

ENHANCED BANDWIDTH MULTIBAND SLOT ANTENNA FOR PORTABLE DEVICES

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Abstract

A microstrip patch antenna with slots is designed and simulated for wireless portable devices. The proposed antenna has a simple structure with a common size of 70 X 20 mm in a 0.8mm thick FR4 substrate with a dielectric constant (ϵ_r) 4.4. With the proposed antenna structure the two wide operating frequency bands of 1.1 and 2.1 GHz can be achieved at 6.18dB gain can be used for GSM and UMTS networks. The return loss, gain and directivity, radiation patterns are measured and compared with a design without slots to prove the advantages of the presented antenna. Details of the antenna design are described and experimental results of the constructed prototypes are presented and discussed.

Keywords: Microstrip patch antenna, Slot antenna, GSM, UMTS.

1. INTRODUCTION

One of the most promising applications of multiband technology is in short-range and high-speed wireless interfaces. The wireless USB (WUSB) may be the first commercial multiband product in market. The WUSB will be a replacement for wired USB and will match the USB 2.0 data rate of 480 Mbps. Microstrip patch antenna is a well-known printed resonant structure consisting of a conducting patch, a substrate and a ground plane. Microstrip antenna's patch shape can be any continuous shape such as square, rectangular, circular, ring and elliptical, where rectangular patch is the most common. This antenna is heavily preferred due to its low profile, lightweight, easy fabrication and being conformable to planar and non-planar surfaces.

In the previous researches a planar patch antenna is used in the existing system to cover the bandwidth requirements of the frequency bands of GSM and UMTS. But due to the large size of resonators placed in those antennas the actual bandwidth requirement is not achieved [1]. Similarly an antenna comprising of a monopole and an inverted U-shaped parasitic radiator is presented. But due to the effects of coupling, the bandwidth could not be reached when operating the monopole [2]. A microstrip fed slot antenna where open ended slots in ground plane is discussed to enhance the bandwidth [3]. U-shaped, metal plate monopole antenna with a pair of wide ended radiating arms and a bevel feed transition to achieve operating bandwidth larger than 7.6 GHz to cover 3.1 to 10.6 GHz UWB band is also presented [4].

A slot antenna with one of its sides has been modified to be in a form of the second iteration Koch fractal curve of compact size for multiband coverage. But the antennas performance

does not match the wireless requirements [5]. A multiband antenna combining a PIFA and multiple slots of volume 40 X 15 X 6 mm³ for GSM, UMTS and PCS is explained. This antenna takes advantage of the current distribution of the slots that couple PIFA to enhance the bandwidth [6]. The following antenna also developed in the previous researches: Tri band slot antenna with three angular slots, Quad band slot antennas with four right angle slots and a multiband CPW-fed slot antenna with a fractal stub and a parasitic line [7]-[8]. But they are not suitable for the WUSB antenna because of their large structures.

Therefore keeping the above issues in mind, the proposed antenna is a multiband antenna with multiple slots is designed to cover the operating frequency bands of GSM850/900/1800/1900 and UMTS2100. The proposed microstrip antenna with slots is designed in a common size of 70 X 20 mm using a FR4 substrate. This antenna has an operating bandwidth of 300 and 420 MHz at a gain of 6.18dB with return loss of 7.7dB is generated which is useful for multiband frequencies. Details of the proposed design and experimental results of the prototype is also described.

2. ANTENNA DESIGN

The physical geometry design of the proposed antenna and their dimensions are shown in the figure 1. The proposed slot antenna contains two layers, the upper radiating patch antenna and the USB dongle surface (WUSB's circuit board) with the USB interface. The upper radiating patch is the main antenna which is located near the USB interface has a small dimension of 18 X 18 mm² and the USB dongle surface's dimension is 70 X 20 mm². The USB interface has a usual dimension of 10 X 5mm².

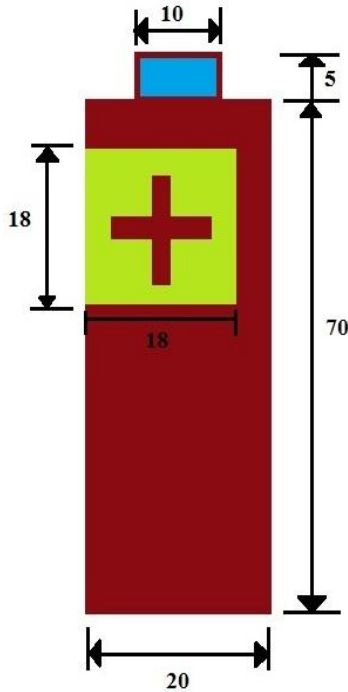


Fig 1 - Dimensions of slot antenna.

The proposed antenna substrate is made of thick FR4 substrate of relative permittivity (ϵ_r) 4.4 with substrate thickness of 0.8 mm. RF signal is transmitted to the proposed antenna through a 50 ohm microstrip coaxial feed line technique. Thus RF power is fed directly to the feed patch using the microstrip connecting coaxial feeding. The design is made using ADS (Advanced Design System) simulation tool. The Slot dimensions are also calculated using Line Calculator tool of ADS. The proposed antenna has to cover GSM850/900/1800/1900 UMTS2100 frequency bands and the antennas performance has to be maintained for high efficiency of the antenna.

The dimensions of the patch antenna is referred using the following formula where the patch width is calculated using,

$$\text{Patch Width (W)} \quad W = \frac{1}{2f(\sqrt{\epsilon_r \mu_0})} \sqrt{\frac{2}{\epsilon_r + 1}}$$

where, μ_0 is the permeability in free space and ϵ_r is the relative dielectric constant of the substrate. Similarly the length of the patch is calculated using,

$$\text{Patch Length (L)} \quad L = \left(\frac{1}{2f\sqrt{\epsilon_{reff}}\sqrt{\epsilon_0\mu_0}} \right) - 2\Delta L$$

Where, ϵ_{reff} is the effective dielectric constant and DL is the patch length extension.

The layout structure of the proposed antenna is shown in the figure 2(a) where the port is connected near the main radiating patch using a 50 ohm microstrip coaxial feed connector. RF signal is transmitted to the antenna through these port and the power is radiated throughout the WUSB surface as the substrates are brought together using layer binding. The isometric view of the proposed structure is shown in the figure 2(b) where the high radiation is indicated in green colour.

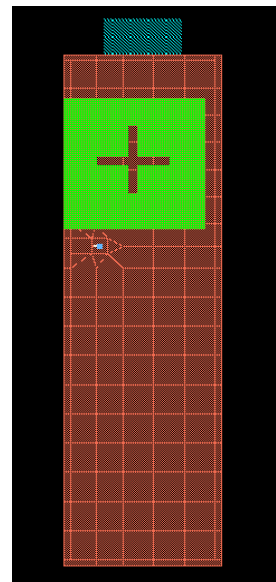


Fig 2(a) – Design of proposed slot antenna using ADS.

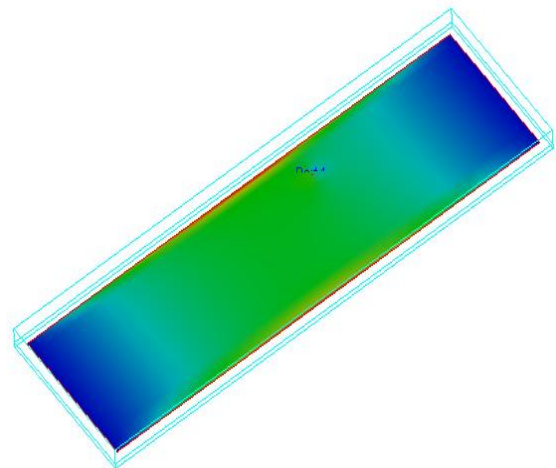


Fig 2(b) – Layout structure of the proposed Antenna using ADS.

3. RESULTS AND OBSERVATION

Figure 3(a) shows the resultant return loss of the proposed multiband antenna with slots which clearly explains that there are multiple frequencies to cover the following bands of GSM and UMTS. There were two resonant frequency bands found in the swept frequency between 0.5GHz to 3GHz. The first frequency band falls from 1GHz to 1.4GHz which covers the frequency band of GSM with a return loss of magnitude -17dB at the peak frequency of 1.15GHz. The second frequency band falls from 2GHz to 2.6GHz which covers the frequency band of UMTS with a return loss of magnitude -22dB at the peak resonant frequency of 2.3GHz.

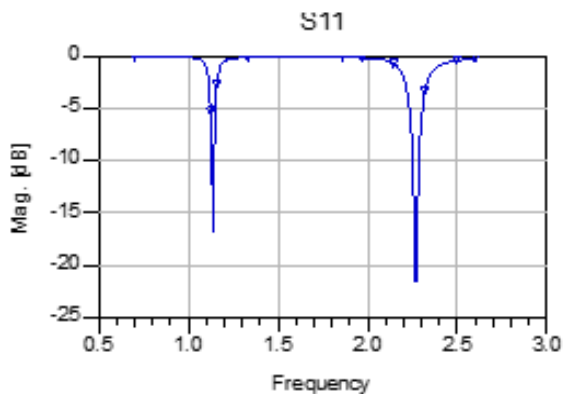


Fig 3(a) – Return loss of the proposed antenna using ADS

The 3D radiation pattern of the proposed antenna is shown in the figure 3(b). It is clearly seen from the figure that the antenna offers an omnidirectional radiation pattern and the red coloured bulge indicates intense radiation while the green coloured pattern indicated less radiation. Figure 3(c) represents the input impedance chart or smith chart of the proposed antenna where the S11 parameters is clearly matched with the zero impedance line. So it is clearly understood that the proposed antenna has a good impedance matching function.

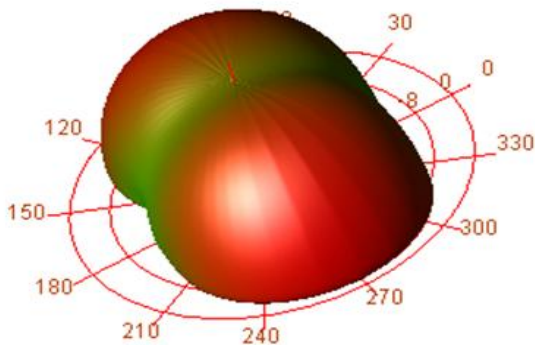


Fig 3(b) – 3D radiation pattern

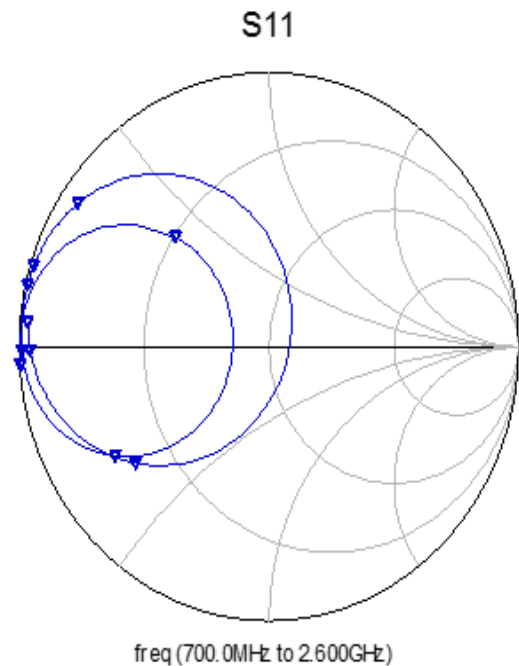


Fig 3(c) – S11 parameter using Smith Chart

The Gain and Directivity of the proposed antenna is shown using the antenna parameters. With respect to the figure 3(d) shown the directivity of the antenna is higher than gain and the gain is 6.1868, which is a good gain.

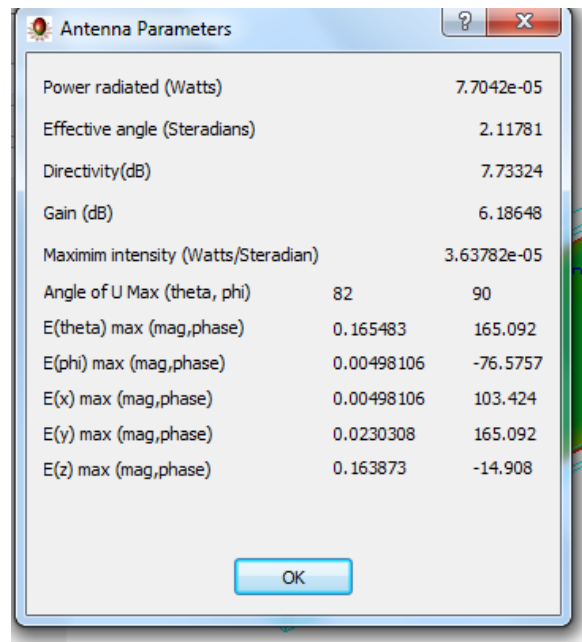


Fig 3(d) – Proposed Antenna Parameters showing Gain and Directivity using ADS.

The parameters of the proposed antenna is shown in the table 1. It is shown that the directivity of the antenna is higher than gain and the gain is 6.1868, which is a good gain.

Table 1 – Proposed Antenna Parameters showing Gain and Directivity.

Substrate	FR4
Feeding Technique	Coaxial feeding
Operating frequency	0.9 & 2.45 GHz
Full null beamwidth	165°
Half power beamwidth	82.5°
Return loss	At 1.15GHz, -17.2dB At 2.25 GHz, -22.4dB
Bandwidth	300MHz & 420MHz
Gain	6.18 dB
Directivity	7.7 dB

4. COMPARISON

In order to prove the advantages of proposed multiband antenna with slots, the proposed prototype is compared with the current prototype antenna without slots or previous research antennas. The comparison is briefed in table 2.

Table 2 – Comparison between previous and proposed research

Comparison	Antenna without slots	Multiband Slot antenna
Return loss	-11 dB	-17dB & -22dB
Bandwidth	110 MHz	300 & 420MHz
Gain	-5dB	6.18dB
Directivity	6dB	7.7dB

5. CONCLUSIONS

Thus a multiband microstrip antenna with slots is designed and discussed. The presented proposed antenna can be operated at GSM and UMTS frequency bands. The antenna has got gain and directivity as compared and proved advantageous with the previous research works. The proposed has peak resonant bands at 1.1 and 2.3 GHz frequency bands with a return loss of -17 and -22dB. The proposed slot antenna has a high gain of 6.18dB and good directivity of 7.7dB. The antenna has got good radiation pattern and perfect phase shifting. Thus the proposed antenna is well suited for

multiband frequencies and they are used for wireless USB dongle applications.

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