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A TRIPLE BAND MICROSTRIP ANTENNA FOR WLAN/WIMAX APPLICATION

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Abstract-- *A compact rectangular microstrip antenna working in triple band for WLAN/WIMAX application is proposed. The three working frequencies of antenna are 2.4/3.2/3.5 GHz covering WLAN/WIMAX bands. IEEE WLAN protocol 802.11 b/g employs 2.4 GHz and WIMAX 3.5 GHz. The antenna is simulated using HFSS 14.0 antenna design software. Wide band characteristics in proposed design is due to various slots present in the design. The designed antenna achieves good impedance matching, return loss (> -10dB), good radiation pattern and consistent gain at all three operating band. The overall dimensions of the antenna are 29.44 mm*38.04 mm*1.6 mm and it is printed on FR4 substrate of dielectric constant 4.4.*

Keywords-*WLAN, WIMAX, Triple band, Slots, RMSA (Rectangular Microstrip Antenna)*

I. INTRODUCTION

In our everyday life, wireless communication plays a major role. Personal mobile communication is used by all nowadays, which took a mandatory position in our life. Over last two decades mobile wireless services grows rapidly. As the wireless standards increases, the need of multiband wideband antenna design have become very important for wireless communication to fulfill the need of modern Handheld communication devices like WLAN, WIMAX, UMTS bands for Bluetooth etc. It is more important to integrate more than one communication standard in a single compact module. Such antennas can work at several frequencies simultaneously.

Recently due to rapid development and to satisfy IEEE 802.11 WLAN standard in 2.4 GHz and WIMAX 3.5 GHz band, dual band and triple band operations in antennas are required. For available requirements, microstrip antennas are widely used because of their attractive features like light weight, low profile, ease in fabrication and low cost.Lot of techniques have been proposed to improve the bandwidth, return loss and radiation characteristics various designs for printed monopole antenna have been widely studied for their geometric configuration such as inverted F antenna, stacked F-radiation strip, F- shaped antenna for 3 resonant frequency. The antenna must be designed in such a way to take up a very small space on printed circuit board systems. A planar printed inverted F antenna is attractive structure but its design is complex. Multiband operating antennas will be complex in structure and need more computation for designing and cost high. By considering above facts a good antenna design is proposed with good gain and multi band characteristics.

In this paper, a potential configuration for a triple band antenna for desired wireless LAN and WIMAX application is proposed. This compact triple band RMSA operates in 2.4/3.2/3.5 GHz frequency bands. The proposed antenna exhibits Omni-directional radiation pattern, good return loss and maintains good gain for 3 operating bands. Various antenna parameters are optimized UsingAnsoft high frequency structure simulator (HFSS). Details of designed antenna, simulation and experimental results are presented and discussed.

II. GEOMETRY OF TRIPLE BAND RECTANGULAR MICROSTRIP PATCH ANTENNA

The geometry of the proposed antenna is explained. The antenna is constructed on a substrate with dielectric constant of εr=4.4 and thickness h=1.6mm. The antenna consists of rectangular patch excited by 50Ω microstrip line or inset cut feed technique. The ground plane dimension is given as W_g*L_g mm (48*40) mm and patch is of dimensions W*L mm. (38.04*29.44) mm printed on FR4 epoxy resin substrate with dielectric constant of ε_r= 4.4. A microstrip line of 50 Ω impedance with width W_o = 3 mm, length Y_1= 5.56 mm with an inset depth of patch Y_o=10.2 mm is used. Various slots of different dimensions are made. The dimensions of slots are given as W_1=1.5 mm W_3=1.3 mm with W_2 = 1.4 mm and Y_o= 10.2mm. A square shape slot with sides Q= wavelength/30 = 4.16 mm is cut across all four corners of patch. Then two identical slots with W_s= 2mm, lengthL_s= 14mm, S_1= 1,5mm were embedded in patch and they are equally placed symmetric to the radiating edge of the patch.

As this antenna uses microstrip inset feed it makes the antenna suitable for integration with microwave circuitry. Antenna bandwidth depends on both slot length and width and some fine tuning is needed to achieve peak resonance for triple band at 2.4/3.2/3.5 GHz.

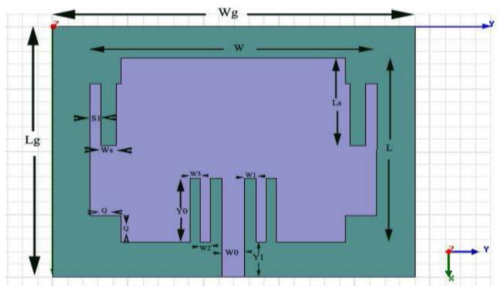

Figure 1- Geometry of triple band microstrip antenna

III. DESIGN SPECIFICATION AND MATHEMATICAL FORMULATION

This model represents the microstrip antenna of width ‘w’ and height ‘h’ separated by a transmission line ‘L’. The microstrip antenna behaves like non homogeneous two dielectric typically with substrate and air.

The three essential parameters for the design of rectangular microstrip antenna are

- Frequency of operation (f_o)
- Height of the substrate (h)
- Dielectric constant of the substrate (ε_r)

3.1. Frequency of operation (f_o): The resonant frequency of the antenna must be selected for designing antenna. The frequency range of the personal communication system (PCS) is from 1850 to 1990 MHz, so the antenna designed must be able to operate in this frequency range. The selected resonant frequency for our design is 2.4 GHz.

3.2. Dielectric constant of the substrate (ε_r): The dielectric material selected for our antenna design is 2.4 GHz with dielectric constant of 4.4. For our design substrate with high dielectric constant 4.4 is selected to reduce the dimensions of the antenna.

3.3. Height of the substrate (h): A microstrip patch antenna to a wireless application should not be bulky. Hence the height of the dielectric substrate is selected as 1.6 mm.

The essential parameters selected are

- F_o= 2.4 GHz
- ε_r= 4.4
- h= 1.6 mm

STEP 1: CALCULATION OF WIDTH (W)

The width of microstrip patch antenna is given as

$$w = \frac{c}{2f0\sqrt{\frac{(\varepsilon r+1)}{2}}} \qquad \text{---- 1}$$

Substituting c=3*10^8 m/s, ε_r=4.4, f_o= 2.4 GHz we get w= 0.0380363 = 38.0363 mm

STEP 2: CALCULATION OF EFFECTIVE DIELECTRIC CONSTANT (ε_{reff})

Equation 2 gives effective dielectric constant as

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1+12\frac{h}{w}\right]^{-1/2} \qquad \text{---- 2}$$

Substituting ε_r = 4.4, w = 38.0363 mm and height h = 1.6 mm, we get ε_{reff} = 4.0858

STEP 3: CALCULATION OF EFFECTIVE LENGTH (L_{eff})

Equation 3 gives the effective length as

$$Leff = \frac{c}{2f0\sqrt{\varepsilon reff}} \qquad \text{----3}$$

Substituting εreff= 4.0858, c= 3* 10^8 m/s and f_o = 2.4 GHz, then L_{eff}= 0.03094 = 30.920 mm

STEP 4: CALCULATION OF LENGTH EXTENTION (ΔL)

Equation 4 gives length extension as

$$L = 0.412\, h \frac{(\varepsilon reff\ +0.3)(\frac{w}{h}+0.264)}{(\varepsilon reff\ -0.258)(\frac{w}{h}+0.8)} \qquad \text{---- 4}$$

Substituting εreff = 4.0858, w = 38.0363 mm, h= 1.6mm, we get ΔL=0.7388mm

STEP 5: CALCULATION OF ACTUAL LENGTH OF PATCH (L)

The actual length is obtained using the equation

$$L= L_{eff} - 2\Delta L \qquad \text{---- 5}$$

Substituting L_{eff}= 30.920 mm and ΔL= 0.7388 mm.

STEP 6: CALCULATION OF GROUND PLANE DIMENSION (Lg & Wg)

Transmission line model is applicable to infinite ground plane only. For practical purpose we use finite ground plane. The results for finite and infinite ground plane is obtained by size of the ground plane greater than patch dimensions by 6 times the substrate thickness all around the periphery. The ground plane dimensions for proposed design is obtained as

L_g = 6h + L = 6(1.6 mm) + 29.4425 mm

= 0.03904 = 39.04 mm = 40 mm

W_g = 6 h + W = 6 (1.6 mm) + 38.0363 mm

= 0.0476= 47.63 mm = 48mm

Similarly calculations are done for other resonant frequencies.

IV. SIMULATION RESULTS AND DISCUSSIONS

4.1. RETURN LOSS

The proposed antenna is simulated sung HFSS antenna design software. Figure 2 shows the simulated and measured return loss of the triple band antenna. The radiating element can be excited at three resonance frequency. The first and second resonance frequency is mainly governed by solts on either side of microstrip line feed. The third resonance frequency is mainly due to the slots which is equally placed symmetric at the radiating edges of the patch. The ground plane dimensions influences good impedance matching at 2.4 GHz, 3.2 GHz, 3.5 GHz. The return loss of the RMSA is greater than -10 dB which shows good performance of the proposed antenna. So that three bands cover WLAN, WIMAX bands.

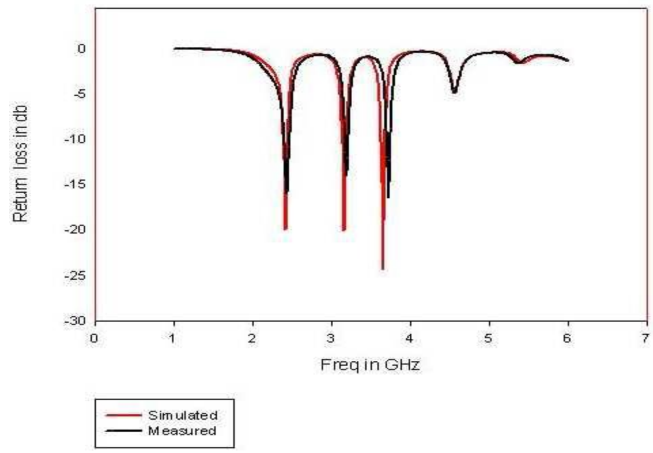

Figure 2- Simulated result of return loss of antenna

4.2. RADIATION PATTERN

By verifying polarization of antenna, it shows that the low cross polarization level confirms that the antenna is linearly polarized over impedance band. The RP in YZ plane are omni directional pattern. Fig 3 and 4 show the RP of the simulated antenna at 2.4 GHz and 3.5 GHz. The antenna shows same RP in all three resonance frequency with small variations.

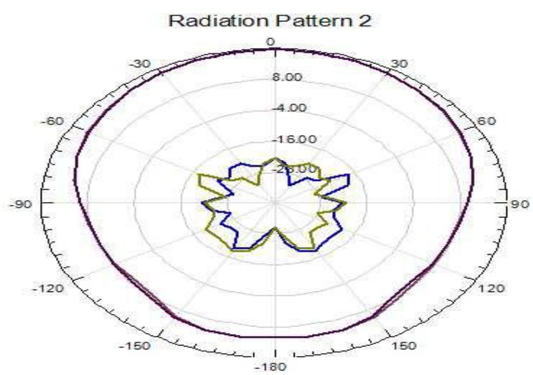

Figure 3 Simulated radiation pattern at 2.4 GHz

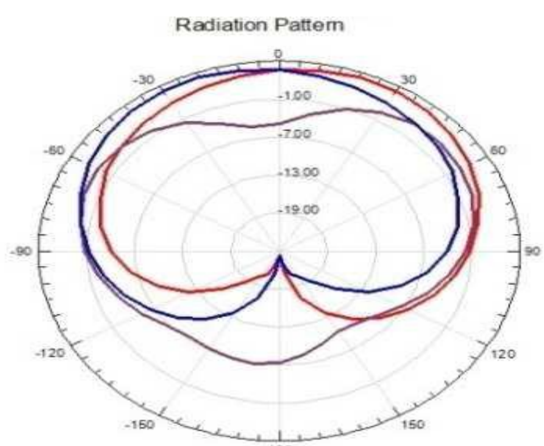

Figure 4- Simulated radiation pattern at 3.5 GHz

4.3. GAIN CHARECTERISTICS

The gain of the simulated antenna is shown in figure 4. The peak gain in 2.4 GHz is about 2.0 dB. While in 3.2/3.5 GHz is about 3.2-3.9 dB. At achieves high gain in 3.5 GHz band.

4.4. CURRENT DISTRIBUTION, E-FIELD AND H-FIELD DISTRIBUTION

In 2.4 GHz band, current is distributed equally on both lower and upper radiating element current is concentrated on the edges of the radiating element. A half wavelength variation in current is observed along edges at resonant frequencies Figure 5 shows simulated current distribution of proposed antenna.

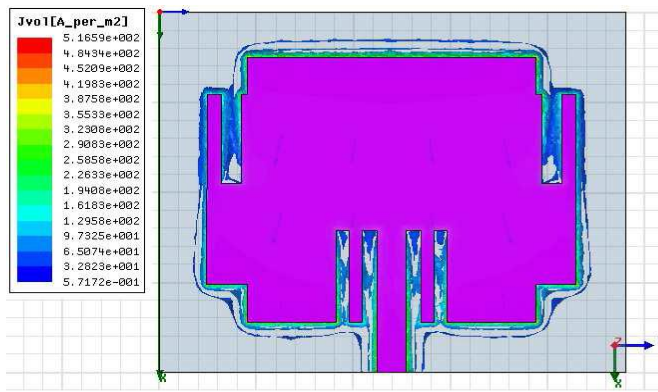

Figure 5- Current distribution in triple band RMS antenna.

V. CONCLUSION

In this paper a compact triple band inset fed RMSA is proposed. The antenna has simulated and results are analyzed. The proposed antenna is suitable to completely cover the IEEE 802.11 WLAN standards of 2.4 GHz and WIMAX band of 3.5 GHz, which is suitable to cover bandwidth of 2.4/3.2/3.5 GHz. Excellent Radiation pattern, return loss characteristics, higher gain and low cross-polarization levels were observed in proposed antenna. It is well known from the results that all parameters like impedance matching, return loss, radiation patterns and gain were improved compared to previous radiating structure. The triple band antenna is suitable for use in wireless mobile applications.

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