Design and Simulation of an Easy Structure Multiband Printed Ring Slot Antenna

M.H. Amini and H.R. Hassani

Abstract— An easy structure printed slot antenna providing multi frequency is designed and simulated. The antenna operates over UMTS/WLAN/MMDS and WIMAX bands. The multiband antenna consists of four ring slots and a single microstrip feed line. To match the input impedance of the antenna to the 50 ohm SMA connector, the width of three slots become narrow in their feeding places. By choosing the appropreate value for angle of θ, good impedance match can be achieved. The fourth slot also is matched through the conventional stub length. The reflection coefficient of the proposed structure is simulated and good result is achieved at each bands through this design. The antenna also has a symmetrical far field radiation patterns suitable for wireless communication networks.

Index Terms—multiband, ring slot, stub, symmetrical.

1 INTRODUCTION

Slotted antennas are traditionally operated at its half-wavelength fundamental resonant mode or quarter one. A dual band slotted patch antenna is presented in [1]. Both of these frequencies are associated with a radiating mode almost identical to that of a standard patch. By using the appropriate resonant width for patch and length for slot, two resonat frequencies is achieved. A triple-band slotted monopole antenna with coplanar waveguide (CPW) fed is proposed in [2]. Two asymmetrical ground planes were used and three-resonat mode is aexited at 2.43, 5.23 and 7.14 GHz bands. By using two types of shaped slots into a rectangular patch a radiator with dual band operation is obtained [3]. Embeded slots excite multiresonant mode and good impedance bandwidths is achieved at 2.42 GHz and 4.8 to 9.62 GHz frequency range which covers WLAN bands. Open- ended slot antennas cut at a ground plane can generate a quarter-wavelength resonant mode [4]. This feature is advantageous over the conventional internal antennas such as the patch planar inverted-F antennas (PIFAs) that have been applied in many mobile phones. Such attractive feature makes the monopole slot antenna very promising for application in the mobile device, Laptop Computer and Vehicular Telematics Applications. Several promising monopole slot antennas for mobile phone applications have also been demonstrated [5]–[9];

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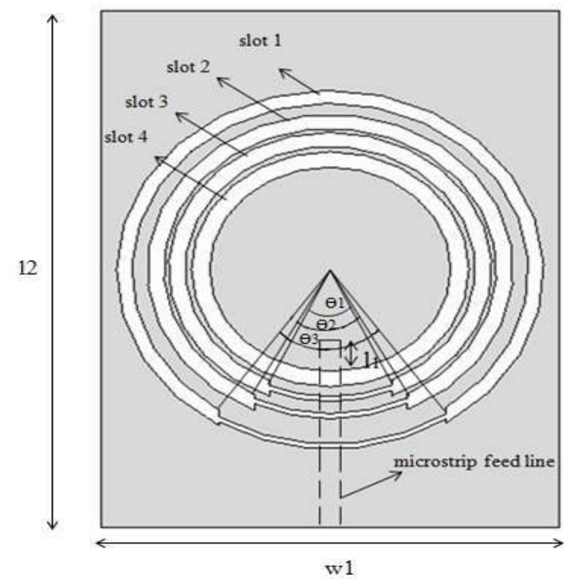


Fig. 1. The configuration of proposed antenna.

these antennas are suitable to be printed on the system circuit board of the mobile phone, making it easy to fabricate at low cost for practical applications. In [10] a novel compact multiband slot antenna is presented by the athors for mobile handsets. By using two slots one in the form of T shape and the other an E shape, five operational bands of GSM900/DCS1800/PCS1900/UMTS and 2.4-GHz-based WLAN bands is achieved. Reference [7] also reports a single fed antenna in the shape of a Maltese cross to support DCS 1800 and GPS bands for mobile handset. Albeit all above multiband structures are small in volume, but are somewhat complicated.

In this paper we illustrate a simple multiband slot antenna which operates at UMTS/WLAN/MMDS and WI-

MAX bands. By use of four ring slots, four resonant frequency is obtained. There is no need for external impedance matching network. Matching of three slots are provided by decreasing their widths around their feeding places. Good results are obtained through this design. The simulation results are carried out by commercially available software package HFSS.

2 Antenna Design

Fig. 1 shows the geometry of the proposed multiband printed slot antenna which operates over 1920-2170 MHz (UMTS), 2.4-2.48 GHz (WLAN), 2.6-2.8 (MMDS) and 3,6-3,8 GHz (WIMAX) bands. The antenna has a dimension of 30×40 mm^2 and is simulated on FR4 substrate with relative permitivity of 4.4 and thickness of 1 mm.

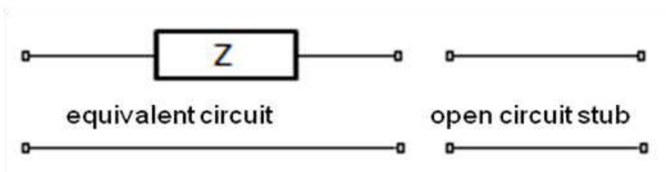
It is well known that a printed slot antenna comprises a slot cut in the ground plane of a dielectric substrate. By various means such a slot can be fed. The simplest is through a microstrip transmission line feed from the other side of the substrate. When a microstrip line is fed at one end, energy would be transfered to the slot at the other end of the microstrip line which has an open circuit. Fig. 2a represents a narrow printed slot antenna. This traditional microstrip line fed narrow slot antenna is modeled by a series equivalent circuit shown in Fig. 2b. In this model the real part of Z represent the radiation resistance. If the open circuited stub is changed in position, the input impedance of the antenna is seen to have a constant resistance part while the reactance changes. The reactive part should be zero if the slot is resonant. While the length of open circuited stub usually affects the imaginary part of Z, this has less effect in our design.

The designed antenna consists of four ring slots which is created on the ground plane and excited through an open circuited microstrip transmission line located on the upper side of the FR4 substrate. Each slot has partially the same circumference with one wavelength in their correspondent resonance frequency. To match the slots #1, #2, and #3, it suffices to decrease their widths around their feeding places. This will cause reduction in impedance of the slot and consequently on the feeding point (SMA connector). The equivalent circuit of such ring slot is illustrated in Figure 3. As displayed in the figure, the radiator equates two impedances z_1 and z_2 located in series on a transmission line. z_1 is the impedance of the part of the slot with a narrow width and z_2 is the impedance of the rest of the annular slot. Varying the value of z_{input}, impedance from the feeding point, is feasible through altering the angle of θ. In fact, appropriate value for θ will provides the matching required for the given structure in each resonance frequency. It must be noted that the forth slot is also matched through l_1 length which is considered as a stub. It is important that decreasement in the slot width will increase the amount of energy transmitted to the next slot and as a result provide better impedance matching for the proposed slots.

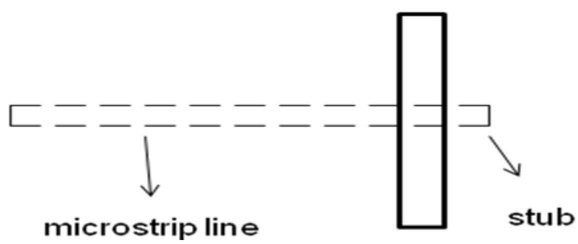
The design parameters of the proposed multiband antenna are listed in TABLE. 1. Fig. 4 shows the simulated reflection coefficient of the antenna. The antenna has the reflection coefficient of about -22 dB, -24 dB, -27 dB and -20 dB at center frequencies of 2 GHz, 2.44 GHz, 2.8 GHz and 3.7 GHz respectively. Fig. 5 also shows the current distribution over surface of the substrate. It can be found from this figure that each slot is excited properly at the desired frequency bands. The normalized simulated far field radiation patterns of the antenna are shown in Fig. 6. As shown in this figure the antenna has good radiation characteristics at each bands. The half power beam widths for each four slots are about 70 degrees in the E-plane. It is apparently that good omnidirectional patterns is obtained through this design.

TABLE 1
Design Size of The Proposed Antenna

Parameter	L1	L2	W1
Value (mm)	1.8	40	30
Parameter	θ_1	θ_2	θ_3
Value (degree)	47	53	67



(a)



(b)

Fig. 2 (a) A line fed narrow slot antenna. (b) the equivalent circuit of the antenna.

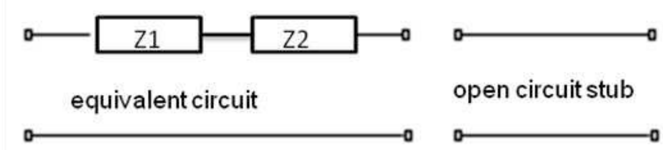


Fig. 3. Equivalent circuit of the proposed antenna.

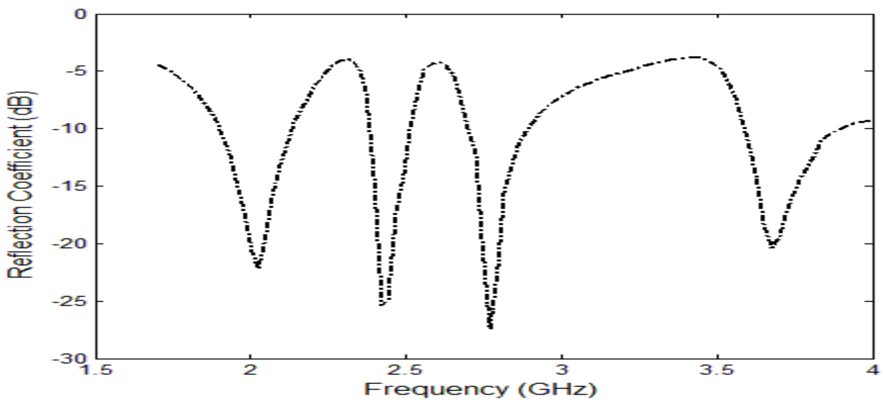


Fig. 4. The reflection coefficient of the proposed antenna.

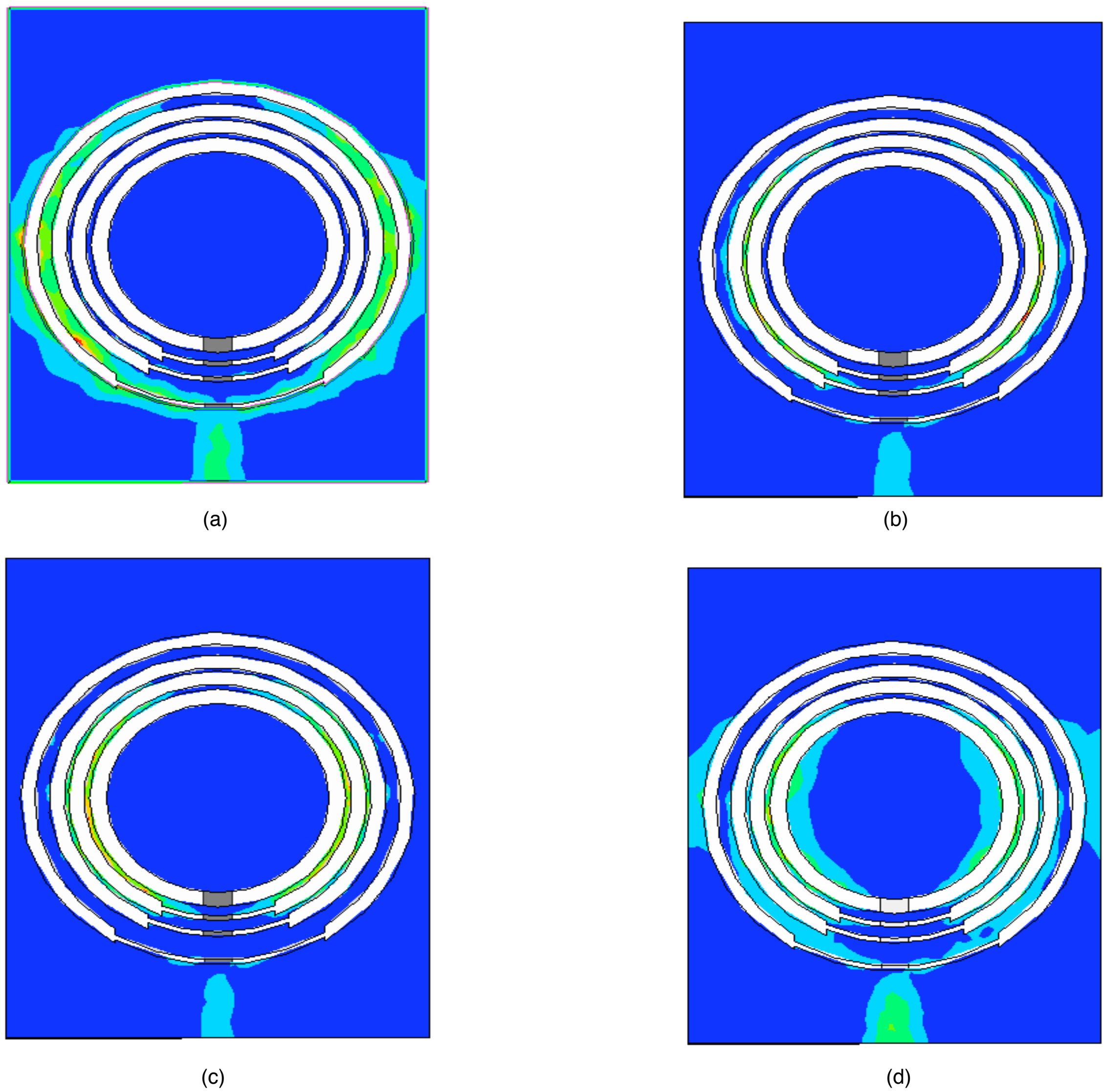


Fig. 5. The current distribution over surface of the substrate at (a) 2 GHz (b) 2.44 GHz (c) 2.8 GHz and (d) 3.6 GHz

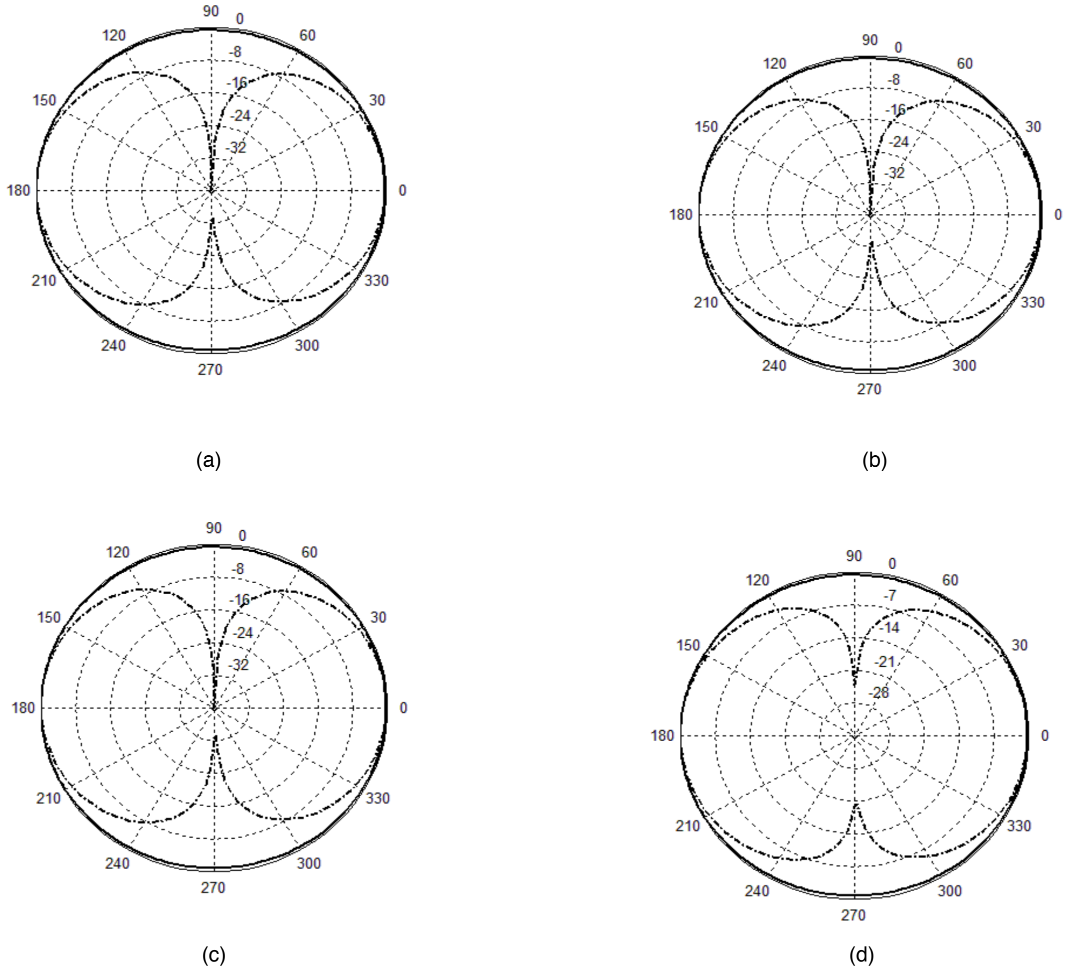


Fig. 6. The Radiation pattern of the proposed antenna at (a) 2 GHz (b) 2.44 GHz (c) 2.8 GHz and (d) 3.6 GHz.

3 Conclusion

An easy structure multiband slot antenna is designed and simulated. The radiator consists of four ring slots and a single microstrip feed line. The antenna works over UMTS/WLAN/MMDS and WIMAX bands. The reflection coefficient of the proposed structure is simulated that is below -20 dB at center frequency of the each bands. The radiation pattern of the antenna is also simulated and good results is achieved in each bands.

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