A Wideband Printed Monopole Antenna with a Co-Planar Waveguide Feeding

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Abstract. A wideband printed monopole antenna with a co-planar waveguide feeding is presented. This antenna provides a frequency range of 1.7 – 6.0 GHz. It is a flat conductor on FR4 printed circuit board. The shape of ground and pole are rectangle that the 2 corners near the feeding point are 25 degree chamfered, symmetrically. The ground is etched to form a co-planar waveguide for feeding. For this work, the antenna is simulated by using computer program before fabricating a prototype. The antenna provides an omni-directional radiation same as donut shape at the low frequency of the operating band. The radiation pattern is change when the frequency is shift to high but still omni-direction. The bandwidth of the antenna is 112% between 1.7 GHz and 6.0 GHz with the reflection coefficient less than -10 dB across the band. Gains of the antenna are 2.3, 4.9, and 3.4 dBi at the frequencies of 1.8, 3.8, and 5.8 GHz, respectively. They are the 3 points of low-, central- and high-frequency of the operating band. The size of the antenna is 70.0 x 40.0 mm². Advantages of the antenna are wideband, low profile structure, light weight, and can be fabricated by FR4 make it low-cost.

1. Introduction

Wireless communication systems such as DCS (Digital Cellular System) has the frequency range of 1.71 – 1.88 GHz, PSC (Personal Communications System) has the frequency range of 1.85 - 1.99 GHz, UMTS (Universal Mobile Telecommunications System) has the frequency range of 1.92 - 2.17 GHz, WiMAX (Worldwide Interoperability for Microwave Access) has the frequency range of 2.496 – 2.690 GHz, and WLAN (Wireless Local Area Network) has the frequency ranges of 2.400 – 2.483 GHz and 5.15 – 5.85 GHz. All systems as indicated must use the antenna for transmitting and receiving signals. Therefore, many antennas are developed for supporting systems above. However, it is noted that each system has operating frequency close to each other. If we have the antenna that can operate covers all system bands, the antenna is interested. Thus, the combination of the operating band covers 1.71 – 5.85 GHz. The antennas which operate cover more than one system is called broadband
antenna [1] while the antenna that operated cover 2 frequency bands together is called dual-band antenna.

Broadband antenna is wideband antenna. Wideband antenna had been proposed in many research works. For example, wideband planar plate monopole antenna [1] that radiated in omni-directional, they provide a very wide bandwidth but had distort beam at the high frequency of the operating band. Same as bi-directional antenna in [2], although it has a wide bandwidth but squeeze beams occurs at the high frequency of the band. Various antenna designs such as those of micro-strip line, co-planar waveguide (CPW), printed monopole antenna, and printed dipole antennas have been proposed in the literature [3]. Therefore, it was shown that a monopole antenna has the ability to give multiband operation.

This paper discussed the wideband printed monopole antenna that can be used to operate with various systems between the frequencies of 1.71 GHz and 5.85 GHz. A prototype that operates in the frequency bands is developed. By etching to form shapes of monopole, ground, and CPW printed on the same side of the FR4, a printed monopole antenna that actives wideband operation from 1.71 - 5.85 GHz is realised. The monopole is able to produce enough operating frequency band. Additionally, the reflection coefficient, far-field radiation pattern and antenna gain of the proposed antenna are demonstrated.

2. Antenna description

Structure of the proposed antenna is shown in Figure 1. (a). The antenna was contributed on an FR4 substrate with a thickness of 1.6 mm and a permittivity of 4.8. The overall dimensions of the structure were 44.0 x 70.0 (a x b) mm². The antenna was fed by a CPW by etching copper ground plane that coated on the surface of FR4 to form double slots and a strip-line which appropriate to the impedance of 50 Ω. The width of the CPW strip-line is s, while the width of the 2 slot-lines is g. Dimensions of the ground plane were w x l where w is the width and l is the length. The 2 upper corners of the rectangle ground are 25° chamfered by the depth of c for adjusting radiated beam as shown in Figure 1. (a). Over the rectangle ground is the flat printed monopole. The width of the flat printed monopole is equal to the width of the ground. Gap between ground and monopole is g. The length of the monopole, l, is used to determine the low frequency start at 1.7 GHz, and the width w is adjusted to vary the impedance for the desire of impedance matching. The 2 corners of monopole near ground are 25°- chamfered by the depth of c as well. The antenna is designed by using a ground plane to form a CPW as proposed which has three functions: (1) a ground plane for the monopole and CPW, (2) radiating element and (3) component to form the distributed matching network with the monopole [3].

For comparing and to confirm the accuracy of the simulation, the prototype of the proposed antenna is fabricated with the dimensions and materials as indicated in Table 1. The prototype of the antenna is shown in Figure 1. (b).
3. Simulated and measured results

3.1. Simulated and measured reflection coefficients

The simulated and measured reflection coefficients are shown in Figure 2. The simulated result of the reflection coefficient agrees with the measured result. The measured reflection coefficients of the antenna provides the bandwidths >112% (<-10 dB) between the frequency range of 1.7 GHz and 6.0 GHz. However, the simulated result is better than the measured one at the high frequency. The discrepancy is mainly due to the error of dimensions between the simulation and the fabricated antenna.

![Figure 2. Simulated and measured reflection coefficients of the proposed antenna](image)

Many parameters are varied to show the characteristics of the proposed antenna. The first parameter is $w$ or the width of the flat monopole and ground. The results of reflection coefficient with different $w$ are showed in Figure 3. It is found that $w$ is influence to the impedance matching. When $w$ is increase from 36.0 to 40.0 and to 44.0 mm, the reflection coefficient between 2.0 and 3.5 GHz is increase. However, if $w$ is greater than 44.0 mm, the operating band is shift to high, especially at the start of the band, it greater than 1.7 GHz.

The second parameter is $l$ or the length of monopole and ground. The results of vary $l$ is showed in Figure 4. It is found that $l$ is influence to impedance matching and operating band. When $l$ is increase

### Table 1. Parameters and their dimensions of the proposed wideband printed monopole antenna

| Parameter | Dimension (mm) |
|-----------|----------------|
| $a$       | 44.0           |
| $b$       | 70.0           |
| $w$       | 40.0           |
| $l$       | 29.0           |
| $c$       | 7.0            |
| $g$       | 0.5            |
| $s$       | 3.0            |
| $t$       | 1.6            |
from 27.0 to 29.0 and to 31.0 mm, the reflection coefficient between 2.0 and 5.0 GHz is decrease and the bandwidth is wide to the low frequency.

![Figure 3. Simulated reflection coefficients when changed parameter w](image)

![Figure 4. Simulated reflection coefficients when changed parameter l](image)

The third parameter is \( c \) or the 25° chamfer of monopole and ground. The results of reflection coefficient with different \( c \) are showed in Figure 5. It is found that \( c \) is influence to the high frequency (3.0 – 6.0 GHz) band. When \( c \) is increase from 5.0 to 7.0 and to 9 mm, the best matching is occur.

The next parameter is \( g \) or the gap of slot-etching. The results of vary \( g \) is showed in Figure 6. It is found that an appropriate of \( g \) is about 0.5 mm.

The last parameter is \( s \) or the width of the strip-line feeding. The results are showed in Figure 7. It is found that an appropriate of \( s \) is about 3.0 mm that is corresponding to the impedance of 50 \( \Omega \).
3.2. Simulated and measured radiation patterns
The experimental was operated in open area to decrease the effect of the reflection. The observed operating frequencies are 1.8, 3.8, and 5.8 GHz as shown in figure 8, 9, and 10, respectively. The 3 observed frequency points are low, mid, and high of the band.

Figure 8 shows the normalized co-polarization patterns of simulated in 3 planes as indicated the coordinate and direction in Figure 1 compare with the measured results at 1.8 GHz. It was found that
the half power beam-widths (HPBW) are 79° for both yz- and xz-plane. The patterns in both planes are symmetry. Gain for this frequency is 2.3 dBi.

Figure 9 shows the simulated and measured co-polarized radiation patterns at 3.8 GHz. It was found that the half power beam-widths (HPBW) are 98° for yz-plane and 2 x 40° for xz-plane. The patterns in both planes are not symmetry. Gain for this frequency is 4.9 dBi in y-direction.

Figure 10 shows the simulated and measured co-polarized radiation patterns at 5.8 GHz. It was found that the half power beam-widths (HPBW) are 68° for yz-plane and 40°, 30° for xz-plane. The patterns in both planes are not symmetry. Gain for this frequency is 3.4 dBi in y-direction.

Figure 8. Simulated (solid line) and measured (doted) co-polarized radiation patterns at 1.8 GHz (a) yz plane (b) xz plane and (c) xy plane.

Figure 9. Simulated (solid line) and measured (doted) co-polarized radiation patterns at 3.8 GHz (a) yz plane (b) xz plane.
Figure 10. Simulated (solid line) and measured (doted) co-polarized radiation patterns at 5.8 GHz (a) yz plane (b) xz plane

4. Conclusions
This paper presented the wideband printed monopole antenna with a co-planer waveguide feeding. The antenna is fabricated on an FR4 substrate in one-side. We were found that the antenna has the measured bandwidth cover various systems between the operating band of 1.7 – 6.0 GHz. Antenna gains are 2.3, 4.9, and 3.4 dBi at the operating frequencies of 1.8, 3.8, and 5.8 GHz, respectively. The advantages of the antenna are low profile structure, light weight, good matching, and can be fabricated with the cheap material. It is the low-cost antenna that suitable for using in various systems.

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