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Human Face Shape Slot Loaded Microstrip Patch Antenna for IMT, WiMAX and C-Band Application

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Abstract: This study presents a new design of patch antenna with Human face shaped slot on the patch. This antenna has dual operating bands and suitable for wireless and C-band application. With a simple design configuration and the human face slot form on patch, the proposed antenna can be used in multiband wireless operations, covering the mobile IMT (3400-3600 MHz), C-band (3400-4200 MHz) and WiMAX (2500-2690 MHz) (3400-3690 MHz) bands. Several properties of the proposed patch antenna in multiband operation, such as bandwidth, radiation pattern, VSWR and measured gain are investigated by High frequency structure simulator v11.

Keyword: Multi band, Patch antenna, WiMAX, IMT, RETURN LOSS, VSWR and HFSS.

INTRODUCTION

Wireless communications have been developed widely and rapidly in the modern world especially during the last decade. The future development of the personal communication devices will aim to provide image, speech and data communications at any time, and anywhere around the world. This indicates that the future communication terminal antennas must meet the requirements of multi-band or wideband to sufficiently cover the possible operating bands. However, the difficulty of antenna design increases when the number of operating frequency bands increases and cover an octave or more.

In addition, for miniaturizing the wireless communication system, the antenna must also be small enough to be placed inside the system. Recently, several microstrip slot antennas [1, 2] and various E-shaped [3], H-shaped [4], C-shaped [5] and U-shaped [6] have been designed. A number of antennas are also proposed for wireless applications [7-13] like, WiMAX, WLAN, DCS, PCS, IMT, etc.

The basic form of microstrip patch antenna includes a bottom ground plane, a dielectric substrate which has certain dielectric constant (ε_r) and finally patch reside on opposite to ground plane. Patch radiates only at the definite frequency band [14]. Figure 1 shows that top view of patch antenna.

The most common disadvantage of microstrip patch antenna is narrow band width. Enhancement of the performance to cover the demanding bandwidth is necessary. There are numerous and well known method to increase the bandwidth of the antenna [15] including increase the substrate thickness, use of low dielectric substrate, use of various impedance matching and feeding techniques , use of multiple resonators and use of parasitic patches.

In this paper, a simple Human face shaped slot loaded patch antenna fed by a coaxial cable is proposed and discussed. The coaxial cable is dislocated from the centre of the antenna. The proposed antenna exhibits dual-band characteristics. The two operating bands 2648 MHz (2570-2730 MHz) and 3582 MHz (3520-3640 MHz) are suitable for IMT (3400-3600 MHz), C band (3400-4200 MHz) and WiMAX (2500-2690 MHz) (3400-3690 MHz) frequency bands.

ANTENNA DESIGN and PARAMETERS

The geometry of the reference antenna is presented in Figure 2. The antenna is printed on FR-4 substrate of thickness 3 mm and a relative dielectric constant (ε_r) of 4.4. The patch having dimension W× L is excited using a 50 Ω microstrip line. All the simulation has been carried out on Ansoft High frequency structure simulator (HFSS) software v11.

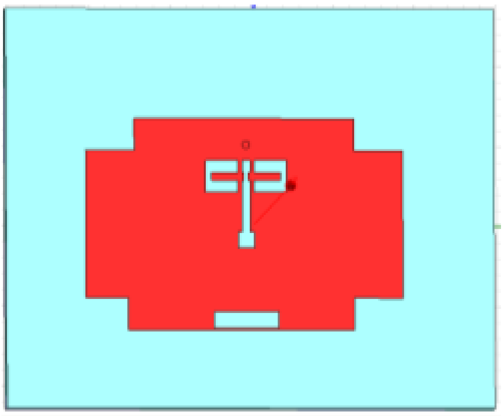

Figure 1: Top view of patch antenna

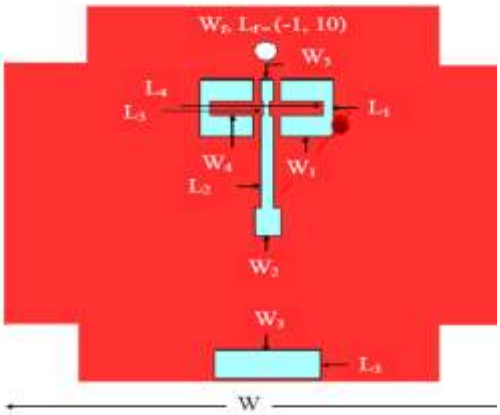

Figure 2: Geometry of the reference antenna

Here antenna design parameters are calculated by following formulas:

$$W = \frac{c}{2f_r}\left(\sqrt{\frac{2}{\varepsilon_r}}\right) \quad (1)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+\frac{12h}{W}}}\right) \quad (2)$$

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{eff}+0.300)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.800\right)} \quad (3)$$

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} \quad (4)$$

$$L = L_{eff} - 2\Delta L \quad (5)$$

$$W_g = W + 6h \quad (6)$$

$$L_g = L + 6h \quad (7)$$

Here W is the width of the patch, L is the length of the patch, ε_{reff} is the effective dielectric constant, c is the speed of light in vacuum, f_r is the target frequency, ε_r is the dielectric constant of the substrate, h is the thickness of the substrate and L_{eff} is effective length of patch and ΔL represents the extension in the length caused by the fringing effect and by considering the dimension of the patch it can easily be ignored, W_g is width of ground plane and L_g is length of ground plane The proposed antenna have patch of dimension 39×26.5 mm^2.

The detail of antenna reference parameters are given in Table 1.

Table 1: Details of reference antenna's parameters

Antenna Component	**Symbols and their values for the proposed antenna (in mm)**
Patch	W= 39, L = 26.5
Feed	W_f = -1, L_f = 10
Substrate	W_g = 60, L_g= 50
Slot	W_1=6, W_2=2, W_3=8, W_4=3, W_5=1, L_1=6, L_2=9, L_3=2, L_4=1, L_5=1

From table 1 it clears that patch width and length calculated by equation (1) and (5) are 39 mm and 26.5 mm. The height of substrate is 3 mm. The ground plane width and length are calculated by equation (6) and (7) and dimension of it is 60 mm and 50 mm respectively. The simulated antenna have small in size and compact in shape. The slot cut on the patch have different dimension in different direction.

SIMULATION AND EXPERIMENTAL RESULTS

The antenna is simulated using Ansoft High Frequency Structure Simulator (HFSS). The Return loss measured is -21.3557 dB and -13.9093 dB at 2.648 GHz and 3.5824 GHz respectively. Figure 3 shows that the return loss of antenna. The antenna have maximum VSWR is 1.50. Figure 4 shows that VSWR of designed antenna. The 10 dB bandwidths are 16% and 12% respectively and the maximum Gain of designed antenna is 2.3217 dBi. Figure 5 and 6 indicate the radiation pattern of proposed antenna. The electric field and magnetic field distribution has been studied using simulation tool and is illustrated in figure 7-10.

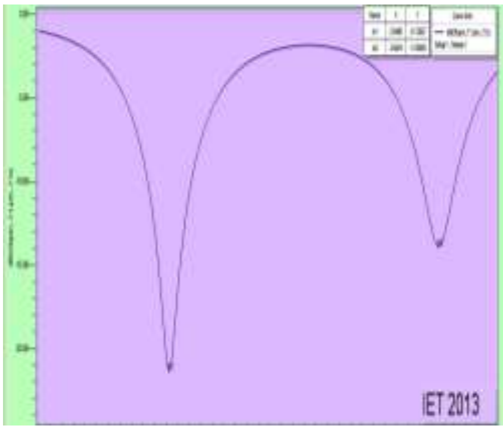

Figure 3. Return Loss of designed antenna

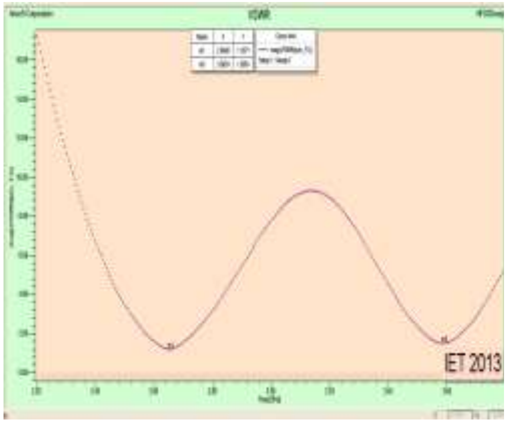

Figure 4. VSWR of designed antenna

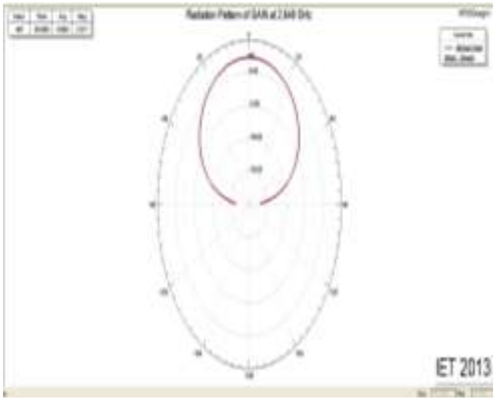

Figure 5. Radiation pattern plot at 2.648 GHz

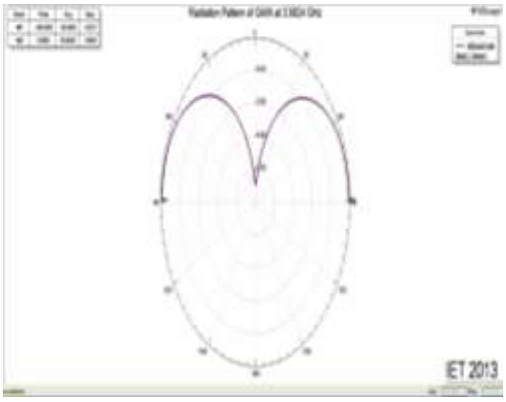

Figure 6. Radiation pattern plot at 3.5824 GHz

The frequency bands that are covered by this antenna is suitable for IMT (3400-3600 MHz), C-band (3400-4200 MHz) and WiMAX (2500-2690 MHz) (3400-3690 MHz) wireless application.

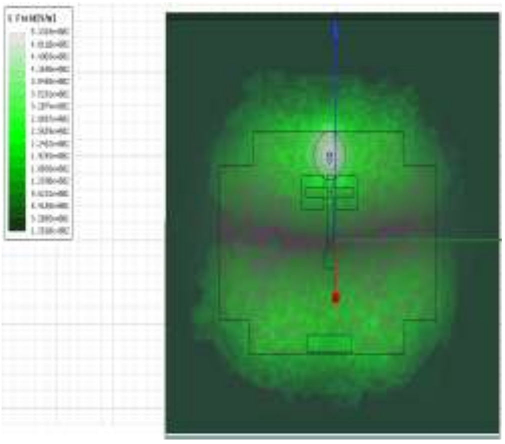

Figure 7. E-field distribution on patch at 2.648 GHz

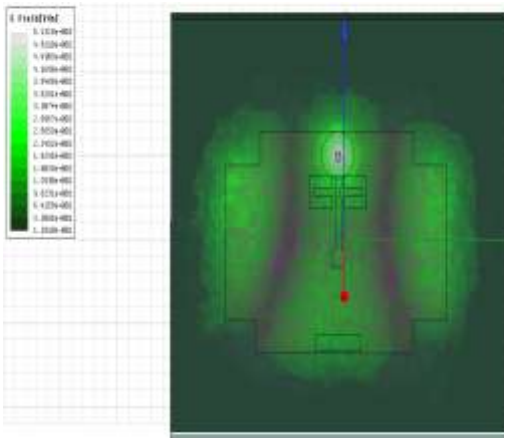

Figure 8. E-field distribution on patch at 3.5824 GHz

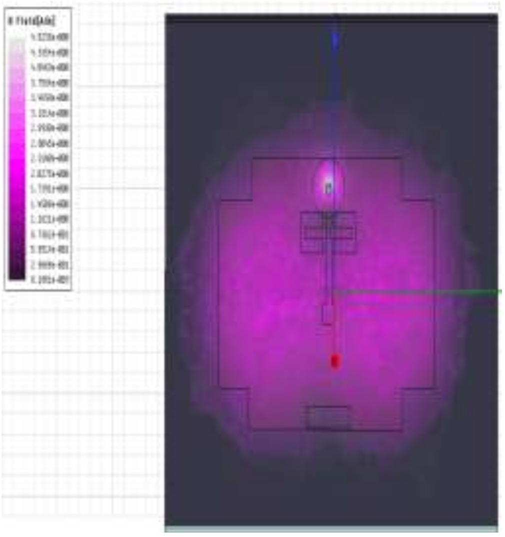

Figure 9. H-field distribution on patch at 2.648 GHz

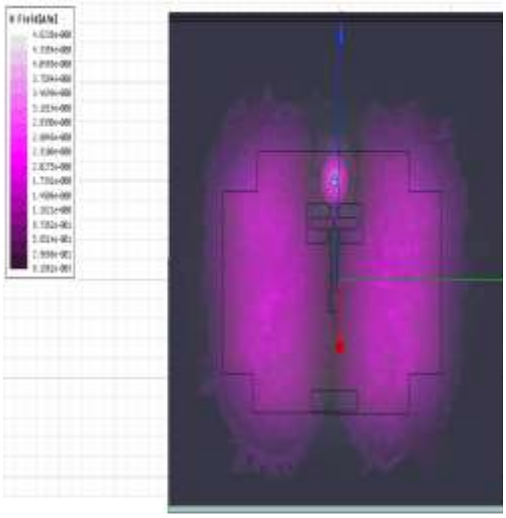

Figure 10. H-field distribution on patch at 3.5824 GHz

CONCLUSION

In this paper, a dual-band Human face shaped slots antenna with coaxial feeding structure has been analyzed and designed. The proposed antenna has the advantages of small size, easy fabrication, and simple construction for the wireless application. Measured results show that the antenna can have the operation bands of 2.648 GHz ((2.57-2.73) GHz) and 3.5842 GHz ((3.52-3.64) GHz). The designed antenna cover the mobile IMT (3400-3600 MHz), C-band (3400-4200 MHz) and WiMAX (2500-2690 MHz) (3400-3690 MHz) frequency bands. The antenna has good radiation patterns and good bandwidth, VSWR ≤ 1.50 and maximum gain is 2.3217 dBi. The simulated results show that the proposed antenna can be a good candidate for the wireless and cellular applications.

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