Small broadband disc-loaded monopole antenna with probe feed and folded stripline

J.-H. Jung, H. Choo and I. Park

A small broadband disc-loaded monopole antenna with a probe feed and folded stripline is presented. The antenna is composed of a rectangular disc with multiple shorting pins and a probe feed with a folded stripline that are coupled electromagnetically. The dimensions of the proposed antenna are $12 \times 12 \times 10$ mm, and it has a measured impedance bandwidth of 700 MHz for VSWR <2 with a centre frequency at 2.54 GHz, which is approximately 27.5% of a fractional bandwidth.

Introduction: Wireless communication systems have rapidly developed into cellular phones, personal communications services (PCSs), and personal digital assistants (PDAs). Antennas in handset units for wireless communications must be small to reduce the size of the handsets and must have a broad bandwidth to provide not only for low-speed voice data but also for high-speed multimedia data. Various types of antennas that satisfy these requirements have been investigated [1]. Planar inverted F antennas (PIFAs) are among the most widely used internal antennas in handsets; PIFAs, however, have poor antenna characteristics, such as a narrow bandwidth and a low gain. U-slots or L-slits have been incorporated into PIFAs in conjunction with L-probe feeds [2, 3], and various feeding structures have been adapted [4] to improve the narrow bandwidth of PIFAs. An impedance bandwidth of up to 30% has been achieved; however, this type of antenna is still too large to be used in handsets.

The disc-loaded monopole antenna is another good candidate as an internal antenna for handsets because it can achieve a broad bandwidth even with a small size. The bandwidth of the disc-loaded monopole antenna can be enhanced when its grounded plates or pins are placed on the loading patch [5, 6]. It has also been shown that the bandwidth of the disc-loaded monopole antenna can be improved greatly by using electromagnetic coupling between two radiators that are packed within a small volume [7]. In this Letter, we propose a small disc-loaded monopole antenna with multiple shorting pins and a probe feed with a folded stripline. The proposed antenna has an impedance bandwidth of 27.56% for VSWR $\leq$2 with a centre frequency at 2.54 GHz and small physical dimensions of $12 \times 12 \times 10$ mm.

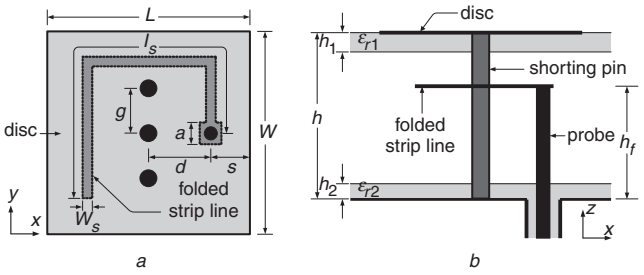

Fig. 1 *Antenna structure*
a Top view
b Side view

Antenna geometry and measured results: Fig. 1 shows the geometry of the proposed antenna. A rectangular disc of length $L = 12$ mm and width $W = 12$ mm is placed at a height of $h = 10$ mm from the ground plane. The rectangular disc is connected to the ground plane with three shorting pins that have the same diameter of $\phi_1 = 1.0$ mm. The shorting pins are placed along the y-axis in the middle of the rectangular disc at equal gaps of $g = 3$ mm. The antenna is excited through a coaxial probe with a diameter of $\phi_2 = 0.86$ mm, which is connected to the end of the folded stripline at a height of $h_f = 8$ mm from the ground plane. The length and width of the folded stripline are $l_s = 23$ mm and $w_s = 0.5$ mm, respectively, and the distances between the stripline and the three edges of the rectangular disc are the same with $s = 1.4$ mm. Since the probe diameter is wider than that of the width of the folded stripline, a small square patch with size $a = 1.3$ mm is formed at the end of the folded stripline to connect with the probe. The centres of the rectangular disc and probe are spaced $d = 4.6$ mm apart. The rectangular disc is placed on a substrate with a dielectric constant of $\varepsilon_{r1} = 10.2$ and a thickness of $h_1 = 1.27$ mm, and the substrate for the ground plane has a dielectric constant of $\varepsilon_{r2} = 3.38$ and a thickness of $h_2 = 0.81$ mm.

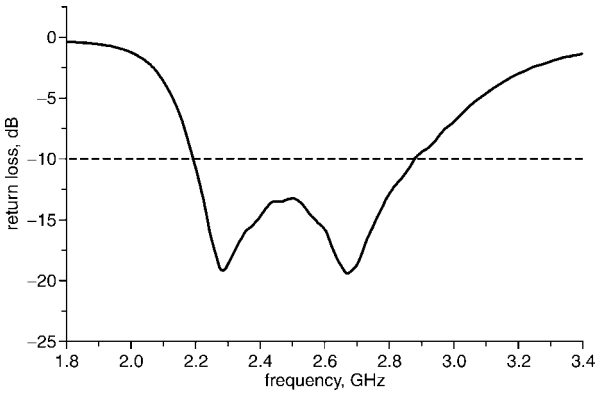

Fig. 2 *Measured return loss*

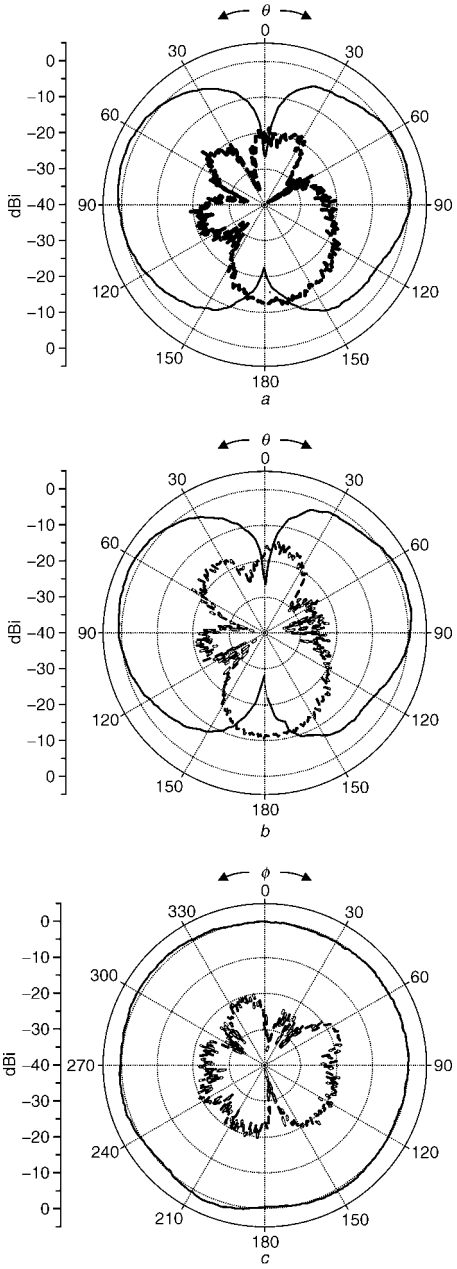

Fig. 3 *Measured antenna radiation patterns at 2.5 GHz*
a x-z plane
b y-z plane
c x-y plane
— E_θ --- E_ϕ

The antenna was fabricated on a ground plane, size 70×70 mm, and the measurement was carried out using an Agilent E5071B network analyser. The measured return loss of the antenna is shown in Fig. 2. The impedance bandwidth of the antenna is from 2.19 to 2.89 GHz for VSWR ≤ 2, which is a fractional bandwidth of 27.56% at the centre frequency of 2.54 GHz. The proposed antenna is less than half the size of the recently proposed bi-triangular plate-fed PIFA [4], and has a similar bandwidth and centre frequency. Fig. 3 shows the measured co-polar and cross-polar radiation patterns for the proposed antenna at 2.54 GHz. The gain of the antenna is 1.72 dBi, with a maximum value at around $\theta = 65^{\circ}$. The azimuth radiation pattern shows a good omnidirectional pattern. The cross-polarised level is approximately 20 dB lower than that of the co-polarised level.

Conclusion: A small broadband rectangular disc-loaded monopole antenna with multiple shorting pins and a probe feed with a folded stripline has been presented. The fractional bandwidth of 27.56% for VSWR ≤ 2 at the centre frequency of 2.54 GHz was achieved with the antenna dimensions of $12 \times 12 \times 10$ mm. The antenna has good omnidirectional radiation characteristics and a relatively high gain, considering its small size.

2 March 2005
Electronics Letters online no: 20050612
doi: 10.1049/el:20050612

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