iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 Issue: VI Month of publication: June 2020

DOI: http://doi.org/10.22214/ijraset.2020.6378

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VI June 2020- Available at www.ijraset.com

Compact 5.4 GHz H-Shaped Slot Antenna for Energy Combining

D. Nagaraju[1], V. Rohith[2], CH. Duggi Raj Kiran[3], L. Sathvik[4]
[1]Assistant Proffesor, [2, 3, 4]Undergraduate Students, of Electronics and Communication Engineering, Matrusri Engineering College, Saidabad, Hyderabad.

Abstract: In this paper, a compact H-shaped slot antenna is proposed. The antenna contains a H-shape slot which is fed through microstrip line, and an open circuited stub is connected for proper impedance matching. A H-shaped slot is used for bandwidth enhancement. The antenna is designed to radiate at 5.4 GHz with a bandwidth of 1.6 GHz. The antenna has an omni-directional pattern across the frequency band. The gain of the antenna is 4.35 dBi at 5.4 GHz. Since, the proposed antenna satisfies all the characteristics of energy harvesting systems, it can be used for energy harvesting systems, at 5.4 GHz 4G-LTE band. CST microwave studio was used for designing the proposed antenna. An excellent agreement is achieved between simulated and measured results.
Keywords: Open Circuited Stub, Bandwidth Enhancement, Slot Antenna, Energy Harvesting, 4G-LTE Band.

I. INTRODUCTION

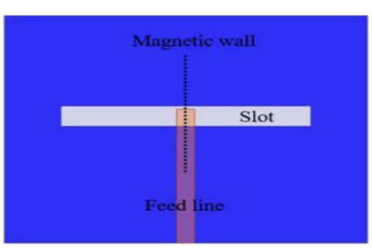
In recent years there has been dramatic increase in the development of wireless systems and low-power integrated electronic circuits, and to study the possibility of powering these type of systems and circuits various research studies have been implemented which involves harvesting of RF ambient electromagnetic energy [1]-[3]. To harvest the RF energy the one of the best method is to use a rectenna. A rectenna is also called as rectifying antenna which consists of receiving antenna, filters and rectifiers (rectifying circuit). The receiving antenna is presented in this paper. For an energy harvesting system the antenna should have some required specifications such as high gain, high directivity, omnidirectional radiation pattern, large bandwidth and high efficiency. If these requirements are met then the antenna can be used for energy harvesting system. To meet the requirements, various methods have been proposed. Several studies concentrate on the receiving antenna where it collects input power as much as possible. If the input power received by antenna is maximum then the energy harvested will be also maximum. Several studies have been using multiband antenna to harvest from different frequency bands [4], antenna with high gain can also be used with energy harvesters [5], combination of EM wave and solar cell is use [6], and rectenna arrays [7]. In paper [8], semicircular slot antenna for rectenna was presented. A compact 5.4 GHz antenna for energy combining is proposed in this paper. This compact feature can be used in rectenna array design to combine higher microwave power at 4G-LTE band.

In further sections the antenna configuration with geometrical parameters with antenna results such as reflection, VSWR and radiation pattern are discussed.

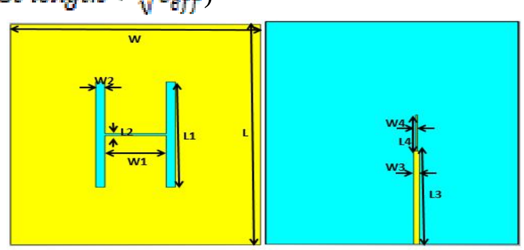
II. H-SHAPE SLOT ANTENNA DESIGN

Starting from conventional microstrip-fed rectangular slot antenna with a magnetic wall at the slot center is shown in Fig.1(a).,the proposed design has a H-shape slot fed by a microstrip feed line and open-circuited stub to adjust impedance matching which is shown in Fig 1 (b). The antenna is designed in CST microwave studio. In designing the antenna FR-4 substrate with a dielectric constant (ε_r) of 4.4 with thickness of 0.8 mm was used. The antenna is compact for using H-shape slot. The H-shape slot increases the bandwidth of the antenna. The resonance frequency of the slot is calculated from (1), where 'c' is the speed of the light and 'ε_{eff}' is the effective dielectric constant. The dimension of the designed antenna is 92 x 73.5 mm^2. Fig 1 (b) and Fig 1 (c) shows the layout and fabricated prototype of the proposed antenna respectively; all the geometrical parameters of the antenna are illustrated in Fig 1.

$$F = c/(slot\ length * \sqrt{\varepsilon_{eff}}) \quad (1)$$

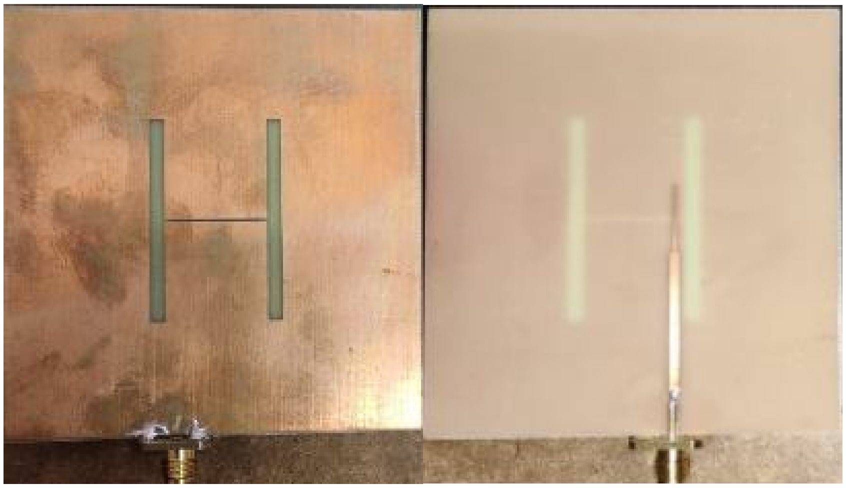


(a)



(b)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VI June 2020- Available at www.ijraset.com



(c)

Fig 1. (a) slot antenna, (b) H-shape slot geometry of proposed antenna and (c) fabricated prototype L = 92 mm, L1 = 44 mm, L2= 0.74 mm, L3= 38.5 mm, L4 = 14.9 mm, W=73.5 mm, W1 = 18 mm, W2 = 2.75 mm, W3 = 1.53 mm, W4 = 0.55 mm

III. ANTENNA RESULTS

A. S-Parameters of antenna

Fig. 2 shows the excellent agreement between the simulated and measured S-parameters (reflection coefficient or return loss) for the H-shaped slot antenna. As seen from the figure, it can be observed that the antenna has a bandwidth for reflection coefficient ≤ -10 dB from 4.8 GHz to 6.4 GHz. Therefore, the bandwidth of antenna is 1.6 GHz. The surface current distribution is shown in the Fig. 3.

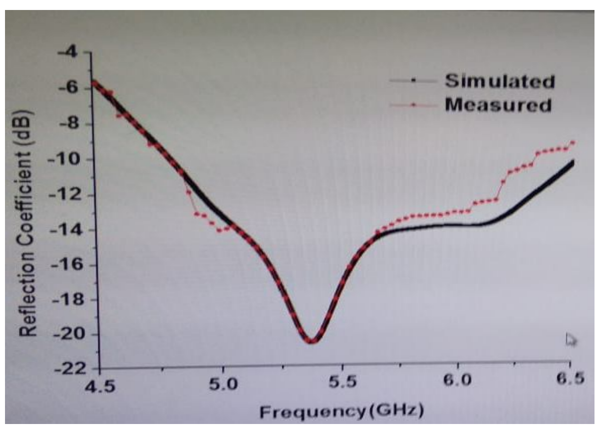


Fig 2. Simulated and measured results of S-parameters of the antenna

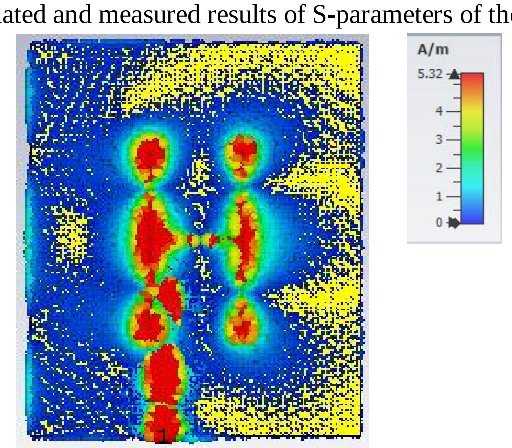


Fig. 3. Surface current distribution of the antenna at 5.4 GHz

B. VSWR

Fig. 4 shows excellent agreement between simulated and measure VSWR for the H-shaped slot antenna. The antenna has VSWR ≤ 2 from 4.8 GHz to 6.4 GHz. The antenna efficiency is more than 90% for the entire bandwidth. The measurements are performed using a vector network analyser. K connector is used in the measurements which effects the measured results slightly.

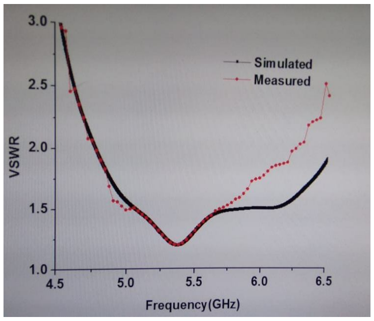


Fig. 4. Simulated and measured VSWR results of the antenna

C. Radiation Pattern

E-plane and H-plane at 5.4GHz is shown in the Fid. 5. The antenna radiates with a gain of 4.35 dBi at 5.4 GHz. The antenna design has a relatively stable radiation patterns over the entire frequency range, and the radiation efficiency is around 90% over the operation frequency range.

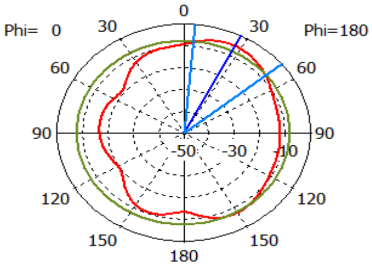


Fig. 5. E-plane "Red line" and H-plane "Green line" radiation pattern at 5.4 GHz

IV. CONCLUSION

In this paper, a H-shaped microstrip slot antenna which resonates at 5.4 GHz frequency was designed and simulated using CST microwave studio software was presented. The designed antenna has achieved very low return loss and excellent voltage standing wave ratio. The optimization strategy employed for investigating the antenna characteristics shows high efficiency to achieve a high performance and high accuracy. The fabricated antenna has a bandwidth of 1.6 GHz and a gain of 4.35 dBi at resonant frequency of 5.4 GHz with an omni directional radiation pattern. Since, the fabricated antenna meets the requirements of energy harvesting systems, it can be used in energy combining techniques.

REFERENCES

[1] C. R. Valenta and G. D. Durgin, "Harvesting wireless power: Survey of energy- harvester conversion efficiency in far-field, wireless power transfer systems", IEEE Microw. Mag., vol. 15, no. 4, pp. 108-120, Jun. 2014.
[2] D. Pavone, A. Buonanno, M. D'Urso, and F. G. Corte, "Design considerations for radio frequency energy harvesting devices", Prog. Electromagn. Res. B. vol. 45, pp. 19-35, Jan 2012.
[3] M. Arrawatia, M. S. Baghini, and G. Kumar, "Broadband bent triangular omnidirectional antenna for RF energy harvesting", IEEE Antennas and Wireless Propag. Lett., vol. 15, pp. 36-39, Feb. 2016.
[4] V. Kuhn, C. Lahuec, F. Seguin, and C. Person, "A multi-band stacked RF energy harvester with RF-to-DC efficiency up to 84%", IEEE Trans. Microw. Theory Techn., vol. 63, no. 5, pp. 1768-1778, May 2015.
[5] M. Abou Al-alaa, A. B. Abdel-Rahman, A. Allam. H. A. Elsadek, and R. K. Pokharel, "Design of a dual-band microstrip antenna with enhanced gain for energy harvesting applications", IEEE Antennas and Wireless Propag. Lett., vol. 16, pp. 1622-1626, 2017.
[6] A. Collado and A. Georgiadis, "Conformal hybrid solar and electromagnetic energy harvesting rectenna", in IEEE Transact. on Circuits and Systems I, vol. 60, no. 8, pp. 2225-2234, Aug. 2013.
[7] U. Olgun, C. C. Chen, and J. L. Volakis, "Investigation of rectenna array configurations for enhanced RF power harvesting", IEEE Antenna Wireless Propag. Lett., vol. 10, pp. 262-265, 2011.
[8] G. Monti, L.Tarricone, and M. Spartano, "X-band plannar rectenna", IEEE Antennas and Wireless Propog. Lett., vol. 10, pp. 1116-1119, Oct. 2011.