ISSN 0974 - 9373

Vol. 27 No. 1 (2023) **J. Int. Acad. Phys. Sci.** pp. 79-85

Design and Simulation of Microstrip Patch Antenna for Advanced Communication Applications

Jitendra Kaushal Srivastava
Department of Electronics, Dr. R.M.L. Avadh University, UP, India
Email : jitendra.srivastava8@gmail.com

Deepak Kumar Verma
Department of Computer Science, Dr. R.M.L. Avadh University, Ayodhya, India
Email : deepak.discrete@gmail.com

(Received October 25, 2022, Revised Dec 12, 2022, Accepted Dec 15, 2022)

Abstract: Microstrip patch antenna is for both domestic and commercial applications, popularly for mobile as it is light weight, simple to build and low cost. The proposed antenna consists of six dipoles on a single common feed. FR-4 Epoxy whose proportionate permittivity is 4.4 and destruction tangent is 0.02 is used for proposed design. The dimensions for the substrate are 15.1794mm x 18.25mm x 1.5mm.It is intended to be operated in 1GHz – 75GHz i.e., from L band to V band with a maximum Return loss of -43.67dB and with a maximum Gain of 5.72dB. For the same design, Rogers whose approximate permittivity is 2.2 and casualty tangent is 0.0009 and Arlon whose contingent permittivity is 6.15 and catastrophe tangent is 0.03 used as substrate materials for the optimal characteristics. Patch aerial potential characteristics are in same manner with resonant frequencies, return loss, gain, bandwidth, VSWR, directivity are taken into account for the analysis of proposed antenna. In Rogers material, maximum Return loss of - 23.51dB with a maximum Gain of 8.66dB and in Arlon material, maximum Return loss of – 34.64dB with a maximum Gain of 9.82dB are measured from HFSS software. The newly generated antenna can therefore, be helpful for multiple wide band utilization depending on the particular substrate material.

Keywords: Microstrip patch antenna, Gain, Return loss and VSWR.

1. Introduction

In advanced version of communication system wireless is the highest priority in modern era. Wireless communication system is one in which the system can transfer the data without not depend as on physical medium[1-4].

This makes to transmit and receive the data with effective manner by radio signal. For the future technology, a low-profile antenna is required for cellular phones, aircraft, satellite utilization[5-6]. Properties of patch antenna are inconspicuousness, convenient to planar and non-homogenous surfaces and dirt-cheap to manufacture using technology of silkscreened printing circuit[6-11]. Occasionally, the micro strip patch antenna operates at a single frequency based on the specifications of the design. In modern era basically conversation perform at many number of frequencies with multiple antenna at the same time and these results are contrive in same chip[12-14]. Patch antenna contains three layers radiating patch, substrate and bottom layer which is fabricated at top, middle and bottom layer. In between the top and bottom layer a dielectric medium is used[15].

The dimensions of micro strip antenna depend on the material of the substrate and performance of the antenna confide in only on the dielectric constant of that particular material. The dielectric constant regulates the speed at which a signal travels through a feed line. The speed can be finely tuned by the manufacturers with proper choice of materials with different dielectric constants. The other relevant factor is the dissipation factor, which contributed to the amount of signal power which is dissipated because it travels through a feed line. A photo-lithographic process is used to construct the micro strip patch antenna. Photo- lithographic technique produces exceptionally definite etched pattern for the micro strip patch[16-17].

2. Design Of Microstrip Patch Antenna

Micro strip Patch antenna is simulated in High Frequency Structural Simulator (HFSS). In proposed antenna consists six dipoles and in between the common feed line whose input impedance is 50Ω. The substrate materials taken here are FR4 Epoxy, Rogers, Arlon. These three substrate materials are taken to compare FR4 Epoxy with the other two materials in Table1.

Table 1. Specifications for Microstrip Patch Areial

Parameters	Description	Optimal Value
L_s	Length of the substrate	15.1794 m
W_S	Width of the substrate	18.25 mm
H	Height of the substrate	1.5 mm
L_g	Length of the ground	15.1794 m
W_g	Width of the ground	18.25 mm
L_{d1}	Length of the Patch 1	13.1794 m

L_{d2}	Length of the Patch 2	11.1794 m
L_{d3}	Length of the Patch 3	9.1794 mm
L_{d4}	Length of the Patch 4	7.1794 mm
L_{d5}	Length of the Patch 5	5.1794 mm
L_{d6}	Length of the Patch 6	3.1794 mm
W_{de}	Width of each Patch	1 mm
L_f	Length of the feed line	2 mm
W_f	Width of the feed line	17.75 mm

3. Results and Discussions

The frequency ranges from 4GHz to 7GHz and resonant frequency is 4.60GHz spread over X band. In spherical co-ordinate system, the value of theta (θ) and phi (ϕ) lies between 0-360 and 0-180 degrees respectively. This aerial model simulated and diversified specification like S-parameters (S_{11}), bandwidth, VSWR, gain, directivity and efficiency at different resonant frequencies for differential substrate material are measured. In Figure. 2 and 3 shown S-Parameter and VSWR for FR-4 EPOXY Substrate material.

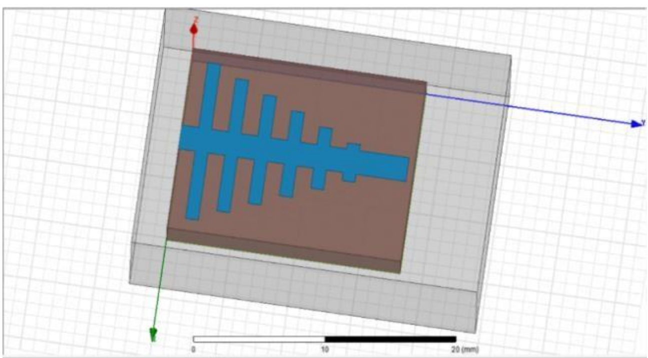


Figure 1: Design of Proposed Microstrip Patch Antenna

The frequency ranges from1GHz to 75GHz with FR-4 Epoxy as substrate material with return loss less than -10dB at seven different resonant frequencies *i.e.*, 5.80GHz, 12.90GHz, 16.30GHz, 23.30GHz, 27.70GHz, 34.40GHz and 39.80GHz,spread over C, Ku, K and Ka Bands. For optimization, two different substrate materials are taken into consideration. They are Rogers and Arlon. With the same frequency range, Rogers RT/duroid 5880 as a substrate material is taken with a return loss underneath - 10dB at eight different frequency resonant i.e., 4.80GHz, 17.60GHz, 22.20GHz, 37.60GHz, 48.20GHz, 59.50GHz, 65GHz, 70.60GHz where the range spreads over C, Ku, Ka, V bands. Similarly, with the same frequency range, Arlon AD600 as a substrate material is taken with a return loss less than -11dB at thirteen different resonant frequencies i.e., 4.90GHz, 13.60GHz, 16.40GHz, 19.50GHz, 23.10GHz, 27.90GHz, 35.20GHz, 39.30GHz, 49.10GHz, 52.70GHz, 60.40GHz, 63.80GHz, 66.90GHz where the range spreads over C, Ku, Ka, V bands respectively.

Figure 2 illustrate that the maximum gain at resonant frequency of 23.30 Ghz and similarly Figure 3 mention 34.40 Ghz and Figure 4 indicates the minimum gain at 5.80 Ghz for FR-4 Epoxy substrate material in proposed microstrip patch antenna design.

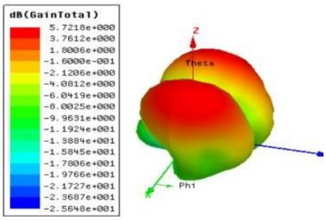


Fig 2 GAIN= 5.72dB at f_r=23.30 GHz

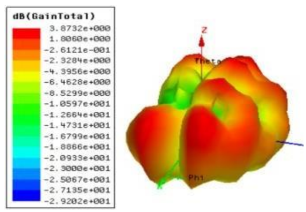


Fig 3 GAIN= 3.87dB at f_r=34.40 GHz

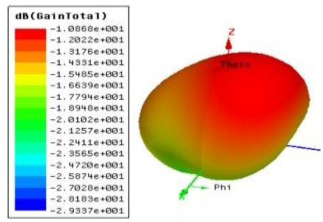


Fig 4 GAIN= 1.63dB at f_r=5.80GHz

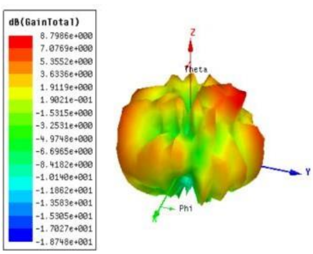


Fig. 5 GAIN= 8.66dB at f_r=59.50GHz

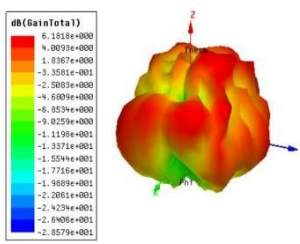


Fig 6. GAIN= 6.17dB at f_r=48.20GHz

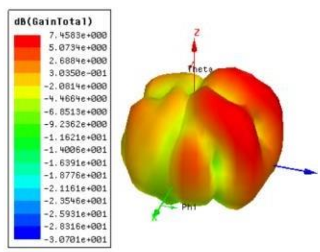


Fig. 7 GAIN= 3.54dB at f_r=22.20GHz

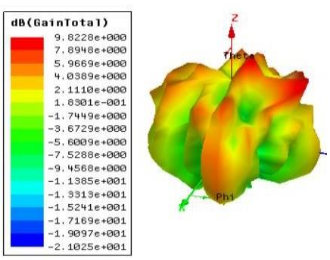


Fig 8 GAIN= 9.82dB at f_r=60.40GHz

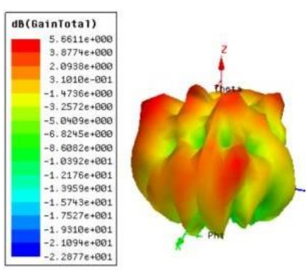
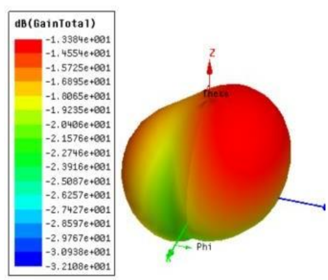


Fig 9: GAIN= 5.66dB at f_r=39.30GHz



Fi g 10:GAIN= 1.38dB at f_r=4.90GHz

Figure 5 illustrate that is 59.50 Ghz, Figure 6 shown mediate gain of 48.20 Ghz and Figure 7 show the minimum gain f_r at 22.20 Ghz for Rogers substrate material in proposed microstrip patch antenna design. Figure 8 shows that the maximum gain at 60.40 Ghz, Figure 9 shows medium aerial gain of 39.30 Ghz and Figure 10 shows the minimum gain at 4.90 Ghz for Arlon substrate material in proposed microstrip patch antenna design.

Figure 11 shows that S-Parameter for three different substrate materials for input as resonant frequency and output as return loss and Figure 12 illustrates the VSWR for three different substrate materials.

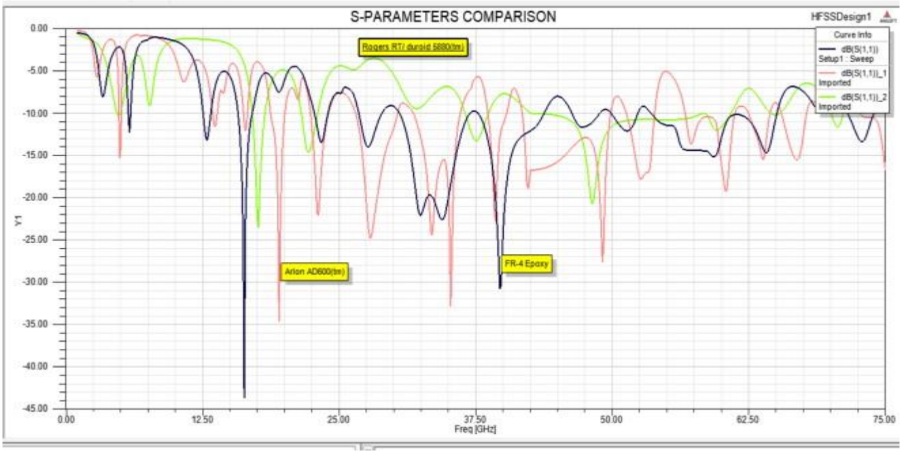


Figure 11: S-Parameters for Three Substrate Materials

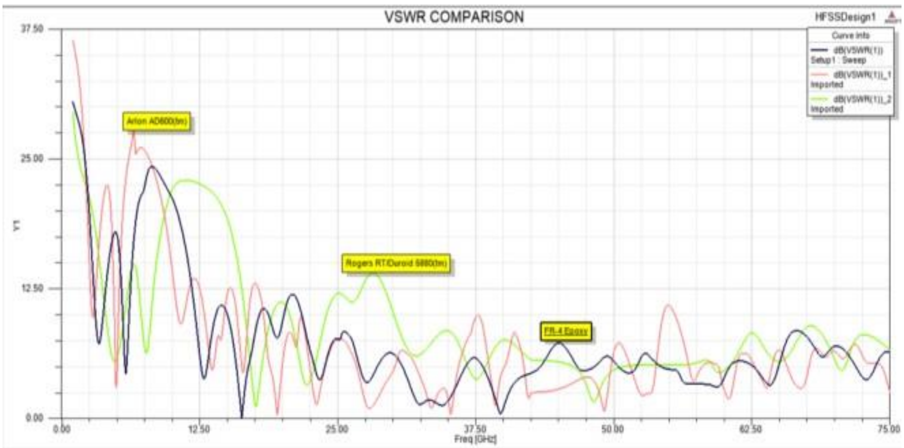


Figure 12: VSWR for Three Substrate Materials

4. Conclusion

The proposed design can be operated at multiple wide bands by changing the substrate material. The design is simulated with different materials such as FR-4 epoxy, Rogers rt/duroid 5880 and Arlon AD600 with relativity permittivity’s of 4.4, 2.2 and 6.15 respectively. Micro strip patch antenna with

FR-4 Epoxy as a substrate material is operated in C, Ku, K and Ka bands. In FR-4 Epoxy, having wide band resonating at 34.40GHz with bandwidth of 11.28GHz respectively, and with a maximum gain of 5.72dB which is operated at Ka- band antenna in Figure 2. In Rogers substrate material having wide band resonating at 15.83GHz with bandwidth of 48.20GHz respectively, and with a maximum gain of 8.66dB which is operated at V-band antenna in Figure 5.

In Arlon substrate material having wide band resonating at 49.10GHz with bandwidth of 8.07GHz and with a maximum gain of 9.82dB which is operated as a V-band antenna in fig 8. So, on optimization, the best material with the highest gain is Arlon AD600(9.82dB) at resonating frequency 60.40GHz and it has wide band in the substrate material Rogers RT/duroid 5880(15.23GHz). Hence, this antenna works for high gain and multiple wide band applications. The final conclusion of the proposed design of Antenna for Arlon substrate material finds out paramount gain and directivity correlated with other substrate materials.

References

1. Y. J. Sung, T. U. Jang and Y.-S. Kim; A reconfigurable antenna for switchable polarization, *IEEE Microwave and Wireless Component Letters*, 14(11) (2004), 534-536.
2. C.-J. Wang and W.-T. Tsai; A slot antenna module for switchable radiation patterns, *IEEE Antennas Wireless Propag. Lett.*, 4 (2005), 202–204.
3. J. T. Aberle, S. H. Oh, D. T. Auckland, and S. D. Rogers; Reconfigurable antennas for portable wireless devices, *IEEE Antennas Propag. Mag*., 45(6) (2003), 148-154.
4. N. Behdad and K. Sarabandi; A varactor-tuned dual-band slot antenna, *IEEE Trans. Antennas Propag.*, 54(2) (2006), 401-408.
5. D. Peroulis, K. Sarabandi, and L. Katehi; Design of reconfigurable slot antennas, *IEEE Trans. Antennas Propag*., 53(2) (2005), 645-654.
6. N. Behdad and K. Sarabandi; Dual-Bnad reconfigurable antenna with a very wide tunability range, *IEEE Transactions on Antennas and Propagation*, 54(2) (2006), 409-416.
7. Noyan Kinayman, M.I. Aksun Mordan; Microwave circuits, *Arect House Londan* 2005.
8. E. Yablonovitch; Photonic band-gap structures, *J. Opt. Soc. Am. B,* 10(2) (1993) 283.
9. Rodney B Waterhouse, R B Waterhouse, Rod Waterhouse; Microstrip Patch Antennas: A Designer's Guide, *Springer 1 edition*, 2003.

10. David M. Pozar, Daniel H. Schaubert; Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays, *Wiley-IEEE Press*, 2008.
11. Emre Erdil, Kagan Topalli, Mehmet Unlu, Ozlem Aydin Civi, and Tayfun; Frequency Tunable Microstrip Patch Antenna.
12. J. S. Roy, N. Chattoraj, N. Swain; New Dual-Frequency Microstrip Antennas for Wireless Communication, *Romanian Journal of Information Science And Technology*, 10(1) (2007), 113-119.
13. A. A. Deshmukh and K. P. Ray; Multi-band configurations of stub-loaded slotted rectangular microstrip antennas, *IEEE Antennas and Propagation Magazine*, 52(1) (2010), 89-103.
14. H. Wong, K. M. Luk, C. H. Chan, Q. Xue, K. K. So and H. W. Lai; Small antennas in wireless communications, *Proceedings of the IEEE*, 100(7) (2012), 2109-2121.
15. D. E. Brocker, D. H. Werner and P. L. Werner, Dual-band shorted patch antenna with significant size reduction using a meander slot, *In Antennas and Propagation Society International Symposium* (APSURSI), 2014.
16. Benjebbour et al; 5G Radio Access Technology, *NTT DOCOMO Technical Journal*, 17(4) (2016), 16-28.
17. N Kumar Reddy, Asish Hazra, Vinod Sukhadeve; A Compact Elliptical Microstrip Patch Antenna for Future 5G Mobile Wireless Communication, *Applied Sciences*, 1 (1) (2017).