Multiband Frequency Three Slot Antennas For Wireless Applications

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Abstract- *This paper focuses on the design of multiband slot antennas for existing wireless services including Bluetooth, GPS, WLAN/ISM, UWB bands. Each antenna offers different advantages, depending on the required application. These antennas are compact and have multiband capability that can be promising candidates for many wireless applicationsThe Proposed slot antenna is very appropriate for various wireless applications like Wi-Fi , WLAN , satellite systems (L, S and C band), UWB (3.1-10.6GHz) system and Aviation services/airport surveillance radars (2.7-2.9 GHz).*

Keywords- Microstrip patch antenna, Feedline, Circular patch antenna, Three slot antennas

I. INTRODUCTION

Wireless communication systems have developed rapidly in recent years, an antenna as a front component is required to have a wide band, good radiation performances. The survey shows a number of antenna design examples that work on some parameters such as operating frequency, radiation pattern, polarization and even antenna designs that can reconfigure multiple parameters at once [1]. The characteristics of antennas are valuable for many modern wireless communication and radar system applications, such as object detection, secure communications, multi-frequency communications, and vehicle speed tests and so on. Microstrip antennas provide very lucrative features such as small size, light weight, low cost, conformability to planar and non-planar surfaces, rigid, and easy installation [2-3]. The slot in the patch changes the electrical dimensions of the patch element and hence gives a variation in the resonant frequency and phase of reflection from an individual patch element [4-5]. Different types of slots in the patch element are used and their dimensions have been varied in order to observe the relationship between maximum attainable linear phase range and the loss performance [6-7]. The size of the microstrip patch antenna is inversely proportional to its frequency. For this reason, microstrip patch antennas are generally used for ultra-high frequency signals. Slotted microstrip patch antenna is capable of sensing frequencies lower than microwave but it would be too large to use [8-10].

II. DESIGNED ANTENNA

Antennas have a consistent set of primary parameters, comprising: frequency, gain, bandwidth, hpbw, side lobes, polarisation, cross polar, return loss, and VSWR.

2.1 Antenna Structure Design

The antennas are designed based on the following procedure for 2 types of antennas namely,

- Microstrip patch antenna
- Circular patch antenna

The following steps and formulas are used for the above mentioned antenna design. the procedure is as follows

- Specify w, l and the cut-off frequencies namely f_r,ε_r and determine the height of the substrate as h.

- For an efficient radiator, practical width that leads to good radiation efficiencies is given by the equation 2.1 and as follows

$$W = \frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \tag{2.1}$$

Where c=free space velocity of light

- Determine the extension of Δl is given by the equation 2.2 and as below,

$$\Delta L = h * 0.412 * \frac{\left(\varepsilon_{eff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{eff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)} \tag{2.6}$$

- The effective radius of the circular patch is given by the equation 2.7 and as follows,

$$(f_r)_{110} = \frac{1.8412 v_0}{2\pi a_e \sqrt{\varepsilon_r}} \quad (2.2)$$

$$a_e = a\left\{1 + \frac{2h}{\pi \varepsilon_r a}\left[\ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{1/2} \quad (2.7)$$

2.2 Three Slot Antennas

- The length of the patch has been extended by each side, the effective length of the patch is given bythe equation 2.3 and as follows,

$$L = L_{eff} - 2\Delta L \quad (2.3)$$

Similarly, for the radius of circular patch antenna is given by the equation 2.4 and 2.5 as follows,

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi \varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{1/2}} \quad (2.4)$$

Where

$$F = \frac{8.791 \times 10^9}{f_r \sqrt{\varepsilon_r}} \quad (2.5)$$

- Hence the resonant frequency for the circular patch antenna is given by the equation 2.6 and as follows,

The three slotted patch antennas are designed for the following specifications and also follows the mentioned design procedure. the table describes the following parameters are used to design the three slot patch antennas.

Table 1 parameters of an three slot antenna at frequency 2.4GHz,2.8GHz, 3.8GHz and 4.9GHz using FR4-Epoxy

Parameters	W (mm)	L (mm)	T (mm)	Material
Ground	60	60	0.05	Copper
Substrate	60	60	4	FR4-Epoxy
Rectangular patch 1	45	30	0.05	Copper
Rectangular slot 1	42	27	0.05	Copper
Rectangular patch 2	30	20	0.05	Copper
Rectangularslot 2	27	17	0.05	Copper
Circular patch 3	Radius =7	nil	0.05	Copper
Circular slot 3	Radius =5	nil	0.05	Copper
Feedline	2	27	0.05	Copper

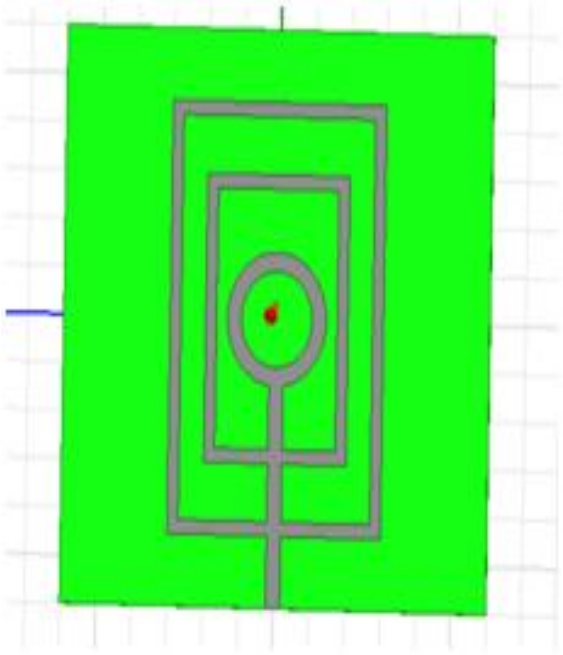

Figure 2.1 Designof Three slot antennas using FR4-Epoxy

Table 2 Parameters of a three slotted antenna at frequency 2.4GHz,2.8GHz, 3.8GHz and 4.9GHz using Roger RT/duroid 5880

Parameters	W (mm)	L (mm)	T (mm)	Material
Ground	80	80	0.05	Copper
Substrate	80	80	4	Roger RT/ Duriod 5880
Rectangular patch 1	55	45	0.05	Copper
Rectangular slot 1	50	40	0.05	Copper
Rectangular patch 2	37	27	0.05	Copper
Rectangular slot 2	32	22	0.05	Copper
Circular patch 3	Radius =10	nil	0.05	Copper
Circular slot 3	Radius =7.5	nil	0.05	Copper
Feedline	2	38	0.05	Copper

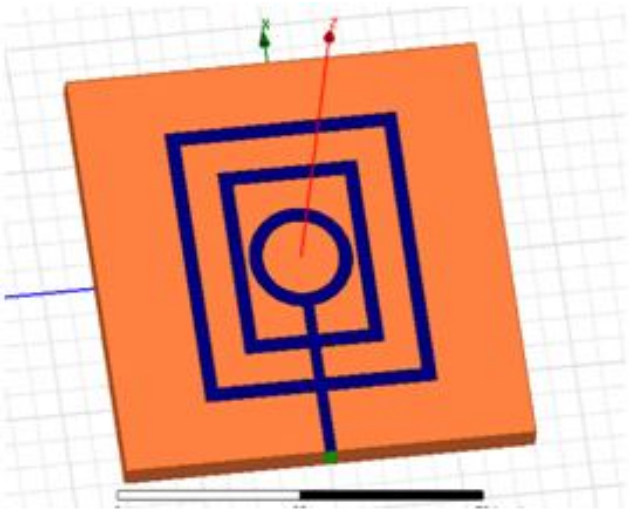

Figure 2.2 Design of Three slot antennas using Roger RT/duroid 5880

III. SIMULATION RESULTS

3.1Design of Antenna

The three slotted patch antenna is capable of work in 4 frequency bands and for 3 applications in a single substrate. This antenna is designed by using two Rectangular slots and one circular slot which are designed optimistically to achieve the minimal return loss over the four bands of frequency spectrum that are

- 2.4 GHz ISM Band
- 3.8 / 4.9 GHz UWB Band (one for TX and one for RX)
- 2.8 GHz as a carrier frequency inaviationservices/airport surveillance radars (2.7-2.9 GHz)

3.1.1 S-Parameter

The S-parameters of 3 slotted patch antenna is about -13.4965dB at frequency 2.4GHz, -11.4736 dB at frequency 2.8GHz,-13.2178 dB at frequency 3.8GHz and -20.0881 dB at frequency 4.9GHz which were represented in the graph of figure 3.1

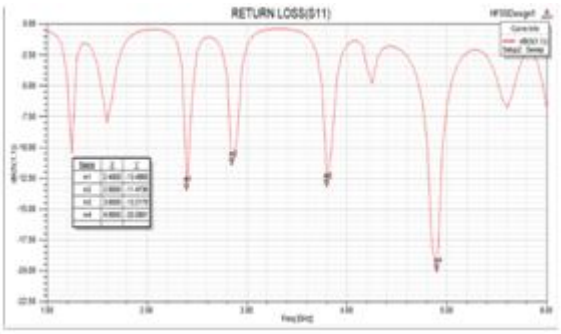

Figure 3.1 Return Loss for three slot antennas using FR4-EPOXY material

The S-parameters of 3 slotted patch antenna is about -13.088dB at frequency 2.4GHz,-8.1794dB at frequency 2.9GHz,-7.088dB at frequency 3.85GHz and -12.4965dB at frequency 4.85GHz which were represented in the graph of figure 3.2

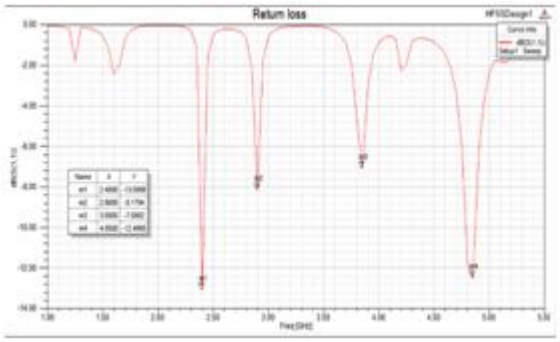

Figure 3.2 Return Loss for Three slot antennas using Roger RT/ Duroid 5880 material

3.1.2 Gain

The below figures 3.3 and 3.4 show the total gain for our design having different substrate that are 6.07 dB and 7.0642 dB respectively.

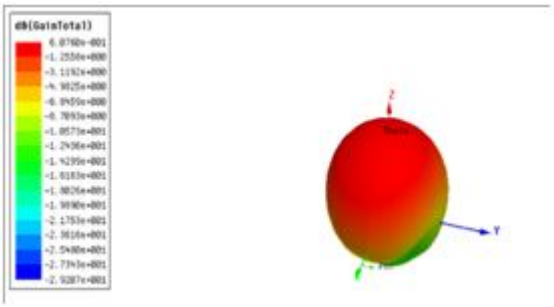

Figure 3.3 Gain for Three slot antennas using FR4-EPOXY material

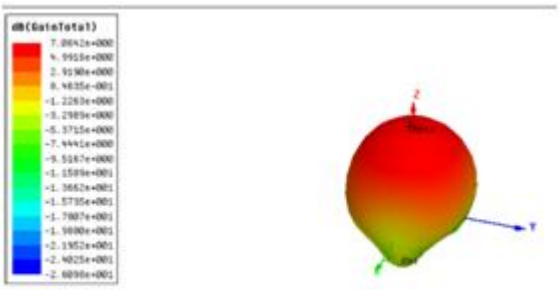

Figure 3.4 Gain for Three slot antennas using Roger RT/ Duroid 5800 material

3.1.3Directivity

The figures 3.5 and 3.6 show the total directivity for this design that are 6.408 dB and 7.476 dB.

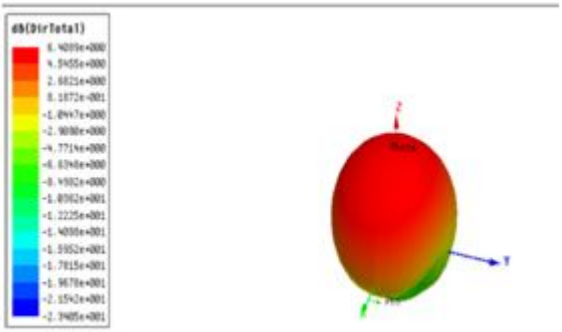

Figure 3.5 Directivity for Three slot antennas using FR4-EPOXY material

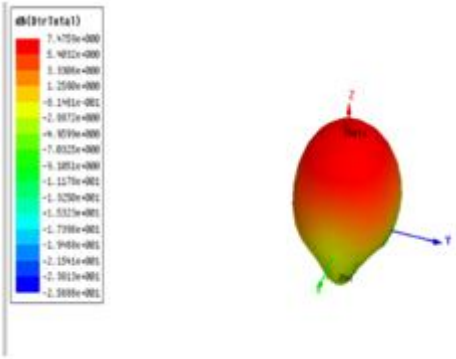

Figure 3.6 Directivity for Three slot antennas using Roger RT/ Duroid 5880 material

IV. CONCLUSION

This paper explored the design of multiband frequency antenna for wireless system. Here, Microstrip patch antenna has been modified into three different type of slots in a single patch antenna. The two proposed antennas resonate at four frequencies, covering a wide range of spectrum from 1 to 6 GHz. The comparison between two different materials shows that the antenna having low permittivity i.e. Roger RT/Duroid 5880 material of (ε_r =2.2) meets acceptable various antenna parameters like gain, directivity and return loss compare to the antenna having FR4-Epoxy material. Hence, the proposed antenna with Roger RT/Duroid 5880 material is good antenna. This antenna design is very appropriate for various applications like Bluetooth, WLAN (2.4GHz), LTE2300, UWB (3.1-6GHz) Satellite systems and Aviation surveillances radar (2.8 band). This antenna design can be further deployed in future research and development process for future enhancement.

REFERENCES

[1] Abirami, M. Alhothaily, A. (2018) 'A Review of Patch Antenna design for 5G in Wireless Communication', IEEE Wireless Communication.

[2] Afifosserain, A. Jose, F. Monserrat, F. (2018) '5G Mobile and Wireless Communication', IEEE Journals

[3] Chang, C. H. Wong, K.L. (2012) 'Printed λ/8-PIFA for penta-band WLAN operation in the mobile phone', IEEE Transactions on Antenna Propagation.

[4] Murli Manohar. (2019) 'Miniaturised low-profile super-wideband Koch snowflake fractal monopole slot antenna with improved BW and stabilised radiation pattern', IEEE Journals & Magazines.

[5] Gaurav Sharma. Anil Kumar. Jaiswal, A.K. Mayur Kumar. Ekta Singh Chauhan. (2016) 'Double band 'A' shape slotted micro strip patch Antenna for wireless communication', IJETT Journals.

[6] Qi Luo. steven Gao. Mohammed Sobhy. Xuexia Yang. (2018) 'Wideband Transmit Array with Reduced Profile', IEEE Journals & Magazines.
[7] Rajneesh Kumar Patel. Nitesh Kumar. (2016)'BridgedDouble U-Slot Microstrip Patch Antenna for Wireless Communication', IJETT Journals.
[8] Sai Sampreeth Indharapu. Abhishikth, M.B. Sulakshana Chilukuri. (2018) 'A Multiband Slot Antenna for Wireless Communication Applications', IEEE Conference.
[9] Subodh Kumar Tripathi. Vinay Kumar. (2011) 'E-Shaped Slotted Microstrip Antenna with Enhanced Gain for Wireless Communication', IJETT Journals.
[10] Yingrui , Yu. Wei Hong. ZhiHoajiang. (2018) **'**E-band Low Profile, Wideband 45° Linearly Polarized Slot-Loaded Patch and Its Array for Millimeter-Wave Communications', IEEE Transactions on Antenna Propagation.