# Multiband Antenna for Wireless Applications Including GSM/UMTS/LTE and 5G Bands

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***Abstract*—A simple ultra thin multiband antenna is introduced. The proposed antenna with four bands covers many wireless applications. The proposed antenna has simple configuration including two open L-shaped slots to create resonat mode at GSM and GPS bands and also two rectangular slots on the radiating element for creating multi resonant modes to meet the specifications of mentioned frequency bands. According to the simple, small and planar configuration, the proposed antenna design is inexpensive and can easily be integrated with the other microwave circuit boards. The proposed antenna has the small size of 10 mm and the total size of 120 mm × 60 mm × 0.5 mm, promising to be used widely in compact and ultra slim handsets.**

***Index Terms*—multiband antenna, planar configuration, wireless applications, wireless handset.**

## I. Introduction

Owing to development of mobile communication systems, the design of modern antennas with compact size, multiband operation, and integrability with other microwave circuits has attracted much attention. As a result, various types of multiband antennas have been reported [1]–[3]; however, by having two or three bands, most existing antennas are unable to cover more bands with one structure.

In this paper, we introduce a four–band slot antenna for the GSM (890–960 MHz), Galileo (1563–1591 MHz), GPS (1575.42 ± 5 MHz), Glonass (1602–1615.5 MHz), DCS (1710–1880 MHz), PCS (1850–1990 MHz), UMTS (1920–2170 MHz), LTE2300 (2305–2400 MHz)/LTE2500 (2500–2690 MHz), WLAN (2.4–2.484/5.15–5.35/5.7–5.8 GHz ), and WiMAX (2.5–2.7/3.4–3.7/5.2–5.8 GHz) applications. Also the proposed antenna is able to cover some suggested bands of 5G systems including 3.3–3.8 GHz, 4.8–4.99 GHz, 5.150–5.925 GHz, 5.925–7.025 GHz, 7.235–7.25 GHz, and 7.750–8.025 frequency ranges [4]. The proposed antenna covers several applications which are narrowband and also provides the essential bandwidth for higher data rate applications.

## II. Antenna Configuration

Fig. 1 shows the structure of the proposed antenna. The antenna is fabricated on a low-loss FR-4 substrate with dielectric constant of 4.3, thickness of 0.5 mm and loss tangent of 0.02. The antenna with a simple structure consists of a rectangular radiation patch, an open L-shaped slot for 900 MHz band, a horizontal open slot for GPS band and two rectangular slots

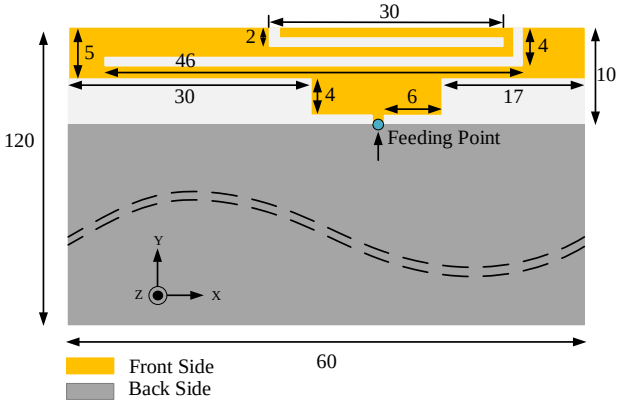


Fig. 1. Configuration of the proposed antenna (unit: mm).

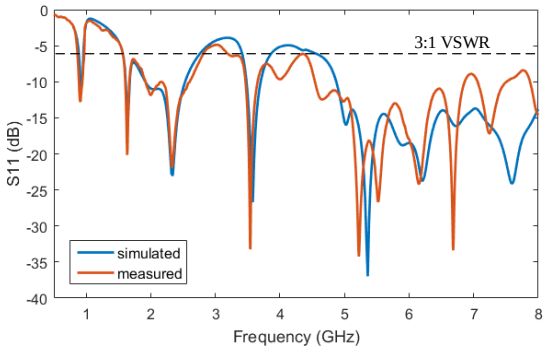


Fig. 2. Comparison between the HFSS (version 15) simulated and measured result of reflection coefficient.

for generating multi resonant modes to meet the specifications of desirable frequency bands. It is notable that an open-end slot can generate a quarter-wavelength resonant mode. Also, a wide slot can create several resonance modes, and by merging nearby resonance modes a wider bandwidth can achieved. The proposed antenna occupies an area of 10 mm × 60 mm, while the ground plane has an area of 110 mm × 60 mm which is a typical system board of mobile devices. A comparison between usage of lumped elements, structure, antenna size and

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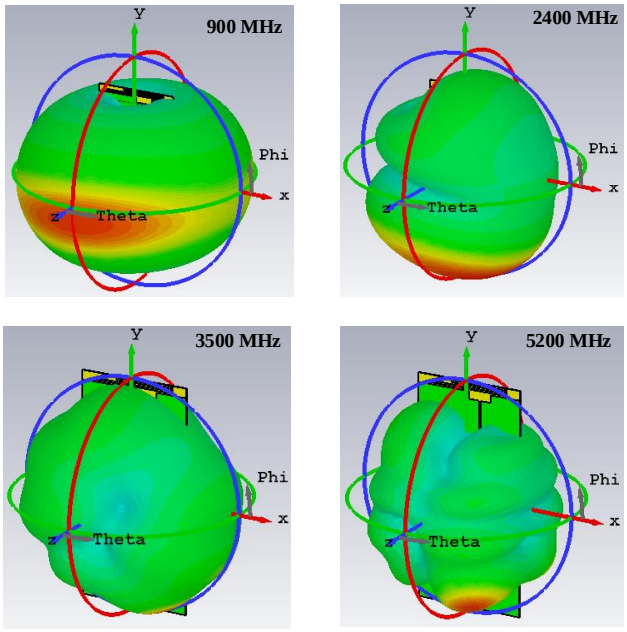


Fig. 3. Radiation patterns of the proposed antenna at different frequencies simulated by CST STUDIO SUITE 2017 Software.

TABLE I
COMPARISON OF THE PROPOSED ANTENNA WITH RECENT WORKS

| [Ref] (year) | [1] (2013) | [2] (2014) | [3] (2015) | Proposed |
|---|---|---|---|---|
| Lumped Element | No | No | Yes | No |
| Structure | Planar | Planar | 3D | Planar |
| Antenna size (mm×mm×mm) | 78×0.6 ×18 | 115×0.5 ×15 | 120×0.8 ×8 | 120×0.5 ×10 |
| -6 dB bandwidth (MHz) | 890–960<br>1570–2500<br>———<br>——— | 790–1061<br>1650–2775<br>3132–6382<br>——— | 800–1150<br>1700–2580<br>———<br>——— | 860-970<br>1560–2820<br>3180–4350<br>4400–8000 |

bandwidth of the proposed antenna with some recent studies is illustrated in Table I. It is notable that simultaneously covering all mentioned frequency bands with one structure is difficult, somehow none of the antenna in [1]–[3] can achieve this goal.

## III. RESULTS AND DISCUSSIONS

To validate the simulation results, the designed antenna is fabricated and tested. The measured reflection coefficient $S_{11}$ is compared to the simulated result in Fig 2. It is seen that the bandwidths for $|S_{11}| < -6$ dB (or VSWR $> 3$) are 12.02% (860-970 MHz) for the 900-MHz band, 57.53% (1.56-2.82 GHz) for the 2-GHz band, 31.07% (3.18-4.35 GHz) for the 3.5-GHz band, and 58.06% (4.4-8 GHz) for the 5.5-GHz band. Note that the $|S_{11}| < -6$ dB as the specification of the impedance matching bandwidth is widely acceptable for practical internal antennas [1], [3], [5], [6].

TABLE II
SIMULATED GAIN AND RADIATION EFFICIENCY RESULTS

| Frequency [MHz] | CST [Gain (dB)–Efficiency (%)] | HFSS [Gain (dB)–Efficiency (%)] |
|---|---|---|
| 900 | 0.8–69.18 | -0.7–76 |
| 2400 | 3.64–61.65 | 4.08–77 |
| 3500 | 1.14–45.7 | 0.99–49 |
| 5200 | 3.79–46.7 | 2.86–55 |

The simulated peak gain and radiation efficiency values of the proposed antenna at different frequencies are presented at Table II. The results which have been obtained from the HFSS and CST softwares are almost close together and acceptable for mobile devices.

Fig. 3. demonstrates the simulated radiation patterns of the proposed antenna at 900 MHz, 2.4 GHz, 3.5 GHz, and 5.2 GHz. It can be observed that the radiation pattern of the proposed antenna at 900 MHz is dipole-like radiation pattern which shows that the radiation characteristic is stable at lower frequency [5]. Moreover, the simulated radiation patterns are almost omni-directional in the X-Z plane (with respect to position of the proposed antenna in the Cartesian coordinate) which are desired for the practical communication applications [1].

## IV. CONCLUSION

In this paper, a simple planar multiband antenna for GSM, Galileo, GPS, Glonass, DCS, PCS, UMTS, LTE2300/LTE2500, WLAN (2.4–5.2–5.8 GHz), WiMAX (2.5–3.5–5.5 GHz) and 5G applications is presented and discussed. The antenna has small, ultra thin, and simple structure. We show that by inserting different slots with proper size in the truncated radiation patch, good multiband features can be achieved. It is also shown that the suggested antenna has good radiation characteristics such as stable radiation patterns, high radiation efficiency, and also acceptable gain values.

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