2010 Wiley Periodicals, Inc. Microwave Opt Technol Lett 52: 2148–2154, 2010; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.25413

Key words: *handset antennas; WWAN antennas; clamshell mobile phone antennas; band-stop circuit*

1. INTRODUCTION

It is well known that the internal wireless wide area network (WWAN) antenna applied in the mobile phone is greatly dependent on the size of the system ground plane, especially for operating in the 900-MHz band [1–2]. For the internal WWAN antenna in the clamshell mobile phone, this becomes an even more critical issue, as the two ground planes (the main ground and the upper ground) are in different orientations when the mobile phone is in the open state (talk condition) and in the closed state (idle condition) [3–15]. For these two different states, the upper ground is in different orientations to the main ground, which usually causes large variations on the performances of the embedded WWAN antenna.

To achieve stable performances of the embedded WWAN antenna in the clamshell mobile phone, the technique of applying a current trap formed by a linear slit embedded close to the connecting strip between the two grounds has been proposed [1]. With the embedded slit of length about 35 mm, strong surface currents excited around the slit are achieved, with other portions of the upper ground showing much weaker surface current distributions; that is, the embedded slit behaves like a current trap for the excited surface currents in the upper ground. This condition results in reduced upper-ground effects on the performances of the embedded WWAN antenna mounted at the main ground. Hence, for the clamshell mobile phone in either the open state or the closed state, small variations on the performances of the embedded WWAN antenna in the two different states are obtained [1].

In this article, we proposed another promising technique of reducing the upper-ground effects on the embedded WWAN antenna in the clamshell mobile phone. The proposed technique applies a small band-stop circuit formed by two parallel LC chip elements at the connecting position of the upper ground to the main ground. Compared to the 35-mm long linear slit as the current trap studied in [1], the proposed band-stop circuit requires a much smaller board space on the upper circuit board on which the upper ground is printed. Owing to its small occupied size, two or more band-stop circuits are hence promising to be embedded on the upper circuit board. In this study, we embedded three proposed band-stop circuits at three different connecting positions between the upper ground and the main ground (Fig. 1). In this case, six different states including five possible operating states with the upper ground in different orientations to the main ground and one closed state with the upper ground in parallel to the main ground are studied. With the presence of the proposed band-stop circuit at the connecting position for each one of the six different states showing various chassis shapes, stable performances of the embedded WWAN antenna can be obtained. This is because the band-stop circuit can perform a parallel resonance [11, 16] at around 900 MHz, which leads to very high impedance seen into the upper ground in the 900 MHz band. This greatly decreases the excited surface currents on the upper ground, making the presence of the upper ground have very small effects on the performances of the WWAN antenna mounted at the bottom of the main ground.

On the other hand, at around 1900 MHz, owing to its shorter wavelength, the surface currents on the upper ground excited by the WWAN antenna on the main ground are small. This behavior for frequencies over the antenna's upper band is similar to that of using the current-trap technique [1]. Thus, over both the 900- and 1900-MHz bands, reduced upper-ground effects on the performances of the embedded WWAN antenna can be obtained. This leads to stable performances of the embedded WWAN antenna in the clamshell mobile phone with six different states studied in this article. Results of the obtained performances of an embedded WWAN antenna in the clamshell mobile phone with the proposed band-stop circuits are presented.

2. CLAMSHELL MOBILE PHONE ANTENNA WITH VARIOUS CHASSIS SHAPES

Figure 1 shows the geometry of a penta-band WWAN antenna printed at the bottom of the main circuit board of the clamshell mobile phone with three band-stop circuits embedded at three different connecting positions of the upper ground to the main ground. The WWAN antenna for the GSM850/900/1800/1900/UMTS operation in this study is a printed uniplanar coupled-fed planar inverted-F antenna (PIFA) occupying a small area of

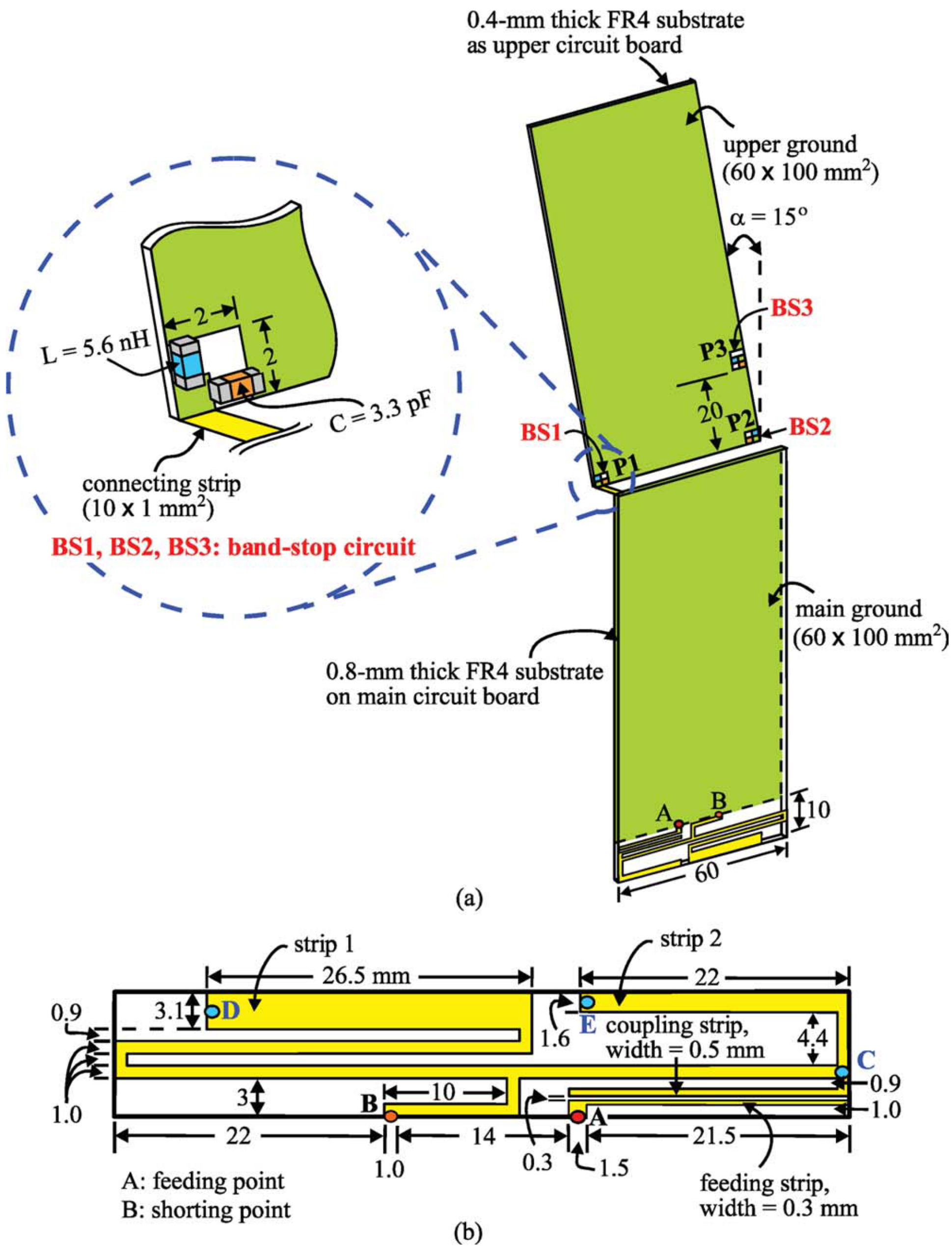

Figure 1 (a) Geometry of a planar coupled-fed PIFA WWAN antenna printed at the bottom of the main circuit board of the clamshell mobile phone with three band-stop circuits embedded at three different connecting positions of the upper ground to the main ground; this geometry is denoted as open state 1 in this study. (b) Dimensions of the metal pattern of the antenna. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

10×60 mm^2 on the main circuit board. This penta-band WWAN antenna in its bent structure has been reported in [17] for the bar-type mobile phone and its planar structure has been studied in [1] for the clamshell mobile phone. The antenna comprises two shorted metal strips of strip 1 and 2 (section CD and CE) excited by a coplanar coupling feed [18–22] to provide two wide bands at about 900 and 1900 MHz to cover the GSM850/900 operation (824 $\sim$ 960 MHz) and GSM1800/1900/UMTS (1710 $\sim$ 2170 MHz) operation. The coplanar coupling feed is formed by a feeding strip and a coupling strip, spaced by a 0.3-mm coupling gap, and excites the two shorted metal strips to achieve the desired wide lower and upper bands for the antenna to cover the penta-band WWAN operation. More detailed operating principle of the studied WWAN antenna can be found in [1, 17].

Figure 2 shows the six different states of the clamshell mobile phone with various chassis shapes studied in the article. The six different states show various orientations of their upper ground to the main ground. Notice that the two grounds are respectively printed on the upper and main circuit boards, which are made of 0.4- and 0.8-mm thick FR4 substrates respectively in the study. Both the upper ground and the main ground have the same size of 60×100 mm^2. For the six different states, three connecting positions at P1, P2, and P3 are required. The open state 1, state 4, and state 5 use the connection at P1, whereas the open state 2 and state 3 use the connection at P3

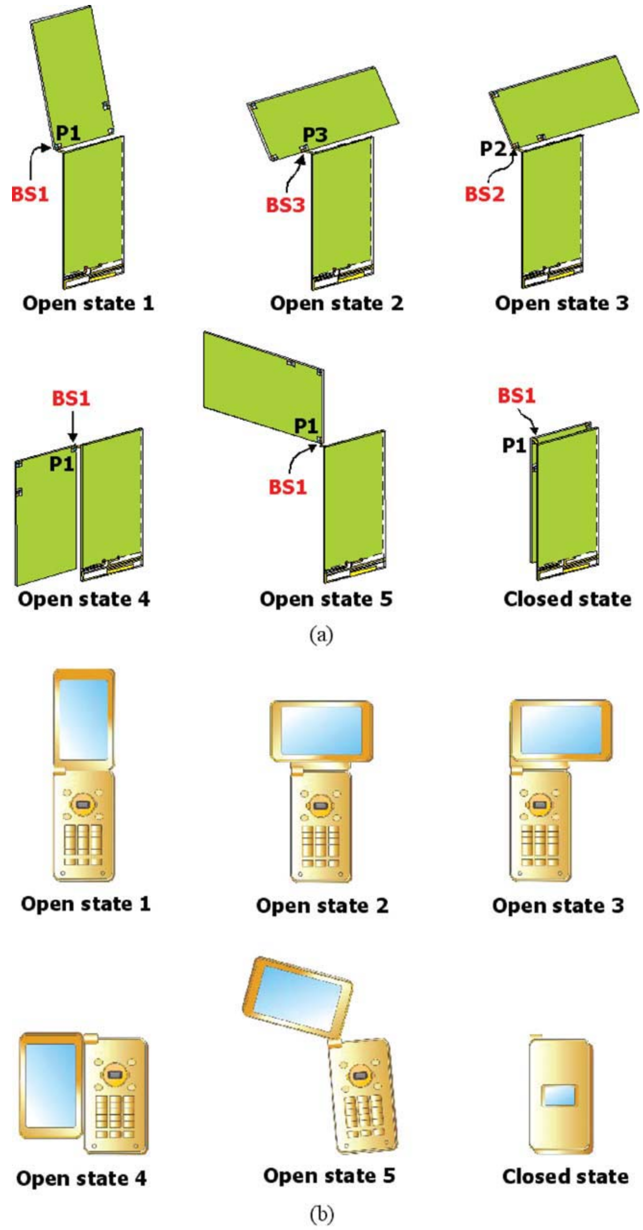

Figure 2 (a) Six different states (five operating states and one closed state) of the clamshell mobile phone with various chassis shapes. (b) The corresponding practical clamshell mobile phones in the six different states studied in the paper. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

and P2, respectively. Note that the switching from one connection position to another is expected to be achieved mechanically; the details are not included in this study.

At each connection position, a band-stop circuit formed by two parallel LC chip elements (chip inductor of 5.6 nH and chip capacitor of 3.3 pF, both having a size of $1.0 \times 0.5 \times 0.5$ mm^3) is embedded; the detailed circuit layout is shown in Figure 1. Each band-stop circuit occupies a small board space of 2×2 mm^2 and will generate a parallel resonance or anti-resonance at around 900 MHz such that very high impedance seen into the upper ground in the 900-MHz band is obtained. In this case, effects of the presence of the upper ground on the performances of the embedded WWAN antenna mounted at the bottom of the main ground can be greatly suppressed. This suggests that although the upper ground shows greatly different orientations to the main ground in the six different states shown in Figure 2, stable performances of the embedded WWAN antenna can be obtained in this study.

3. RESULTS AND DISCUSSION

The antenna for the clamshell mobile phone in the open state 1 is first studied. Figure 3 shows the measured and simulated return loss of the antenna in the open state 1. The simulated results are obtained using Ansoft simulation software High Frequency Structure Simulator (HFSS) [23]. The measured data agree with the simulated results. Over the two desired operating bands of 824 $\sim$ 960 MHz for the GSM850/900 operation and 1710 $\sim$ 2170 MHz for the GSM1800/1900/UMTS operation, the impedance matching is all better than 3:1 VSWR (6-dB return loss), which is widely used as the design specification for the internal mobile phone antennas.

To analyze the effect of the band-stop circuit, Figure 4 shows the simulated return loss and input impedance of the antenna in the open state 1 for the cases with and without the band-stop circuit. In Figure 4(a), it is clearly seen that there are large variations of the impedance matching in the 900-MHz band, while the impedance matching over other frequency ranges is almost the same. This behavior can be explained more easily from the input impedance curves shown in Figure 4(b). When the band-stop circuit is not present, the upper ground will cause large variations of the input impedance seen by the embedded WWAN antenna. By adding the band-stop circuit, parallel resonance at around 900 MHz can be generated, which makes the connection between the upper ground and main ground functions like an open circuit such that the effects of the upper-ground presence are suppressed. Good impedance matching over the 900-MHz band is hence maintained as it is in the bar-type mobile phone case studied in [17].

The cases of the clamshell mobile phone in other operating states are studied in Figure 5. The simulated return loss of the antenna in the open state 1, state 2, and state 3 is presented in Figure 5(a). Very small variations in the impedance matching for the three different states are seen. Figure 5(b) shows the simulated return loss for the open state 1, state 4, and state 5; small variations are also seen for the three cases. Figure 5(c) shows the results for the open state 1 and closed state. Small effects are also seen in the 900-MHz band. For the upper band, although there is some degradation in the return loss, the impedance matching is still acceptable for practical applications of the clamshell mobile phone in the closed state (idle condition) [1].

The radiation characteristics of the clamshell mobile phone in the six different states are also studied. Figure 6 shows the simulated three-dimensional (3-D) radiation patterns at 925, 1795, and 2045 MHz for the antenna in the open state 1, state 2, and state 3. The corresponding results in the open state 4, state 5, and closed state are plotted in Figure 7. The obtained 3-D radiation patterns are similar to each other, especially for those at 925 MHz which generally show omnidirectional or near-omnidirectional radiation patterns. The measured radiation patterns at 925, 1795, and 2045 MHz for the open state 1 are also plotted in Figure 8 for comparison. The measured radiation patterns are similar to the corresponding simulated results for the open state 1 shown in Figure 7(a).

The simulated radiation efficiency of the antenna for the clamshell mobile phone in the six different states is also studied. The simulated radiation efficiency considers the mismatching condition and is presented in Figure 9. From the results, the variations in the radiation efficiency are in general larger for

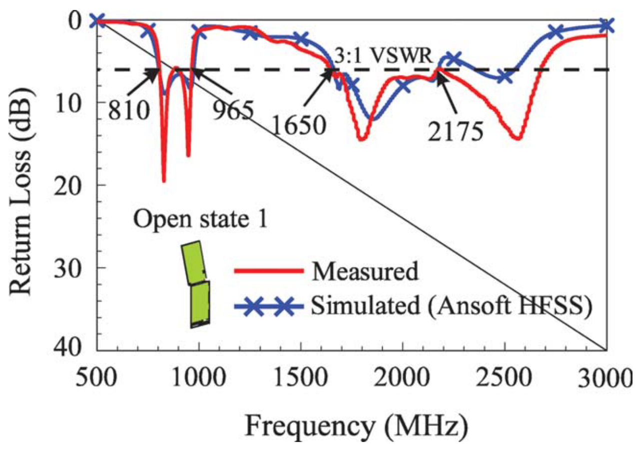

Figure 3 Measured and simulated return loss of the antenna in the open state 1. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

frequencies in the lower band [Fig. 9(a)] than in the upper band [Fig. 9(b)]. This behavior is reasonable as the presence of the upper ground and the band-stop circuit has relatively very small effects on the impedance matching in the upper band. However, from the obtained results in Figure 9, the radiation efficiency is

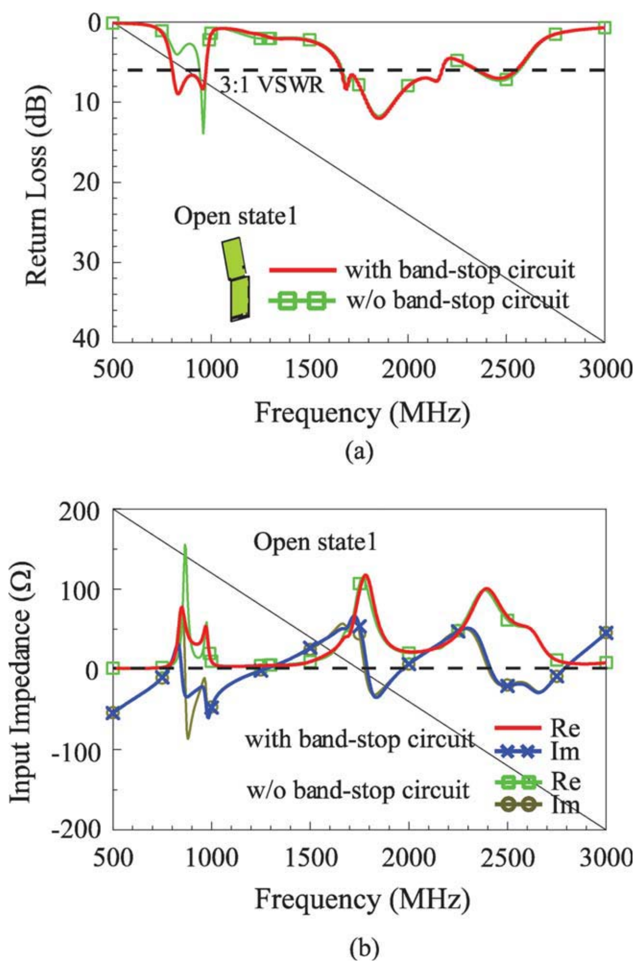

Figure 4 Simulated (a) return loss and (b) input impedance of the antenna in the open state 1 for the cases with and without the band-stop circuit. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

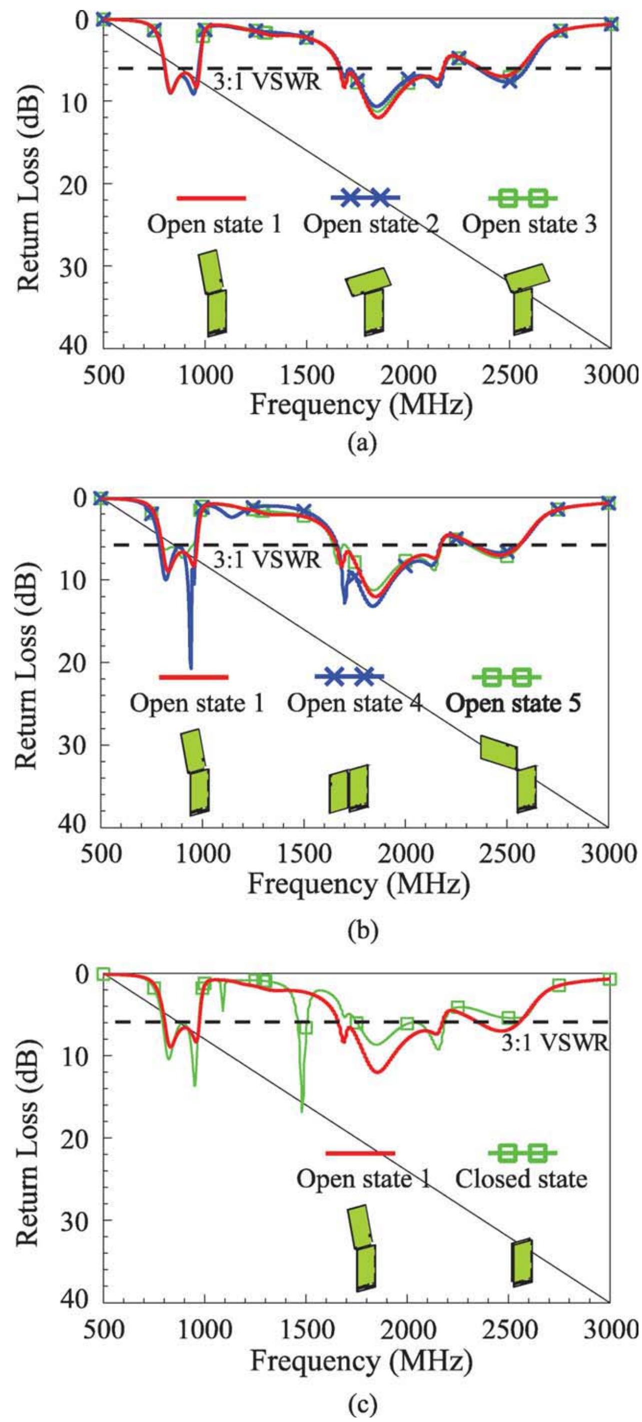

Figure 5 Simulated return loss of the antenna in (a) the open state 1, state 2 and state 3, (b) the open state 1, state 4, and state 5, and (c) the open state 1 and closed state. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

generally all better than 50% over the lower and upper bands, which is acceptable for penta-band WWAN operation in the practical applications.

4. CONCLUSION

A clamshell mobile phone with embedded band-stop circuits at the connecting positions between its two ground planes for achieving stable performances of the embedded WWAN antenna has been proposed. The antenna performances for six different

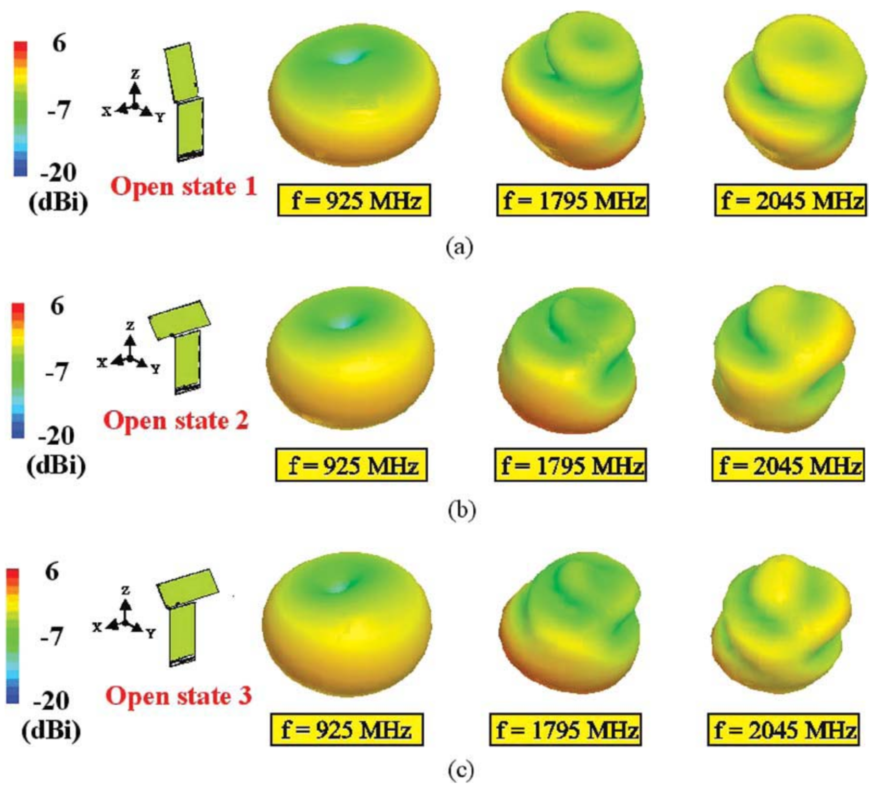

Figure 6 Simulated three-dimensional (3-D) radiation patterns at 925, 1795, and 2045 MHz for the antenna in (a) the open state 1, (b) the open state 2, and (c) the open state 3. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

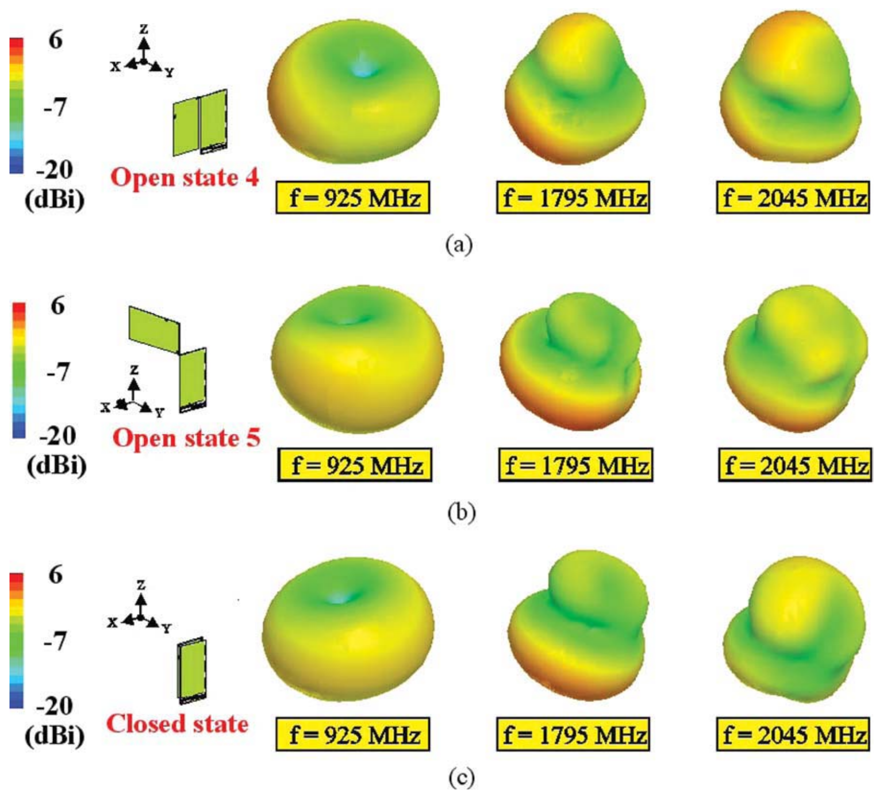

Figure 7 Simulated three-dimensional (3-D) radiation patterns at 925, 1795, and 2045 MHz for the antenna in (a) the open state 4, (b) the open state 5, and (c) the closed state. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

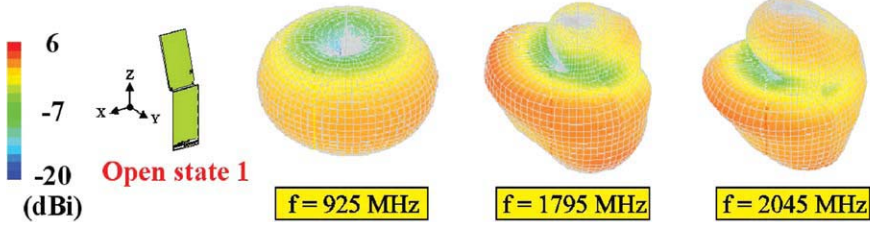

Figure 8 Measured three-dimensional radiation patterns for the antenna in the open state 1. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

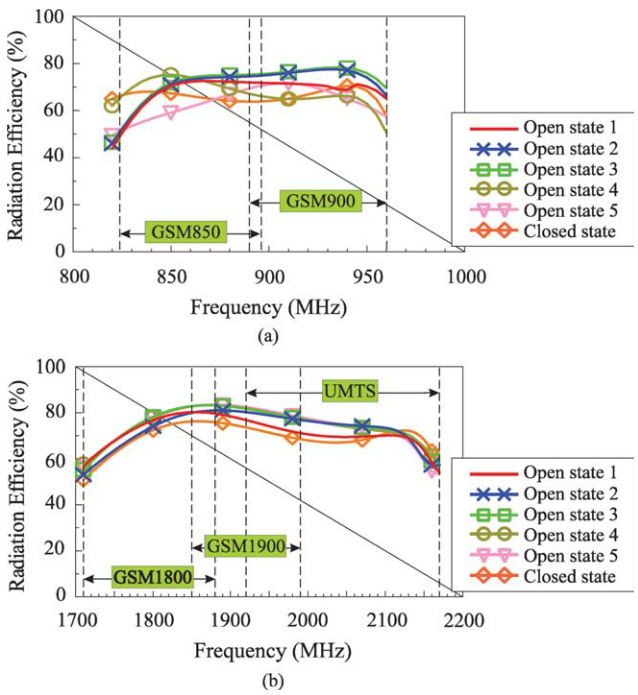

Figure 9 Simulated radiation efficiency of the antenna in the six different states shown in Figure 2. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

states of the clamshell mobile phone in which the upper ground is in various orientations to the main ground have been studied. Although the clamshell mobile phone is in various chassis shapes for the studied six different states, small variations in the obtained impedance bandwidths have been obtained, which is owing to the reduced upper-ground effects obtained in the proposed design. The embedded WWAN antenna can cover the desired penta-band operation including the GSM850, GSM900, GSM1800, GSM1900, and UMTS bands in all the six different states studied here. It is also expected that stable performances of the embedded WWAN antennas for other possible states different from those studied here can still be obtained.

REFERENCES

1. C.T. Lee and K.L. Wong, Internal WWAN clamshell mobile phone antenna using a current trap for reduced groundplane effects, IEEE Trans Antennas Propag 57 (2009), 3303–3308.
2. P. Vainikainen, J. Ollikainen, O. Kivekas, and I. Kelander, Resonator-based analysis of the combination of mobile handset antenna and chassis, IEEE Trans Antennas Propag 50 (2002), 1433–1444.
3. T. Sugiyama, H. Horita, Y. Shirakawa, M. Ikegaya, S. Takaba, and H. Tate, Triple-band internal antenna for clamshell type mobile phone, Hitachi Cable Rev (2003), 26–31.
4. P.L. Teng, T.W. Chiou, and K.L. Wong, Internal planar monopole antenna for GSM/DCS/PCS folder-type mobile phone, Microwave Opt Technol Lett 39 (2003), 106–108.
5. J.H. Byun, J.H. Lee, B.M. Lim, and S.K. Kim, Dual antenna capable of controlling radiation characteristics in a mobile communication terminal, U.S. Pat. 6,707,431 B2, (2004).
6. K.L. Wong, S.W. Su, C.L. Tang, and S.H. Yeh, Internal shorted patch antenna for a UMTS folder-type mobile phone, IEEE Trans Antennas Propag 53 (2005), 3391–3394.
7. K.L. Wong, W.C. Su, and F.S. Chang, Wideband internal folded planar monopole antenna for UMTS/WiMAX folder-type mobile phone, Microwave Opt Technol Lett 48 (2006), 324–327.
8. K.L. Wong, Y.W. Chi, B. Chen, and S. Yang, Internal DTV antenna for folder-type mobile phone, Microwave Opt Technol Lett 48 (2006), 1015–1019.
9. M. Tzortzakakis and R.J. Langley, Quad-band internal mobile phone antenna, IEEE Trans Antennas Propag 55 (2007), 2097–2103.
10. B.S. Collins, Improving the RF performance of clamshell handsets, In Proceedings of IEEE International workshop on antenna technology: small antennas and metamaterials (2006), pp. 265–268.
11. H. Liu, A. Napoles, and B.O. White, Wireless device with distributed load, U.S. Pat. 7,199,762 B2 (2007).
12. C.I. Lin and K.L. Wong, Printed monopole slot antenna for penta-band operation in the folder-type mobile phone, Microwave Opt Technol Lett 50 (2008), 2237–2241.
13. K.L. Wong and S.Y. Tu, Ultra-wideband coupled-fed loop antenna for penta-band folder-type mobile phone, Microwave Opt Technol Lett 50 (2008), 2706–2712.
14. C.H. Chang, K.L. Wong, and J.S. Row, Coupled-fed small-size PIFA for penta-band folder-type mobile phone application, Microwave Opt Technol Lett 51 (2009), 18–23.
15. C.H. Wu and K.L. Wong, Ultra-wideband PIFA with a capacitive feed for penta-band folder-type mobile phone antenna, IEEE Trans Antennas Propag 57 (2009), 2461–2464.
16. Y.W. Chi and K.L. Wong, Very-small-size folded loop antenna with a band-stop matching circuit for WWAN operation in the mobile phone, Microwave Opt Technol Lett 51 (2009), 808–814.
17. K.L. Wong and C.H. Huang, Printed PIFA with a coplanar coupling feed for penta-band operation in the mobile phone, Microwave Opt Technol Lett 50 (2008), 3181–3186.
18. C.H. Chang and K.L. Wong, Internal coupled-fed shorted monopole antenna for GSM850/900/1800/1900/UMTS operation in the laptop computer, IEEE Trans Antennas Propag 56 (2008), 3600–3604.
19. C.T. Lee and K.L. Wong, Uniplanar coupled-fed printed PIFA for WWAN/WLAN operation in the mobile phone, Microwave Opt Technol Lett 51 (2009), 1250–1257.
20. C.H. Chang and K.L. Wong, Printed λ/8-PIFA for penta-band WWAN operation in the mobile phone, IEEE Trans Antennas Propag 57 (2009), 1373–1381.
21. K.L. Wong and S.J. Liao, Uniplanar coupled-fed printed PIFA for WWAN operation in the laptop computer, Microwave Opt Technol Lett 51 (2009), 549–554.
22. Y.W. Chi and K.L. Wong, Quarter-wavelength printed loop antenna with an internal printed matching circuit for GSM/DCS/

PCS/UMTS operation in the mobile phone, IEEE Trans Antennas Propag 57 (2009), 2541–2547.
23. Ansoft Corporation HFSS Available at http://www.ansoft.com/products/hf/hfss/.

HYBRID SURVEILLANCE SYSTEM BY USING MULTI FREQUENCY BANDS ENHANCEMENT

M. Bunruangses,[1] K. Sunat,[1] S. Mitatha,[2] and P. P. Yupapin[3]
[1] Department of Computer Engineering, Mahanakorn University of Technology Cheum-Sampan Road, NongChok, Bangkok Thailand 10530
[2] Department of Computer Engineering, Faculty of Engineering King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand
[3] Advanced Research Center for Photonics, Physics Division, Faculty of Science King Mongkut's Institute of Technology Ladkrabang, Bangkok, 10520, Thailand; Corresponding author: kypreech@kmitl.ac.th

Received 19 November 2009

ABSTRACT: *We present a new design of a surveillance system via hybrid network in which is integrate wire, wireless less, Ad hoc network, vehicular Ad hoc network, sensor network, and cellular wireless network. We propose the dense wavelength division multiplexing wavelength enhancement, whereas the increasing in channel capacity and signal security can be provided. The increasing in number of channel can be obtained by the increasing in wavelength density, whereas the security is introduced by the specific wavelength filter, which is operated by the central operator. The optical communication wavelength enhancement is reviewed. The advantage is that the proposed system can be implemented and used incorporating with the existed communication link in hybrid wireless system, where the privacy can be provided, which is discussed in details.* © 2010 Wiley Periodicals, Inc. Microwave Opt Technol Lett 52: 2154–2158, 2010; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.25412

Key words: *surveillance wireless network; hybrids network; 3G and 4G cellular wireless; VANET*

1. INTRODUCTION

The surveillance systems depend on three key capabilities [1]: resistance, recognition, and recovery, where the resistance is the capability of a system to repel attacks, the recognition is the capability to detect attacks as they occur and to evaluate the extent of damage and compromise, and the Recovery is the capability to maintain essential services and assets during attack, limit the extent of damage, and restore full services following attack. The surveillance systems are occurrence from many enhance technologies, such as cellular wireless, wire network, wireless network, Ad hoc network, Vehicle Ad Hoc Network (VANET), and cellular network. Mobile Ad Hoc Network (MANET) formed dramatically through the cooperation and self-organizations of mobile nodes; connect via wireless link, no centralized administrator and free to move randomly by used IEEE 802.11 standard and CSMA/CA. Vehicular Ad Hoc Network (VANET), one type MANET to support modern intelligent transportation systems by site in vehicle and no limitations of the power consumption., but movement under constrains of street lane and traffic rule, and communicate base on short-range wireless communication [2] protocol. Simultaneously, the cellular wireless [3] is the cellular telephony, has a small coverage region or cells. Each cell area is approximated with a hexagonal and sites a base station at the center and contact with mobile stations by any standard for instance CDMA2000 [22]. Currently, hybrid network are combing these technology to support the third (3G) and fourth (4G) generation [4–6]. In this article, survivability hybrid wireless network, propose the new platform intermediary to link between nodes by using the dense wavelength division multiplexing (DWDM). The rest of this article is structure as follows. Section 2 revises operating principle, the multi-frequency bands generation. Section 3 proposed the DWDM Frequency Enhancement for Simultaneous Wireless Up-Down Link. Section 4 applied for the surveillance system on the basis of VANET applications. In section 5 is the conclusion of this work and section 6 is acknowledgement.

2. MULTI FREQUENCY BANDS GENERATION

Light from a monochromatic light source is launched into a ring resonator with constant light field amplitude (E_0) and random phase modulation as shown in Figure 1, which is the combination of terms in attenuation (α) and phase (ϕ_0) constants, which results in temporal coherence degradation. Hence, the time dependent input light field (E_{in}), without pumping term, can be expressed as [7]

$$E_{in}(t) = E_0 \exp^{-\alpha L + j\phi_0(t)} \tag{1}$$

where L is a propagation distance (waveguide length).

We assume that the nonlinearity of the optical ring resonator is of the Kerr-type, i.e., the refractive index is given by

$$n = n_0 + n_2 I = n_0 + \left(\frac{n_2}{A_{eff}}\right)P, \tag{2}$$

where n_0 and n_2 are the linear and nonlinear refractive indexes, respectively. I and P are the optical intensity and optical power, respectively. The effective mode core area of the device is given by A_{eff}. For the microring and nanoring resonators, the effective mode core areas range from 0.10 to 0.50 μm^2 [8].

When a Gaussian pulse is input and propagated within a fiber ring resonator, the resonant output is formed, thus, the normalized output of the light field is the ratio between the output and input fields ($E_{out}(t)$ and $E_{in}(t)$) in each roundtrip, which can be expressed as [9].

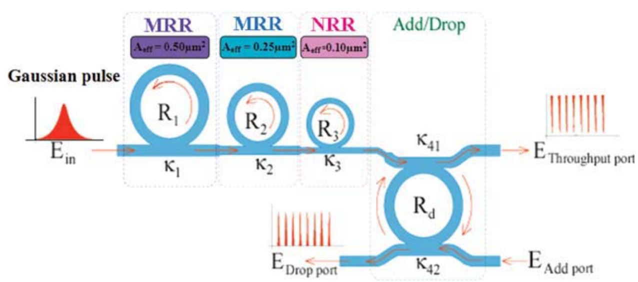

Figure 1 A schematic of a Gaussian soliton generation system, where R_s: ring radii, κ_s: coupling coefficients, R_d: an add/drop ring radius, A_{eff}: Effective areas, MRR: Microring resonator, NRR: Nanoring resonator, K_{42} and K_{42} are add/drop coupling coefficients. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]