iJRASET

International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 Issue: IV Month of publication: April 2017

DOI: <http://doi.org/10.22214/ijraset.2017.4015>

www.ijraset.com

Call: ☎ 08813907089

E-mail ID: ijraset@gmail.com

Circularly Polarized Multi Band Patch Antenna for High Frequency Wi-Fi and Wi-MAX Application Simulated with CST Studio Suite

Dr. D. Selvaraj¹, Kavianand G², Karthikeyan P³, Balaji M⁴, Gowri Ganesh K⁵

¹Professor, ^{2,3,4,5}UG Scholar, Department of Electronics and Communication Engineering
Panimalar Engineering College, Chennai 600123, Tamil Nadu, India.

Abstract: A circularly polarized multi band patch antenna for high frequency application was proposed. The main purpose of this antenna is for wireless communication mainly Wi-Fi and WiMAX applications and also satisfy the bandwidth quotation of 5G application. In our work, we presented a concept of designing antenna that can work simultaneously 1.1 / 2.8 / 3.3 / 5.7 / 6 and 7.4 GHz for multiple wireless and Network applications. The special shaped patch antenna is used to attain multiple bands. It is an I shaped antenna, along with a tilted and inverted two u shaped antenna patched over it. One thick inverted U shaped antenna, tilted with 45° and another is of thin inverted u shaped antenna that tilted 90° in accordance with a previous tilted patch, that is about 45° to I shaped antenna but on opposite side of thick patch. It is connected to thick U shaped patch not with an I shaped patch. All rotation and tilting are done in horizontal axis. A 6*6 square metallic patch antenna was designed in back for simple frequency selecting purpose. Those Metallic patch surfaces behave as a simple frequency select surface (FSS). The main purpose of this antenna is to achieve a frequency range of 5.7/6 GHz which are used for WiMAX application all over the world but the use depends upon the countries and 7.4 GHz which is proposed by USA for 5G applications.

Keywords: Multiband antenna; Circularly polarized antenna; Wi-Fi and WiMax application; proposed 5G bandwidth; Patch antenna; CST studio suite;

I. INTRODUCTION

In 1886 Hertz built the first radio link service which acts as a milestone for the antenna development, since that the most critical technology involved in antenna design, which helped people to get connected globally. Due to the rapid development in the radio technology, several advancements happened in antenna technology for the past 130 years. We made our own advancement that, a circularly polarized multi band antenna was proposed. The main purpose of this antenna is for wireless Wi-Fi and WiMAX applications and also a proposed 5G bandwidth.

Wireless applications are going to rule the communication systems of next generations, hence a lot of research and development is going on in the wireless communication systems, concentrating on multi bandwidth and multi-functional antenna systems. In this antenna a multiple band, say six bands are identified for primary use.

Since the linearly polarized (LP) antennas have their own drawbacks, circularly polarized (CP) antennas took its place over time, in the modern wireless communication systems. There available a multiple patch antenna separately for each frequency application but not on a single antenna. So we are here to deal with a single patch antenna, that can handle all threads over distinguished different frequency simultaneously.

In our work, we presented a concept of designing antenna that can work simultaneously 1.1 / 2.8 / 3.3 / 5.7 / 6 and 7.4 GHz for wireless Network applications. These multiple bands are attained by using and special shaped patch antenna. It is an I shaped antenna, along with a tilted and inverted two u shaped antenna patched over it. One thick inverted U shaped antenna, tilted with 45° and another is of thin inverted u shaped antenna that tilted 90° in accordance with a previous tilted patch, that is about 45° to I shaped antenna but on opposite side of thick patch. It is connected to thick U shaped patch not with an I shaped patch. All rotation and tilting are done in horizontal axis. The 6*6 square metallic patch antenna was designed in back for simple frequency selecting purpose. Those Metallic patch surface behave as a simple frequency select surface (FSS). The main purpose of this patch antenna is to achieve a frequency range of 5.7 / 6 GHz which are used for WiMAX application all over the world and 7.4 GHz proposed for 5G application by USA. Antennas has to be designed in such a way that it must be efficient enough for the practical applications. So the

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

design must be smaller and less complicated, which tend to be the motive of our design.

II. DESIGNING OF ANTENNA

The proposed antenna's design could be carried out as a three step procedure, where Preperm 1000 lossy of 1.53 mm thickness and a dielectric constant of 10. On which the multi-band CP antenna is suspended. The Preperm 1000 lossy is selected mainly for its variable dielectric constant property. The next step is designing the metallic Frequency Selecting surface, which is carried out by referring the reflection phase characteristics. Tri band patch antenna design is shown in Fig 1.

The final stage is designing a patch antenna which is to be held at a height h above the FSS. The Frequency selecting surface composed designed in a 6×6 layout each is of square shaped that overall comprises of 36 unit cells. It is designed on a Taconic RF-35 substrate. Its thickness is 1.53 mm, dielectric constant is 3.4 and a loss tangent of 0.002. Consider L to be the horizontal (x-plane) distance between the bottom edge of antenna substrate and FSS substrate. The Frequency Selecting Surface in an antenna is shown in Fig.2 which is simulated by using CST Studio Suite.

Fig 1. Tri band Patch antenna design

Fig 2. Frequency selecting Surface

A. Tri Band Patch Antenna Design

1.1 GHz, 2.8 GHz, 3.3 GHz are the three frequency bands that are attained by using and special shaped patch antenna. It is an I shaped antenna, along with a tilted and inverted two u shaped antenna patched over it. One thick inverted U shaped antenna, tilted with 45° and another is of thin inverted U shaped antenna that tilted 90° in accordance with a previous tilted patch, that is about 45° to I shaped antenna but on opposite side of thick patch. It is connected to thick U shaped patch not with an I shaped patch. Fig.1 shows the structure of Tri-band patch antenna. All rotation and tilting are done in horizontal axis. The final optimized geometrical structure of the tri-band CP patch antenna was obtained through simulations with CST Studio Suite.

B. Frequency Selecting Surface Design

The geometry of the square unit cell and the patch implemented are 19.55 mm and 22.185 mm respectively. The unit cell is designed with calculated reflection phase, that throttles between $+90^\circ$ and -90° with

- 1) 5.7–5.45 GHz, as its frequency range with 5.7 GHz resonant frequency.
- 2) 6.15–5.85 GHz, as its frequency range with 6 GHz resonant frequency.
- 3) 7.75–7.15 GHz, as its frequency range with 7 GHz resonant frequency.

The overall size of the frequency selecting surface is 135.2×135.2 mm. A wave port which excites the CP patch was placed above the frequency selecting surface(FSS), at an altitude of 28.2 mm. The Fig.2 Shows the design of FSS.

C. Finalizing Antenna Design

The multi-band Circularly polarized patch antenna is first suspended at an altitude of 28.2 mm from the center of the frequency

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

selecting surface. The characteristics of antenna for various unit cells of different number and character were studied. 6×6 metal patches were inferred along horizontal (x axis) and vertical axis (y axis) to have a better output. Finally, the necessary alterations and changes are made in position and dimensions antenna are made to get the best results at the required frequencies : 1.1 GHz, 2.8 GHz, 3.3 GHz, 5.7 GHz, 6 GHz and 7.4 GHz

III. ANALYSIS OF DESIGNED ANTENNA

S-parameter, Efficiency and VSWR (Voltage Standing Wave Ratio) is considered as the most important parameter of the antenna. The S-parameter and Efficiency are shown in Fig.3 and Fig.4 respectively.

Fig 3. S-Parameter

Fig 4. Maximum gain over frequencies

The fig.3 shows that the radiation of antenna is best at implied frequencies: 1.1/ 2.8/ 3.3/ 5.7/ 6 and 7.4 GHz. The Fig.4 shows the maximum gain of the antenna on all frequencies. It is to be noted that the gain is high on desired frequency than other frequencies. The relationship between the output and the input terminals or ports can be analysed and described by an S-parameter. In antenna design return loss is a highly considerable parameter, which gives the magnitude of the reflected power from the antenna, if the parameter hits 0dB then all the power is reflected and no sign of power radiation.

The remaining power is accepted by antenna itself, so it is neither absorbed nor radiated by the antenna. Practically most of the power delivered to the antenna gets radiated hence VSWR directly impacts on the return loss of the antenna. The theoretical (simulated) and the practical return loss is shown in Fig. 3. the theoretical and measured results comes nearly close together, with some inevitable refinements with corresponding boundary conditions in the simulation environment.

VNA (Vector Network Analyser) is used to measure return loss and by using that we can plot S11. The proposed antenna design has

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

shown a significant Multi-Band operation in the frequencies: 1.1GHz, 2.8GHz, 3.3GHz, 5.7GHz, 6GHz and 7.4GHz.

Fig 5. Farfield directivity plot for 1.1 GHz

Fig 6. Farfield directivity plot for 2.8 GHz

Fig 7. Farfield directivity plot for 3.3 GHz

Fig 8. Farfield directivity plot for 5.7 GHz

The farfield directivity analysis and gain of the antenna for various frequency are shown from Fig.4 to Fig 10. Each radiation pattern for each frequency has its own parameters. The parameters to be considered are main lobe magnitude, main lobe direction, side lobe level, radiation efficiency, total efficiency and directivity.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Fig 9. Farfield directivity plot for 6 GHz

Fig 10. Farfield directivity plot for 7.4 GHz

The considered parameters for the designed antenna is tabulated below.

Frequency	: 1.1
Main lobe Magnitude	: -4.42 dB
Main lobe direction	: -175.0 deg.
Angular Width (3 dB)	: 120.1 deg.
Side lobe level	: -4.3 dB
Radiation Efficiency	: -6.993 dB
Total Efficiency	: -8.187 dB
Gain	: 4.118 dB
Frequency	: 5.7
Main lobe Magnitude	: 9.7 dB
Main lobe direction	: -55 deg.
Angular Width (3 dB)	: 27 deg.
Side lobe level	: -4.9 dB
Radiation Efficiency	: -0.3609 dB
Total Efficiency	: -0.9020 dB
Gain	: 10.31 dB
Frequency	: 2.8
Main lobe Magnitude	: 7.37 dB
Main lobe direction	: 0 deg.
Angular Width (3 dB)	: 70.5 deg.
Side lobe level	: -8 dB
Radiation Efficiency	: -0.3986 dB
Total Efficiency	: -0.7273 dB
Gain	: 8.118 dB
Frequency	: 6
Main lobe Magnitude	: 5.06 dB

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Main lobe direction	: 60 deg.
Angular Width (3 dB)	: 41.3 deg.
Side lobe level	: -3.2 dB
Radiation Efficiency	: -0.3734 dB
Total Efficiency	: -0.7307 dB
Gain	: 8.104 dB
Frequency	: 3.3
Main lobe Magnitude	: 8.96 dB
Main lobe direction	: 25 deg.
Angular Width (3 dB)	: 67.7 deg.
Side lobe level	: -9.6 dB
Radiation Efficiency	: -0.1467 dB
Total Efficiency	: 0.1629 dB
Gain	: 8.958 dB
Frequency	: 7.4
Main lobe Magnitude	: 8.09 dB
Main lobe direction	: -70 deg.
Angular Width (3 dB)	: 35.6 deg.
Side lobe level	: -2.6 dB
Radiation Efficiency	: -0.49 dB
Total Efficiency	: -1.625 dB
Gain	: 8.677 dB

The radiation pattern of an antenna for different frequencies are shown below in 3D model diagram. These 3D models are shown below.

Fig 11. Radiation Pattern for 1.1 GHz

Fig 12. Radiation Pattern for 2.8 GHz

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Fig 13. Radiation Pattern for 3.3 GHz

Fig 14. Radiation Pattern for 5.7 GHz

Fig 15. Radiation Pattern for 6 GHz

Fig 16. Radiation Pattern for 7.4 GHz

IV. CONCLUSION

The Circularly Polarized Multi band patch antenna for high frequency Wi-Fi and WiMAX Application and proposed 5G frequency range was designed, fabricated and characterized. The same is simulated using a simulation tool named CST Studio suite. In this antenna the six frequency bands was achieved. For NFC application 1.1 GHz is used, WLAN applications the frequency band of 2.8 / 5.7 / 6 GHz and for WiMAX applications the frequency band of 3.3 GHz was achieved effectively with high efficiency. It is to be noted that proposed 5G bandwidth of 7.4 GHz is also achieved.

The performance properties of the proposed antenna are analysed for the optimized dimensions and the proposed antenna was designed successfully.

REFERENCES

- [1] T. T. Le and H. C. Park, "Very simple circularly polarised printed patch antenna with enhanced bandwidth," *Electron. Lett.*, vol. 50, no. 25, pp. 1896–1898, 2014.
- [2] F. Yang and Y. Rahmat-Samii, "A low profile single dipole antenna radiating circularly polarized waves," *IEEE Trans. Antennas Propag.*, vol. 53, no. 9, pp. 3083–3086, 2005.
- [3] Hoang, The Viet, et al. "Quad-Band Circularly Polarized Antenna for 2.4/5.3/5.8-GHz WLAN and 3.5-GHz WiMAX Applications." *IEEE Antennas and Wireless Propagation Letters* 15 (2016): 1032-1035.
- [4] S. Verma and P. Kumar, "Compact triple-band antenna for WiMAX and WLAN applications," *Electron. Lett.*, vol. 50, no. 7, pp. 484–486, 2014.
- [5] T. Wu, X. W. Shi, P. Li, and H. Bai, "Tri-band microstrip-fed monopole antenna with dual-polarisation characteristics for WLAN and WiMAX applications,"

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Electron. Lett., vol. 49, no. 25, pp. 1597–1598, 2013.

- [6] S. Gao, Q. Luo, and F. Zhu, "Circularly polarized antennas," Wiley-IEEE Press, New York, November 2013.
- [7] J. G. Baek and K. C. Hwang, "Triple-band unidirectional circularly polarized hexagonal slot antenna with multiple L-shaped slits," IEEE Trans. Antennas Propag., vol. 61, no. 9, pp. 4831–4835, 2013.
- [8] X. L. Bao and M. J. Ammann, "Printed triple-band circularly polarised antenna for wireless systems," Electron. Lett., vol. 50, no. 23, pp. 1664–1665, 2014.
- [9] T. V. Hoang and H. C. Park, "Very simple 2.45/3.5/5.8 GHz triple-band circularly polarised printed monopole antenna with bandwidth enhancement," Electron. Lett., vol. 50, no. 24, pp. 1792–1793, 2014.
- [10] K. Agarwal, Nasimuddin, and A. Alphones, "RIS-Based compact circularly polarized microstrip antennas," IEEE Trans. Antennas Propag., vol. 61, no. 2, pp. 547–554, 2013.
- [11] H. L. Zhu, S. W. Cheung, K. L. Chung, and T. I. Yuk, "Linear-to-circular polarization conversion using metasurface," IEEE Trans. Antennas Propag., vol. 61, no. 9, pp. 4615–4623, 2013.
- [12] S. Clavijo, R. E. Diaz, and W. E. McKinzie, "Design methodology for sevenpiper high-impedance surfaces: An artificial magnetic conductor for positive gain electrically small antennas," IEEE Trans. Antennas Propag., vol. 51, no. 10, pp. 2678–2690, 2003.
- [13] A. E. I. Lamminen, A. R. Vimpari, and J. Saily, "UC-EBG on LTCC for 60-GHz frequency band antenna applications," IEEE Trans. Antennas Propag., vol. 57, no. 10, pp. 2904–2912, 2009.
- [14] K. Agarwal, Nasimuddin, and A. Alphones, "Triple-band compact circularly polarised stacked microstrip antenna over reactive impedance meta-surface for GPS applications," IET Microw. Antennas Propag., vol. 8, no. 13, pp. 1057–1065, 2014.
- [15] Tuan Le, Tu, Viet Hoang The, and Hyun Chang Park. "Simple and compact slot-patch antenna with broadband circularly polarized radiation." Microwave and Optical Technology Letters 58.7 (2016): 1634-1641.
- [16] Tang, Hongyan, et al. "Compact broadband CP monopole antenna with tilted branch." Electronics Letters 52.21 (2016): 1739-1740.
- [17] Bernard, Loïc, G. Chertier, and Ronan Sauleau. "Wideband circularly polarized patch antennas on reactive impedance substrates." IEEE Antennas and Wireless Propagation Letters 10 (2011): 1015-1018.
- [18] Chi, Li-Pin, et al. "A wideband wide-strip dipole antenna for circularly polarized wave operations." Progress In Electromagnetics Research 100 (2010): 69-82.
- [19] Reddy, V. V., and N. V. S. N. Sarma. "Triband circularly polarized Koch fractal boundary microstrip antenna." IEEE antennas and wireless propagation letters 13 (2014): 1057-1060.
- [20] Park, Hyun Chang. "Very simple 2.45/3.5/5.8 GHz triple-band circularly polarised printed monopole antenna with bandwidth enhancement." Electronics Letters 50.24 (2014): 1792-1793.
- [21] Park, Hyun Chang. "Very simple 2.45/3.5/5.8 GHz triple-band circularly polarised printed monopole antenna with bandwidth enhancement." Electronics Letters 50.24 (2014): 1792-1793.
- [22] Sree, Y. Navya, et al. "Multiband circularly polarized symmetrical fractal boundary microstrip antenna for microwave applications." Advances in Computing, Communications and Informatics (ICACCI), 2015 International Conference on. IEEE, 2015.
- [23] Kuo, Chi-Jung, et al. "A novel wideband circularly polarized dual-fed slot antenna with microstrip feeding network." Journal of Electromagnetic Waves and Applications 30.2 (2016): 175-187.
- [24] Prajapati, Pravin R., M. Srinivasulu, and M. V. Kartikeyan. "Realization of circular polarized microstrip antenna with Arc-slot fractal geometry." Microwave, Optical and Communication Engineering (ICMOCE), 2015 International Conference on. IEEE, 2015.
- [25] T. V. Hoang and H. C. Park, "Very simple 2.45/3.5/5.8 GHz triple-band circularly polarised printed monopole antenna with bandwidth enhancement," Electron. Lett., vol. 50, no. 24, pp. 1792–1793, 2014.
- [26] Zhangfang, Hu, et al. "Design of a modified circular-cut multiband fractal antenna." The Journal of China Universities of Posts and Telecommunications 23.6 (2016): 68-75.
- [27] Ta, Son Xuat, Ikmo Park, and Richard W. Ziolkowski. "Circularly polarized crossed dipole on an HIS for 2.4/5.2/5.8-GHz WLAN applications." IEEE Antennas and Wireless Propagation Letters 12 (2013): 1464-1467.
- [28] Cai, Tong, et al. "Low-profile compact circularly-polarized antenna based on fractal metasurface and fractal resonator." IEEE Antennas and Wireless Propagation Letters 14 (2015): 1072-1076.
- [29] Qing, Xianming, and Zhi Ning Chen. "A compact circularly polarized slotted patch antenna for GNSS applications." IEEE Transactions on Antennas and Propagation 62.12 (2014): 6506-6509.
- [30] Ta, Son Xuat, and Ikmo Park. "Dual-band operation of a circularly polarized radiator on a finite artificial magnetic conductor surface." Journal of Electromagnetic Waves and Applications 28.7 (2014): 880-892.
- [31] Saurav, Kushmanda, et al. "Multiband circularly polarized cavity-backed crossed dipole antenna." IEEE Transactions on Antennas and Propagation 63.10 (2015): 4286-4296.
- [32] Saurav, Kushmanda, et al. "Multiband circularly polarized cavity-backed crossed dipole antenna." IEEE Transactions on Antennas and Propagation 63.10 (2015): 4286-4296.
- [33] Liu, Neng-Wu, et al. "A dual-broadband circularly polarized antenna with unidirectional radiation pattern." Progress In Electromagnetics Research C51 (2014): 11-18.

10.22214/IJRASET

45.98

IMPACT FACTOR:
7.129

IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)