Broadband CPW-fed folded-slot monopole antenna for 5.8 GHz RFID application

W.-C. Liu and Z.-K. Hu

A folded slot is introduced to expand the impedance bandwidth and miniaturise the size of a coplanar waveguide (CPW)-fed patch monopole antenna for radio frequency identification (RFID) applications. The designed antenna, which, including ground plane, is only 13 mm in height and 11 mm in width, can operate at the 5.8 GHz band with measured impedance bandwidth and average antenna gain of 30% and ≥ 5 dBi, respectively, and also conical radiation patterns. These properties make the antenna suitable for RFID tags.

Introduction: Radio frequency identification (RFID) systems have recently received much attention for use in efficiently tracking and identifying objects in various supply chains from the security and control points of view. RFID systems basically consist of a read/write device and a tag, and data is transferred between the tag and the read/write device wirelessly by means of electromagnetic waves at the assigned bands of 125 kHz, 13.56, 869, 902–928 MHz, 2.45 and 5.8 GHz [1]. The tag, which includes the antenna and a microchip transmitter, must have a low profile, low cost and especially small size for valuable and easy use when it is attached to the object to be identified. Therefore, a suitable antenna for use in a tag becomes more important. So far, several antenna designs for use in RFID systems have been proposed, including the meander line structure [2], the aperture-coupled structure [3], and the CPW-fed folded-slot structure [4]. These designs are either complex in antenna structure or large in antenna size for practical applications.

In this Letter, a novel design of a broadband planar monopole antenna, consisting of a slotted patch and a CPW-fed structure such that only a single-layer substrate is required for the antenna, is presented. By properly selecting a folded slot on a rectangular patch, compact antenna size, broad impedance bandwidth and good radiation characteristics suitable for the RFID application at 5.8 GHz could be achieved. Details of the antenna design and both theoretical and experimental results are presented and discussed.

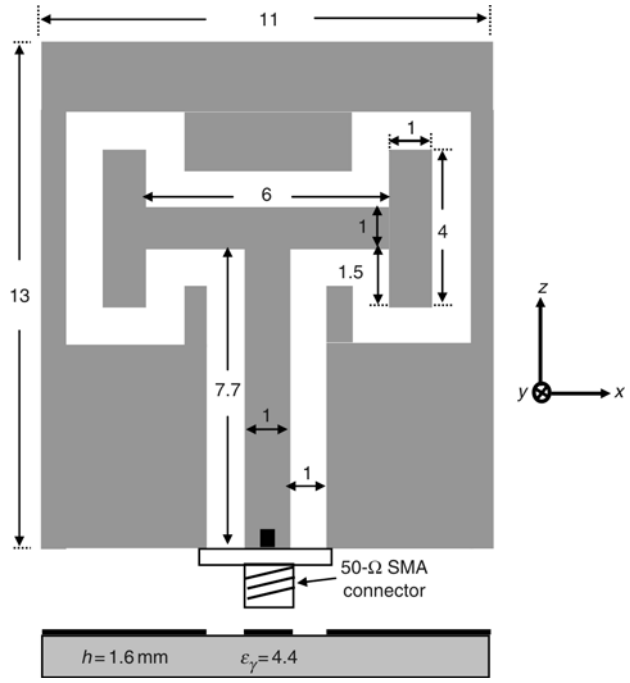

Fig. 1 *Configuration of proposed broadband CPW-fed folded-slot monopole antenna for 5.8 GHz RFID application (dimensions, mm)*

Antenna configuration: The configuration of the proposed antenna design is shown in Fig. 1. The antenna has a simple structure by constructing it on one side of an FR4 dielectric substrate (thickness 1.6 mm and relative permittivity 4.4). The antenna is symmetrical with respect to the longitudinal direction and its basis is a rectangle patch inserted by a folded slot to form a monopole structure with an H-shaped strip fed by a CPW feedline. Clearly, the radiating element of this antenna is thus separated from the ground plane by the folded slot. We first studied the dimensions of the antenna by simulation with the aid of IE3D electromagnetic software, and then adjusted them by experiment. Finally, the dimensions of the fabricated antenna were chosen to be of height 13 mm and width 11 mm, which are both close to one-quarter wavelength in free space at resonance, and a fixed width of 1 mm was used for the folded slot. For the H-shaped strip, the ends of the horizontal section with strip width 1 mm and length 6 mm were appropriately connected to the centres of the two vertical sections, each with strip width 1 mm and length 4 mm. The CPW feedline, with a signal strip of width 1 mm and length 7.7 mm, and a gap distance of 1 mm between the signal strip and the coplanar ground plane, was chosen to feed the H-shaped strip centrally from its bottom edge. Moreover, in this design the total length of the folded slot is 44.4–48.4 mm, or about 0.86–0.94 wavelength relative to the resonant frequency of 5.8 GHz, and this indicates that the antenna size can be effectively reduced by use of the slot-folding technology.

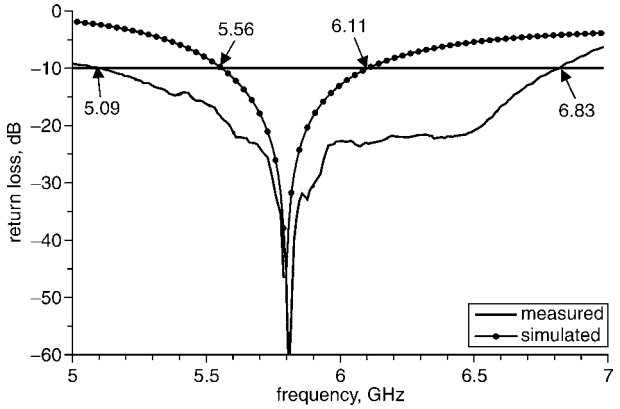

Fig. 2 *Measured and simulated frequency responses of input return loss for proposed antenna*

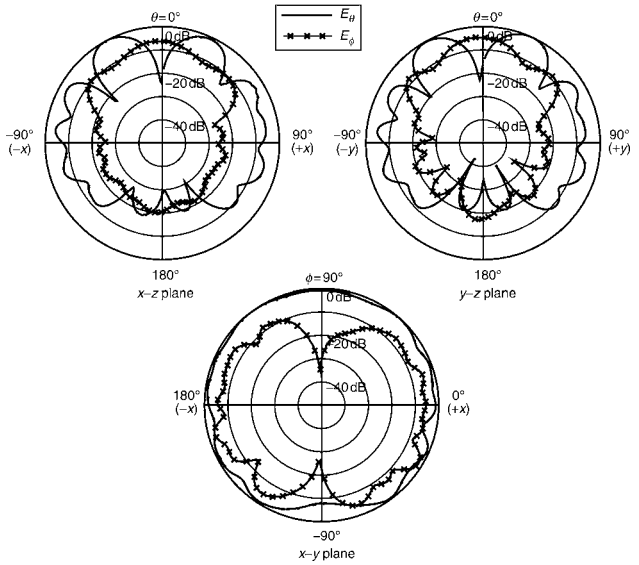

Fig. 3 *Measured far-field radiation patterns at 5.81 GHz for proposed antenna*

Results and discussion: The prototype of the proposed broadband CPW-fed folded-slot antenna with optimal geometrical parameters as shown in Fig. 1 was constructed and tested. Fig. 2 shows the measured and simulated frequency responses of return loss for the proposed design for the purpose of comparison. As can be seen from the simulation, the antenna is excited at 5.8 GHz with a –10 dB impedance bandwidth of 550 MHz (5.56–6.11 GHz). However, the measured results show that the resonant mode is excited at 5.81 GHz, which is almost the same as that from simulation, and accompanied by a much wider impedance bandwidth of 1.74 GHz (5.09–6.83 GHz), or about 30% with respect to 5.81 GHz. Agreement between the experiment and simulation is generally good, and the experimental case

provides a much better and wider impedance matching condition. Obviously, the proposed design has sufficient bandwidth to cover the requirement of the RFID 5.8 GHz system or even the wireless local area network (WLAN) standards in the 5.2 GHz (5.15–5.35 GHz) and 5.8 GHz (5.725–5.825 GHz) systems.

Fig. 3 shows the measured far-field radiation patterns at 5.81 GHz for the proposed antenna. The conical radiation patterns in the E-planes (x–z and y–z planes) and almost omnidirectional pattern in the H-plane (x–y plane) are observed. Note also that the radiation characteristic of this design is found to be stable since similar patterns have also been measured at other operating frequencies across the band. Fig. 4 shows the measured peak antenna gain for frequencies across the operating band. The range of antenna gain is 3.2–6.1 dBi.

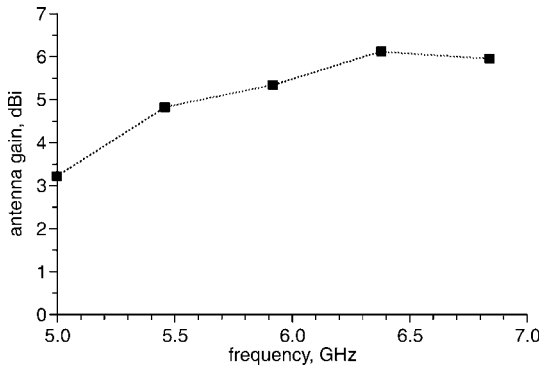

Fig. 4 *Measured antenna gains for proposed antenna*

Conclusions: A compact low-profile CPW-fed patch monopole antenna with broadband performance has been proposed and implemented. With the insert of a folded slot to the patch, the proposed antenna can be designed to have a bandwidth of 30%, good radiation performance and peak antenna gain of more than 3.2 dBi, but is only 13×11 mm in antenna size. The antenna is mechanically robust and easy to fabricate and integrate with the application-specific circuit. This design is not only suitable for use in RFID systems but is also applicable to WLAN 5.2/5.8 GHz communication systems.

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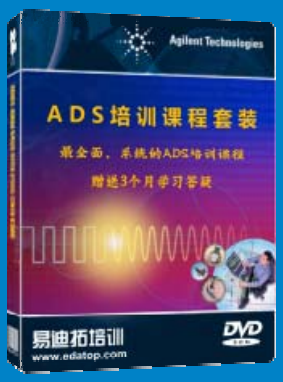

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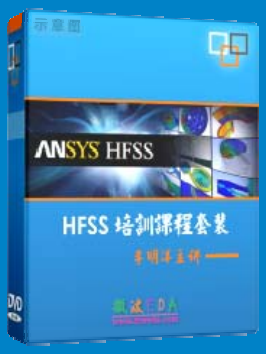

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