Compact Multiband Microstrip Patch Antenna with H and U Slots

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Abstract

In this project we have presented the use of a patch antenna with combination of H and U shaped slot fed by Coaxial cable to realize multiband application with compact size and very low return loss. The VSWR parameter found to be less than 2 within the operating frequency range. Multi band antenna is designed for the frequency ranges 2.05GHz - 2.1GHz, 2.38GHz - 2.43GHz, 3.29GHz-3.35GHz, 3.62GHz-3.70GHz, 5.35GHz - 5.52GHz when H and U slot cut in the patch. It can be used for UMTS, BLUETOOTH, WIFI, WLAN, WIMAX, ISM applications. This Antenna was simulated with the use of FDTD Numerical analysis.

1. Introduction

The rapid growth of mobile communication systems has forced to the use of novel antennas for base and mobile station applications, personal digital assistants (PDA), mobile phone, notebook computer, etc... Earlier, mobile systems were designed to operate for one of the frequency bands of 2G (second generation) systems, which are Global System for Mobile Communications (GSM) networks, Digital Cellular System (DCS) and Personal Communications Service (PCS) [1, 2].

Nowadays numerous wireless communication systems use several frequency bands such as GSM 900/1800/1900 bands, PS Universal Mobile Telecommunication Systems (UMTS) and UMTS 3G expansion bands and Wi-Fi (Wireless Fidelity)/ Wireless Local Area Networks (WLAN) bands [3,4].

Conventionally, because a single antenna cannot operate at all of these frequency bands, multiple different antennas covering these bands separately can be used [4, 5]. However usages of many antennas are usually limited by the volume and cost constraints of the applications [6]. Therefore, Microstrip patch antennas are essential to provide multi-functional operations for wireless communication. A multi-band antenna can be defined as the antenna operating at distinct frequency bands, but not at the intermediate frequencies between bands [7, 11].

In our work Multiband Antenna can be designed by using combination of H and U shaped slot on the patch fed by coaxial cable. In early implementation of antennas was suffered from narrow bandwidth, complicated technique of Feeding, use of many layers and many patches. Therefore various approaches have been proposed in the literature to reduce these limitations. Our approach is to cutting H and U shaped slot in the patch, notches are introduced within the matching band, resulting multiband Microstrip patch antenna

2. Antenna Configuration

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point to50Ω, so it just needs to use a 50Ω coaxial cable with N-type coaxial connector [8]. The N-coaxial connector is coupled to the back side of the Microstrip antenna (the ground plane) and the Centre connector of the coaxial will be passed through the substrate and soldered to the patch is shown in the Fig.1. Thickness of the ground plane, substrate and the patch is 0.035mm, 1.6mm and 0.035mm. length and width of the ground plane is 60mm and 60mm. FR4 is used as a substrate, characteristic impedance of this antenna is 50ohm, Dielectric constant of the substrate is $€_r$=4.5

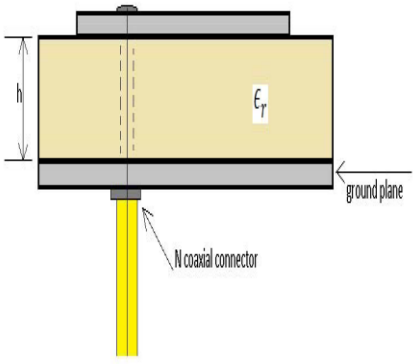

Fig: 1. Geometry of the Coaxial fed Microstrip Patch Antenna

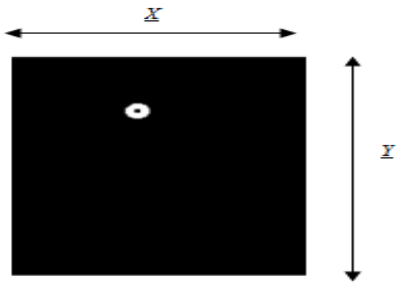

Fig: 2. Geometry of the Multiband Microstrip patch antenna with H and U slot (Bottom view)

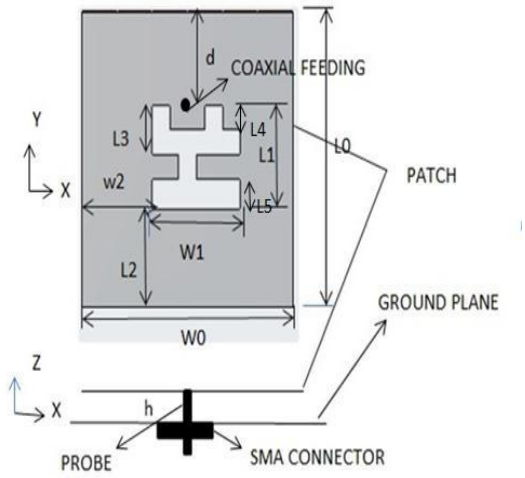

Fig: 3. Geometry of the Multiband Microstrip patch antenna with H and U slot (Top view)

The geometry of the multiband Microstrip patch antenna with H and U slot(Bottom view, Top view) is shown in (Fig.2.,Fig.3.) parameters of the proposed antenna are tabulated in Table .1.

3. Design Consideration

The width of the rectangular patch is

$$W = \frac{c}{2f_r\sqrt{\frac{2}{\epsilon_r+1}}}$$

The actual length is given by,

$$L = \frac{c}{2f_r\sqrt{\epsilon_{reff}}} - 2\Delta L$$

The width and the length of the ground plane are given by

$$W_g = 6h + W$$

$$L_g = 6h + l$$

Dielectric constant (effective) is given as

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}}$$

Small changes in length is given as

$$\Delta L = 0.412h\frac{(\epsilon_r+0.3)(\frac{W}{h}+0.264)}{(\epsilon_r-0.3)\left(\frac{W}{h}+0.8\right)}$$

3.1 Parameters of the H and U shaped Slot Antenna

Parameters	Unit (mm)
W0	60
L0	60
W1	25
L1	21
W2	20
L2	20
W3	10
L4	5
L5	6
D	20
H	1.6

Table: 1. Parameters of the H and U shaped Slot Antenna

4. Simulation Results

Designed Microstrip patch antenna is simulated over FDTD Numerical analysis. To calculate the bandwidth of an antenna we have to analyze the return loss curve which is shown in Fig.4. It is clear that the proposed design having five resonant frequencies at 2.05GHz to 2.1GHz, 2.38GHz to 2.43GHz, 3.62GHz to 3.70 GHz, 3.29GHz to 3.35GHz, 5.35GHz to 5.52GHz corresponding Reflection coefficient value is given in Table2 and also corresponding Total Efficiency, Radiation Efficiency, Directivity values are given in Table.3.For better impedance matching resonant frequency must lie below -10 dB and Efficiency will be high in that frequency.

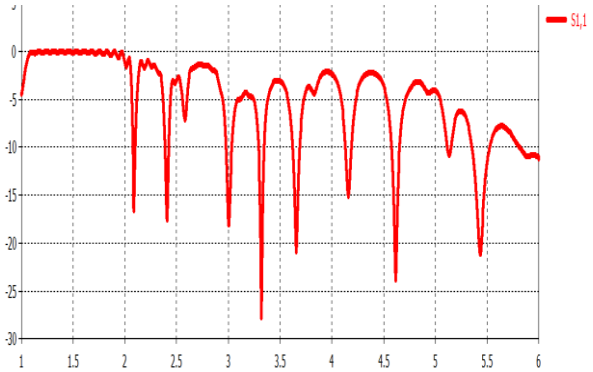

Fig: 4. Return loss of the Multi Band Patch Antenna with H and U slot

Another important parameter which is related to the return loss curve and bandwidth is the VSWR which determines if the bandwidth in the above said frequency bands are useful or not. According to theory the VSWR should be below 2dB for the entire frequency range in which antenna has to operate. The simulated VSWR curve is shown in Fig.5.

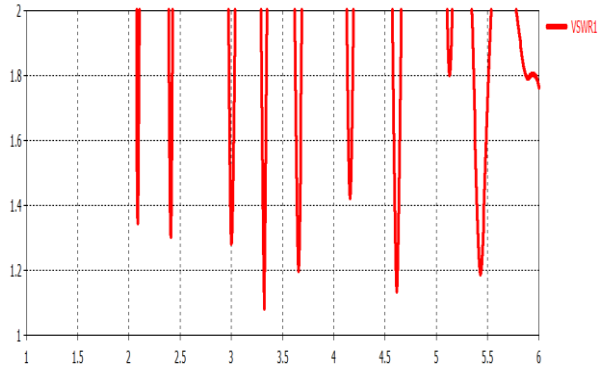

Fig: 5. VSWR plot of the multi band patch antenna with H and U slots

4.1 Five Band Frequencies with Reflection Coefficient Values

Table: 2. List of Five Band Frequencies with Reflection Coefficient Values

Resonant Frequencies	Reflection Coefficient (|S11| In Db)
2.05 GHz – 2.1 GHz	-17
2.38 GHz – 2.43 GHz	-18

Freq (GHz)	Radiation Efficiency (dB)	Total Efficiency (dB)	Directivity (dBi)
2.075	-8.706	-9.290	4.716
2.405	-6.107	-6.189	6.421
3.32	-6.458	-6.466	7.566
3.66	-5.888	-5.932	8.441
5.435	-10.37	-10.40	5.843

3.29 GHz – 3.35 GHz	-27
3.62GHz - 3.70GHz	-21
5.35GHz - 5.52GHz	-21

4.2 Calculation of Bandwidth

The bandwidth is usually expressed as the ratio of the upper-to-lower frequencies of acceptable operation.

Impedance Bandwidth = $((F_H-F_L)/F_c)$ 100%

$F_{H=}$ higher frequency, $F_{L=}$lower frequency,

F_C=Centre frequency

i) $F_{H=}$2.1 GHz, $F_{L=}$2.05 GHz, F_C=2.075 GHz
Impedance Bandwidth = $((F_H-F_L)/F_C)$ 100% = ((2.1-2.05) /2.075)100% = 2.409GHz

ii) $F_{H=}$2.38 GHz, $F_{L=}$2.43 GHz, F_C=2.405 GHz
Impedance Bandwidth = $((F_H-F_L)/F_C)$ 100% = ((2.43-2.38)/2.405)100 = 2.079 GHz

iii) $F_{H=}$3.29 GHz, $F_{L=}$3.35 GHz, F_C=3.32 GHz
Impedance Bandwidth = $((F_H-F_L)/Fc)$ 100% = ((3.35-3.29)/3.32)100% = 180 MHz

iv) $F_{H=}$3.62 GHz, $F_{L=}$3.70 GHz, F_C=3.66 GHz
Impedance Bandwidth= $((F_H-F_L)/FC)$ 100% =((3.70-3.62)/3.66)100% = 218 MHz

v) $F_{H=}$5.35 GHz, $F_{L=}$5.52 GHz, F_C=5.435 GHz
Impedance Bandwidth= $(F_H-F_L)/F_C)$ 100% = ((5.52-5.35)/5.435)100% = 312 MHz

4.3 Radiation Efficiency, Total Efficiency Directivity Values of Resonant Frequencies

5. Conclusion

A multi-band antenna has been designed, with a complete analysis on its geometrical parameters. Its 10-dB impedance bandwidth covers the bands of 2.05-2.1 GHz, 2.38-2.43GHz, 3.29-3.35GHz, 3.62-3.70GHz, 5.35-5.52GHz making it ready for WIFI, WLAN, WIMAX, BLUETOOTH, ISM, UMTS applications. Thus the proposed design of multiband antennas results in a structure which is simpler and easier to fabricate. Finally H and U shaped slot multiband Microstrip patch antenna was designed and reflection coefficient, radiation pattern, VSWR were simulated for corresponding resonant frequencies. These antennas can be further improved in terms of bandwidth, VSWR, Return loss and efficiency by using various methodologies. In future work, the proposed antenna structure will be fabricated and testing for measuring return loss and radiation pattern, VSWR by using Network Analyzer and Patch Test Bench and it will be analyzed mathematically.

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