Metallic short backfire antenna with halved size and wideband characteristics

Longsheng Liu, Han Wang, Yue Li, Zhijun Zhang and Zhenghe Feng

A short backfire antenna is proposed for 5.2/5.8 GHz wireless local area network (WLAN) applications. Wideband impedance matching is achieved by employing a truncated monopole as the exciter. Moreover, power-handling capability could be enhanced by the all-metallic configuration. The proposed antenna with halved size has two configurations when placed on a ground plane to meet the demands for different applications.

Introduction: In the past decades, there has been an increasing demand for high-gain and wideband directional antennas in wireless applications such as wireless local area networks (WLANs), local multipoint distribution service systems and world interoperability for microwave access [1]. The short backfire antenna (SBA), first conceived by Ehrenspeck in 1960 [2], is one of the most competitive candidates for such wireless applications owing to its high-gain, low sidelobe level and compact construction [3]. SBA usually consists of a primary reflector, a sub-reflector, a rim and an exciter with corresponding feed structure (usually dipole, waveguide or microstrip patch). SBA suffers from insufficient impedance bandwidth (typically only 3–5% for voltage standing wave ratio ≤ 1.5), which is inherent in narrowband characteristic of the feed structure and high-Q (quality factor) leaky cavity resonance of SBA itself [4]. Plenty of researches have been reported on improving the impedance bandwidth to 20–30% by modifying the cavity into arc or conical shapes [4, 5], employing different kinds of exciters (e.g. unbalance-fed patch with H-shaped slot [6], a planar monopole with an H-shaped slot [1] and L-probe fed microstrip patch [7]) and optimising both the cavity shape and the exciter [3].

However, complicated cavity shapes and excitation configurations used in these designs increase the complexity of design and raise the manufacturing cost; besides, average power-handling capability is fairly limited by the heatsink capabilities of the substrate used in the excitation structure [8].

In this Letter, we present a halved SBA operating at 5.2/5.8 GHz WLAN. The features of the proposed antenna include simple structure, broad bandwidth and high power-handling capability. High-frequency structure simulator software is used to optimise this antenna and a reasonable agreement between the measured and simulated results is observed. Details of the proposed designs and the results are presented in the following Sections.

Antenna structure: As shown in Fig. 1, the proposed antenna, only half the size of the traditional SBA, consists of a large semi-circular primary reflector, sub-reflectors including a small semi-circular reflector and a semi-annular reflector, a rim and a truncated monopole.

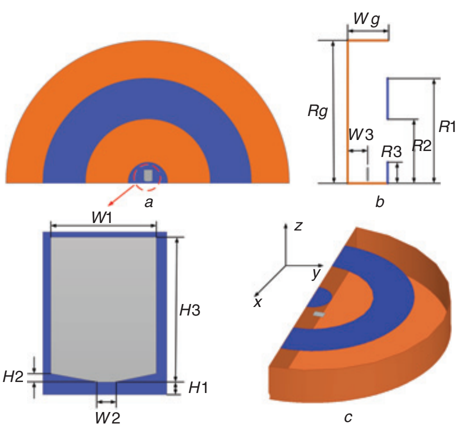

Fig. 1 *Configuration of proposed antenna (Rg = 136, Wg = 38, R1 = 100, R2 = 60, R3 = 19, W1 = 8, W2 = 1, W3 = 19, H1 = 1, H2 = 0.5 and H3 = 11, all values are in millimetres)*

a Top view
b Sectional side view
c Panoramic view

Similar to the conventional SBA, the proposed antenna also operates in a leaky cavity mode. The primary reflector captures most of the energy radiated by the monopole, whereas the sub-reflectors act as diffracting obstacles. Therefore, strengthened power is radiated along the axis from the open cavity after multiple reflections between them. The dimensions of the reflectors and the rim are carefully adjusted for a desirable radiation performance, such as a higher gain and a lower sidelobe level.

Instead of being excited by a dipole, a patch or a waveguide, the proposed SBA is excited by a truncated monopole, simplifying the excitation structure. A semi-miniaturised type-A connector is connected to the truncated monopole from the backside of the rim. As a variation of planar cone-shaped monopole antenna, the truncated monopole has been theoretically analysed and experimentally verified to yield wide-impedance bandwidth [9, 10]. As shown in Fig. 2, some representative parameters of the truncated monopole are investigated to further understand their effects on impedance performance of the proposed antenna. Wideband impedance matching can be obtained by optimally tuning the dimensions of the truncated monopole.

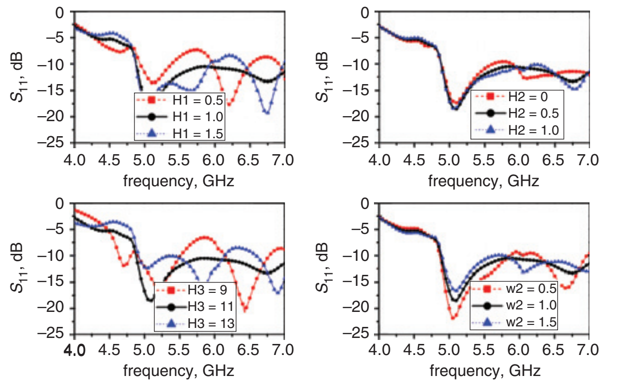

Fig. 2 *Simulated S_{11} of proposed antenna against different dimensions of truncated monopole (all values are in millimetres)*

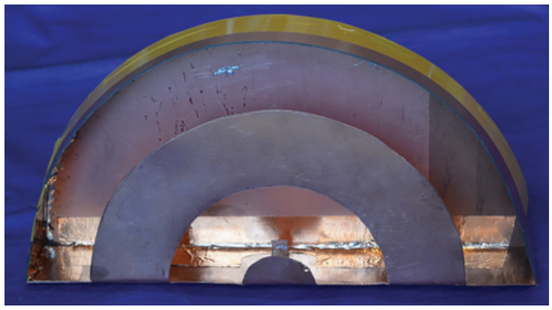

Fig. 3 *Photograph of proposed antenna*

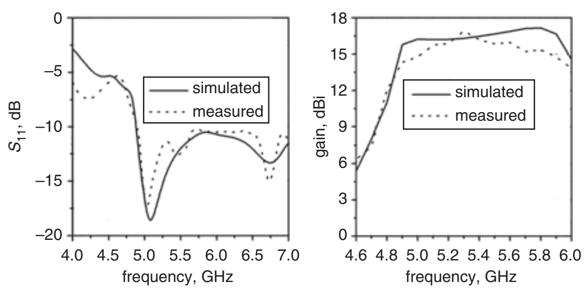

Fig. 4 *Simulated and measured S_{11} and gain*

Results and discussion: To demonstrate the validity of the presented design strategy, as depicted in Fig. 3, a prototype antenna, made of copper sheets with a thickness of 0.8 mm, was fabricated and measured. The reflection coefficients were obtained by a vector network analyser Agilent ENA E5071B, whereas the radiation patterns were measured in an ETS-Lindgen anechoic chamber. Simulated and measured results are given in Figs. 4 and 5. Reasonable agreement between them could be observed and the discrepancy could be due to the effect of fabrication tolerance and measurement errors.

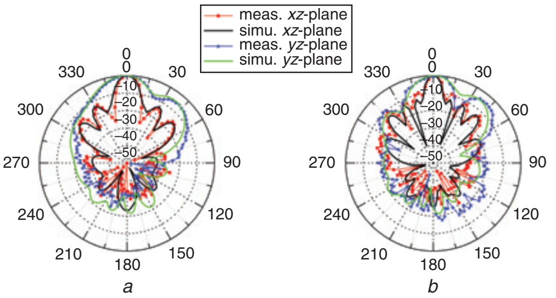

Fig. 5 *Simulated and measured radiation patterns of proposed antenna*
a At 5.2 GHz
b At 5.8 GHz

Fig. 4 shows the simulated and measured reflection coefficient and gain. Both the simulated and measured results cover a frequency band of 4.9 to over 7 GHz for $S_{11} \leq -10$ dB. The measured gain shown in Fig. 4 ranges from 15.5 to 17 dBi over the 5.2/5.8 GHz WLAN band.

Stable radiation patterns are observed over the whole operating frequency band. The simulated and measured patterns at 5.2 and 5.8 GHz in both *xz* and *yz* planes are illustrated in Fig. 5. The proposed antenna exhibits broadside directive patterns with a front-to-back ratio better than 20 dB. The asymmetric pattern with wide beamwidth in the *yz*-plane is caused by the asymmetric and halved aperture along the *yz*-axis.

As illustrated in Fig. 6, when placed on the ground plane of a practical system, the proposed antenna offers flexible deployment options to meet the demands for different applications. Configuration A provides a remarkable enhancement in the bore-sight gain of about 7 dBi due to mirror effect of the infinite ground plane and nearly quarter-sphere radiation from one of the corners between the SBA and the infinite ground plane.

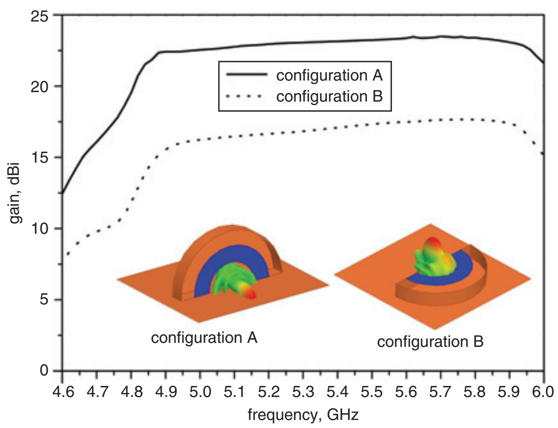

Fig. 6 *Simulated gain for different configurations (both placed on infinite ground planes)*

Conclusion: A metallic SBA with a halved size for 5.2/5.8 GHz WLAN has been designed and tested. Good impedance matching is achieved by using a truncated monopole as the exciter without complicated feed structure. Based on the experimental results for the impedance and radiation characteristic, the proposed antenna is expected to be suitable for wideband and high-gain point-to-point or point-to-multipoint wireless communications.

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One or more of the Figures in this Letter are available in colour online.

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