Compact Multiband Antenna with a Dual-arm Monopole Structure for Mobile Phone and WiMAX Application

#David DELAUNE[1], Ning GUAN[1], and Koichi ITO[2]

[1] Optics and Electronics Laboratory, Fujikura Ltd., Japan

1440 Mutsuzaki, Sakura-shi, 285-8550 Chiba, Japan, E-mail: delaune@lab.fujikura.co.jp

[2] Department of Medical System Engineering, Chiba University, Japan

1-33 Yayoi-cho, Inage-ku, Chiba-shi, 263-8522 Chiba, Japan

1. Introduction

Recently, multi-band and wideband operation are getting popular through the rapid development of modern wireless communication systems.

For mobile phones, Global System for Mobile communications (GSM) is the most popular standard in the world. Its ubiquity makes international roaming very common between mobile phone operators, enabling subscribers to use their phones in many parts of the world. Most GSM networks operate in the 900 MHz or 1800 MHz bands. Many GSM phones support three bands (900/1800/1900 MHz or 850/1800/1900 MHz) or four bands (850/900/1800/1900 MHz) [1]. Currently, the market aiming at providing multiple services within a single communication unit, there is a greater demand for the multiband antenna such as penta-band (2100 MHz band added to the previous quad band phone) [2].

Furthermore, in the near future, mobile devices will require antennas to support communications using multiple wireless protocols [3]-[5], like the Worldwide Interoperability for Microwave Access (WiMAX) that is a telecommunications technology aimed at providing wireless high-rate data over long distances in a variety of ways, from point-to-point links to full mobile cellular type access [6].

Consequently, in this paper, a very low profile and very small antenna (0.12 x 0.05 x 0.01 λ_{920}, where λ_{920} represents the wavelength at 920 MHz) is introduced, aimed at multiband application in the mobile phone. The proposed antenna is a folded printed monopole with two branches, one of them being bent into a loop shape that enables the higher-mode resonance to be shifted towards the low frequencies, the other branch broadening the bandwidth of the higher-mode resonance. The discussed antenna can meet the demand for the current market, as well as WiMAX application, in a single unit.

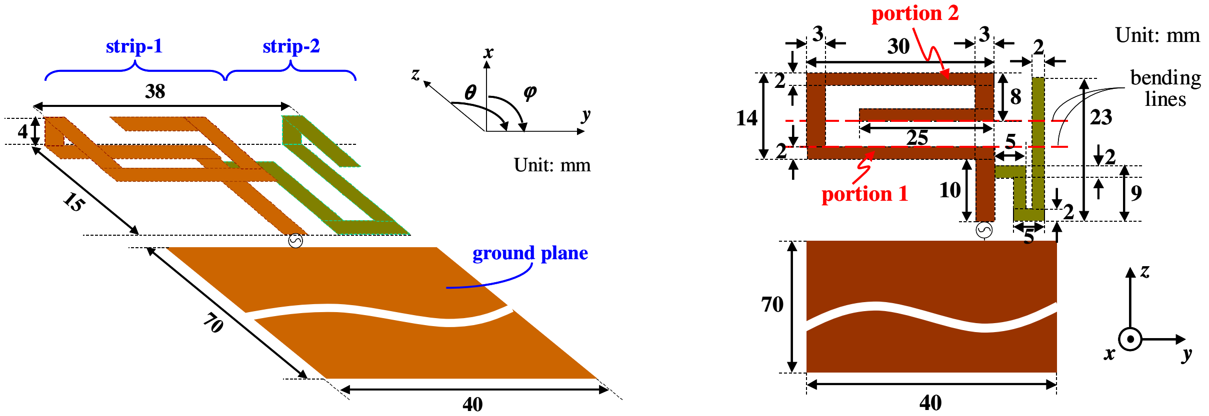
2. Antenna configuration

The configuration of the proposed antenna is shown in Fig. 1. The antenna is located above the top edge of the system ground plane with a small distance of 3 mm from this one. The antenna is composed of two branches formed by a longer resonant strip (strip-1) and a shorter resonant strip (strip-2).

The bent strip-1, which is folded into a loop shape, generates a fundamental mode at 920 MHz and a second mode at about 2145 MHz. It is clear from this graph that the higher-mode resonance (mode 2) that is usually 3 times the fundamental one (mode 1) for a straight monopole, shifts towards the lower frequencies. This lower band is used for the GSM operation. Strip-2 generates a fundamental mode at about 2355 MHz (mode 3), which overlaps with the second mode of strip-1 to form a wide band; hence, enabling the coverage of GSM/DCS/PCS/UMTS and WiMAX bands (Fig. 2).

Strip-1 and strip-2 are folded so that space can be saved, which is a must in requirements for mobile phone antennas, and so that frequency resonances can be arranged as shown in Fig. 3. This figure shows the influence of the folding of strip-1 on resonance. The ratio of portions 1 and 2 - as indicated in Fig. 1(b) - is numerically varied, while the overall length of strip-1 is kept constant to about a quarter wavelength at 920 MHz. It is clear from the graph that while the first resonance does not change (about 920 MHz), the higher-mode resonance can be freely shifted when appropriately varying the ratio of portions 1 and 2.

Fig. 4 shows the relation between modes and current distribution for both strip-1 and strip-2. From this figure, it can be seen that in both fundamental modes, the current flows on the whole length of each strip and gets weaker as it propagates. Meanwhile, in the higher mode, although the current flows on the whole length of the strip, its phase changes and its direction of propagation becomes opposite at a certain point.



(a) wrapped structure (b) unwrapped planar structure

Figure 1: Composition of the antenna

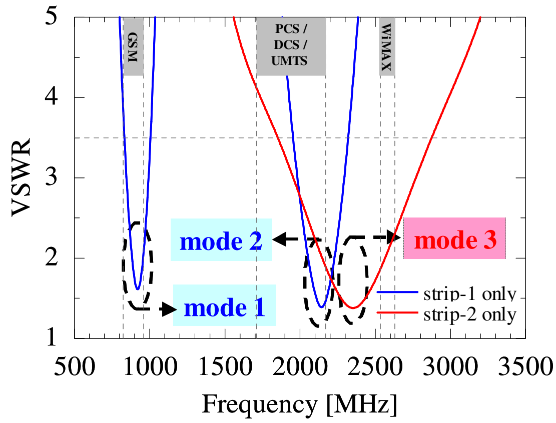


Figure 2: Input characteristics

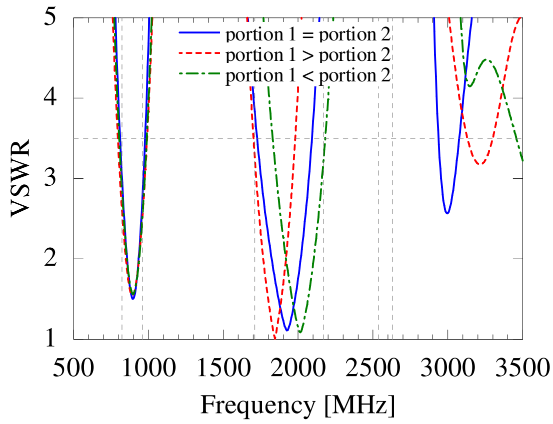


Figure 3: Influence of folding on resonance

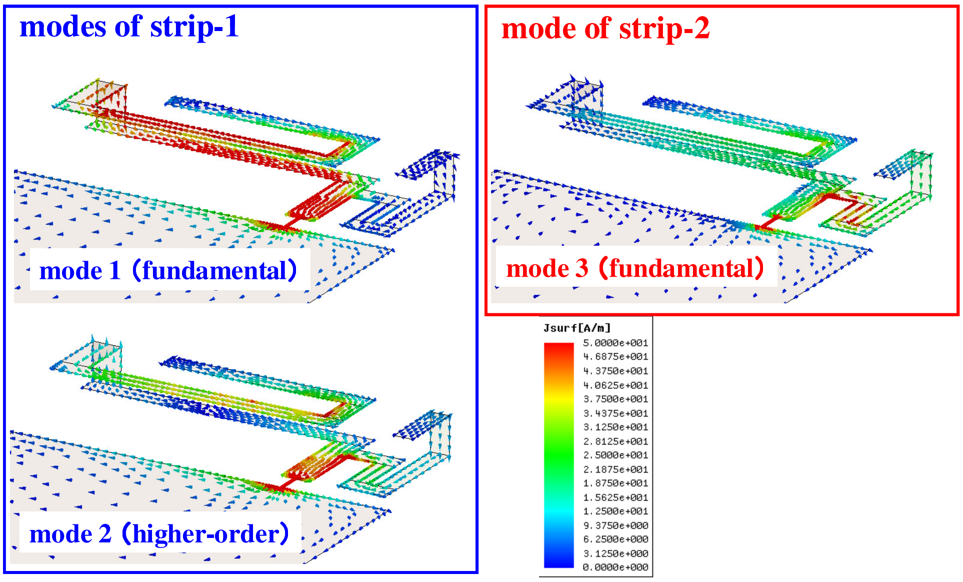


Figure 4: Relation between modes and current distribution

3. Results

Fig. 5 shows the voltage standing wave ratio (VSWR) for the proposed antenna. The obtained impedance bandwidths are 125 MHz, 785 MHz, and 245 MHz for the bands of interest, when VSWR is chosen to be less than 3.5.

Radiation characteristics of the antenna are also studied (see Fig. 6). Almost omni-directional radiation patterns are observed in the *xy* plane and figure-of-eight shaped radiation patterns are observed in the other planes. The typical gain values are summarized in Table 1.

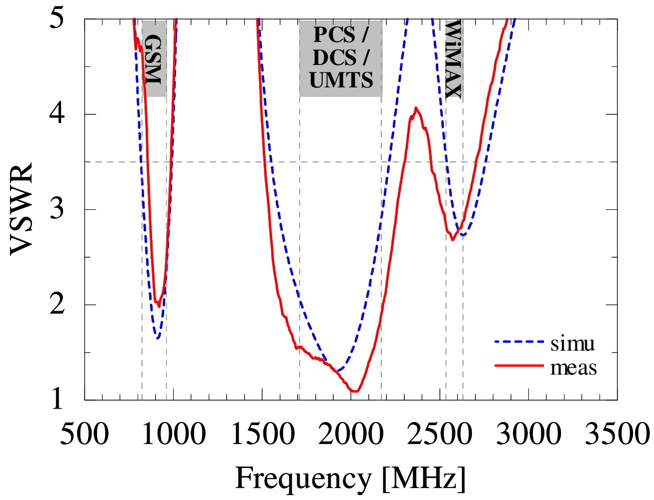


Figure 5: VSWR of the proposed antenna

Table 1: Gain values (*xy* plane)

Band	Peak [dBi]	Minimum [dBi]	Average [dBi]
GSM (*f* = 920 MHz)	-0.2	-6.6	-2.1
DCS / PCS / UMTS (*f* = 2020 MHz)	3.0	0.0	1.5
WiMAX (*f* = 2575 MHz)	-1.9	-24.6	-6.3

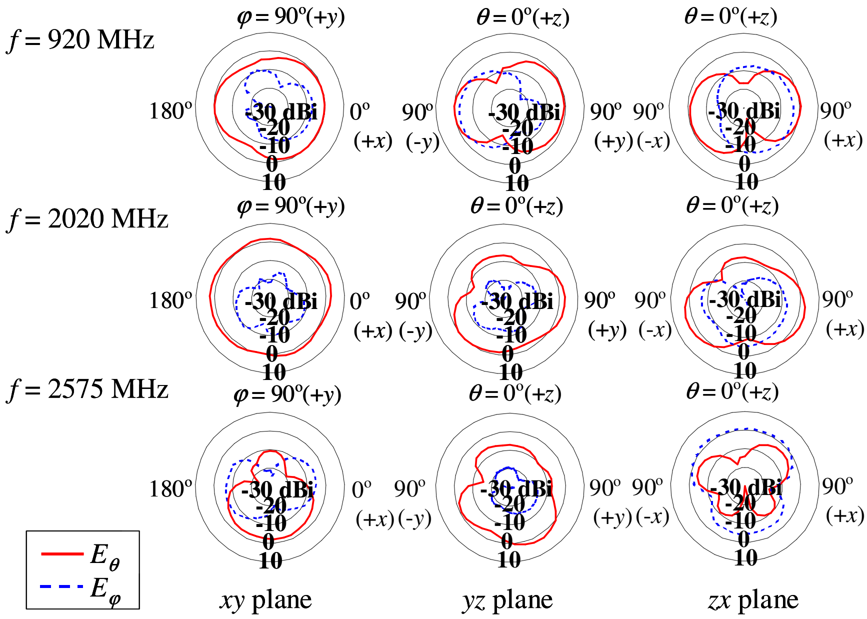


Figure 6: Radiation patterns of the proposed antenna

4. Conclusions

A printed monopole antenna for penta-band operation (including WiMAX operation) in the mobile phone has been proposed and studied. The antenna occupies a volume of 38 x 15 x 4 mm^3 with a very low height as compared to others, yet it can cover three wide bands centred at about 920 MHz, 2020 MHz, and 2575 MHz to realize GSM/DCS/PCS/UMTS/WiMAX operation. Good radiation characteristics of the antenna over the operating bands have also been observed. The proposed antenna is very promising for application in the mobile phone as an internal antenna for penta-band operation.

References

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