VOL. 10, NO 22, DECEMBER, 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

DESIGN OF RECTANGULAR MICROSTRIP PATCH ANTENNA USING STEPPED CUT AT FOUR CORNERS FOR BROADBAND/ MULTIBAND APPLICATION

Waheeb Salim Abdulrab, Md Rafiqul Islam and Mohamed Hadi Habaebi
Departmental of Electrical and Computer Engineering in International Islamic University of Malaysia, Kuala Lumpur, Malaysia
E-Mail: waheebtashan@yahoo.com

ABSTRACT

Design of rectangular microstrip patch antenna (RMPA) using stepped cut at four corners for broadband/multiband application is presented in this paper. Stepped cut at four corner technique is used in order to increase the bandwidth and gain of the antenna. Design and simulation of Modified rectangular microstrip patch antenna are done by CST Microwave Studio software. Four stages are presented for the proposed broadband MRMPA design. The first stage is a single mode RMPA and by increasing steps at the corner of the patch antenna a dual band, multiband and broadband are obtained. As the steps are increased, the antenna's operating bandwidth is also enhanced. The frequencies ranges of this design vary from 900MHZ to 3.5 GHz. Hence this design can be used for GSM (900MHz/1.5GHz), WiFi (2.4GHz), LTE (2.6GHz) and WiMax (3.5 GHz) applications.

Keywords: long term evolution, modified rectangular microstrip patch antenna, rectangular microstrip patch antenna.

INTRODUCTION

Antenna is the interface of the wireless communication systems to the channel which is the most sensitive part [1] Patch antennas (Microstrip antennas) are one of the most popular antennas due to their low profile, conformable, easy, inexpensive, small size and versatile in terms of realization and are thus been widely used in a various useful applications [2], [3]. In contrast microstrip patch antenna (MPA) has some disadvantages such as low gain and narrow band. Most bandwidth Figure-1 shows the rectangular microstrip patch antenna (RMPA) configuration, including a dielectric substrate located between a radiating patch and a ground plane. Generally, the patch is prepared of conducting material such or copper in any shape. Most of the previous contributions in this research area were to increase the BW of MPAs [4] by increasing the substrate thickness [5]. Array microstrip antenna which has been proved to successfully increase

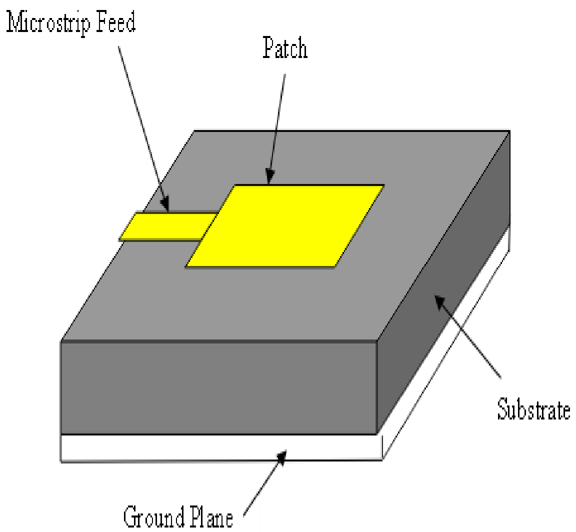


Figure-1. Structure of microstrip patch antenna.

the antenna gain, antenna efficiency, and beam scanning directivity [6]. In order to simplify analysis and performance prediction, the patch is generally configured as square, rectangular, circular, triangular, and elliptical in shape [7].

This paper is organized as follows: section 1 is an introduction, section 2 is a concept of stepped cut at four corners, section 3 is a design and simulation of proposed broadband/multiband antenna system which contains Antenna Configuration, Results and Discussion, section 4 is conclusion and finally the references which I have cited.

VOL. 10, NO 22, DECEMBER, 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

CONCEPT OF STEPPED CUT AT FOUR CORNER TECHNIQUE

In order to achieve a broadband/multiband antenna many patches are etches on the FR-4 substrate. By increasing the number of steps at the corner of the patch, the number of exited resonance frequencies over the bandwidth will be increased. The corners's lengths and widths decreased at every stage. For the first stage which is Single Mode RMBA the patch antenna considered as the main patch which has no stepped cut at four corners which explained under antenna configuration part. Then by using stepped cut at four corner's technique such as in stage 2, the number of patches will be increased and the number of resonant frequencies will also be increased. However based on the equations (1-4), the length L and the width of the patch antenna are calculated.

$$W = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

$$L = \frac{v_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \quad (2)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \quad (3)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)(W/h + 0.264)}{(\varepsilon_{reff} - 0.258)(W/h + 0.8)} \quad (4)$$

By the equations (1-4) the Length L and the width W of the single mode is 80mm, 102mm respectively. The single mode patch antenna is considered the basic patch of the antenna design which has a resonant frequency of 900MHz. Then to obtain a dual mode with a resonant frequency of 2.6 GHz, the length L= 27mm and the Width W =35mm is designed. By increasing stepped cut at four corners in every stage the resonant frequencies as well as the gain of the antenna will be increased.

DESIGN OF PROPOSED BROADBAND/MULTIBAND ANTENNA

Antenna configuration

The previous section describes the details of the proposed antenna design. The frequencies of GSM (900MHz/1.5GHz), WiFi (2.4 GHz), LTE (2.6GHz) and WiMax (3.5 GHz) are considered in design. FR-4 dielectric substrate is used in this design with relative permittivity εr=4.3. the thickness of the substrate *h* = 1.6 mm, Length *Ls* =90 mm and width *WS* = 130 mm is used as shown in Figure-1 Radiating patch on the top of the dielectric substrate,while the ground plane is on bottom of the dielectric substrate, and made of copper material with thickness *t* = 0.035 mm and conductivity σ = 5.96$e^{\wedge 7}$ s/m. The ground plane length LG = 18 mm and width *WG* = 90 mm, a transmission line fed with width *WF*= 3 mm and length *LF* = 20 mm was used in order to achieve 50 Ω output impedance matching.

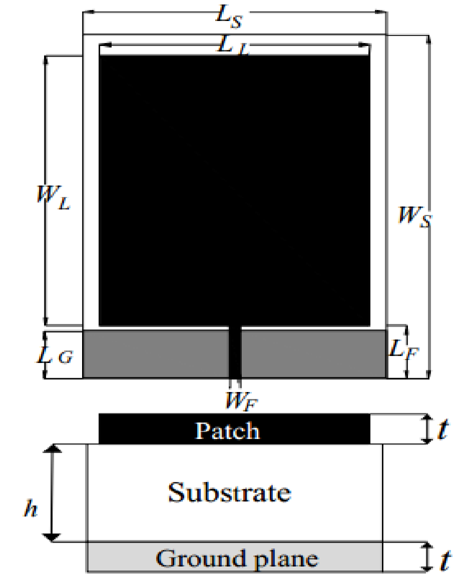


Figure-2. Geometric details of the patch antenna. Top and side view.

Figure-3 presents four stages of antenna's structure.

Stage I, Single mode without stepped cut at four corner technique. At stage1 The Length $L_{L=}$ 80mm and width $W_{L\ =}$ 102mm, thus stage 1 patch antenna is considered the main patch. Stage 2, Dual mode Modified rectangular microstrip patch antenna with stepped cut at four corner technique. At stage 2 The Length of empty space cut corner $L_{L1\ =}$ 27mm and the width $W_{L1\ =}$ 35mm.

Stage 3, Multi-mode MRMPA where the number of stepped cut at four corner technique are increased.

Stage 4, Broadband MRMPA which contains of a large number of steps, the Length and the width of the corners are very small which reach to 0.011mm and 0.014mm respectively.

VOL. 10, NO 22, DECEMBER, 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

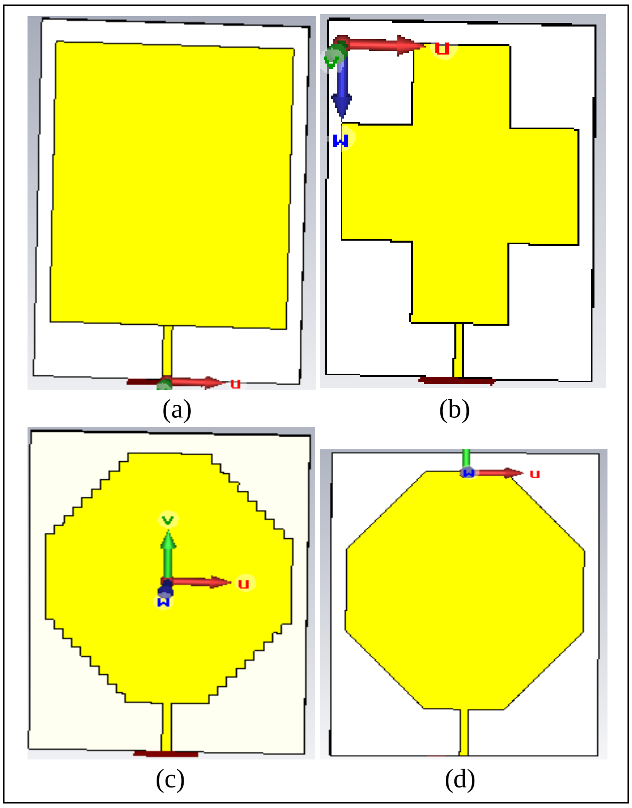


Figure-3. Designed structures of proposed antenna. (a)Single mode RMPA (b) Dual mode MRMPA (c) Multi-mode MRMPA (d) Broadband MRMPA

RESULTS AND DISCUSSIONS

Simulated return loss of a single mode and dual mode microstrip patch antenna are shown in Figure-4. It is obvious that single mode has only one resonant at 1 GHz, while dual mode has two resonances at 0.9 and 3.6 GHz.

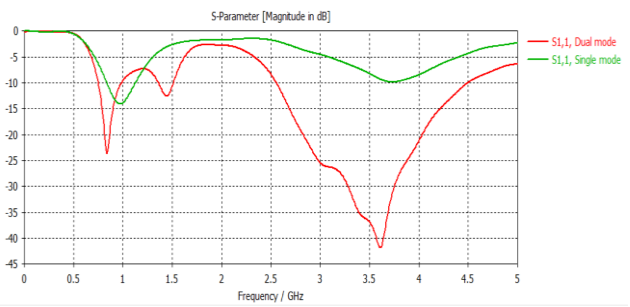


Figure-4. Simulated return loss of a single mode and dual mode.

Simulated Return loss of multi mode and broadband mode is shown in Figure-4. In multimode four resonances are obvious at 1.0, 1.6, 2.55 and 4.2 GHz. In broadband, bandwidth from 0.8GHz to 4.5 GHz is achieved.

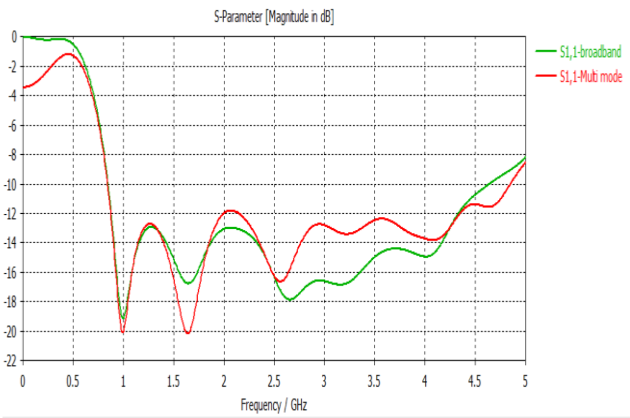
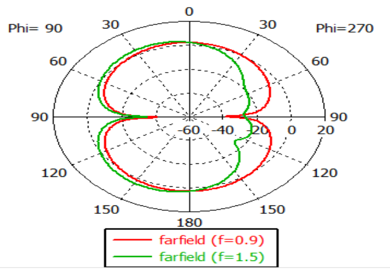
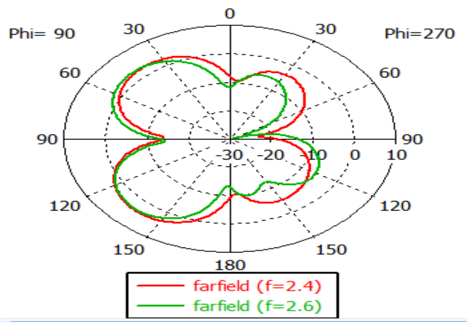


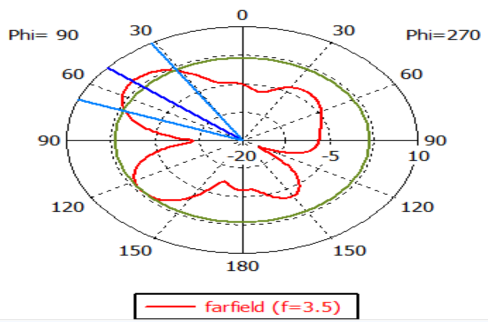
Figure-5. Simulated return loss of a multi mode and broadband of MRMPA.



(a)



(b)



(c)

Figure-6. Simulated radiation patterns of the broadband MRMPA (a) 0.9GHz, 1.5GHz (b) 2.4GHz, 2.6GHz and (c) 3.5GHz.

Figure-6 shows the far field radiation pattern of the Broad band MRMPA. In Figure-5, a stable omnidirectional far field pattern at 0.9 and 1.5 GHz frequency and almost bidirectional at 2.4, 2.6 and 3.5 GHz frequency have been achieved.

Table-1. Return loss and gain of broadband MRMPA.

	Return loss (dB)		**Gain** dBi	
Frequency operation	**Designed antenna**	**Reference antenna**	**Designed antenna**	**Reference antenna**
0.9GHz	-13.5	-16	2.35	2.5
1.5 GHz	-15.1	-14.1	4.25	4.1
2.4 GHz	-14.78	-11.5	4.9	4.0
2.6 GHz	-17.64	-11	6.1	4.6
3.5GHz	-15	-	5.9	-

Table-1 shows the comparison between the designed antenna and the reference antenna [4] in term of return loss and gain. By increasing the number of steps at the corners, the number of excited resonance frequencies over the impedance BW is investigated. If the number of steps at the corners increases infinitely, the steps become smaller and reach a point that the step path is near to zero. The results obtained by this design enhanced the gain and directivity. The gain obtained by this design is more enhanced than the article [4] also the frequency operation 3.5GHz which can be used by WiMax is covered. The gain reached to 6dBi at frequency of 2.6GHz which is more enhanced compared to 4.6dBi obtained by the reference antenna. The bandwidth can be defined by *VSWR* or input impedance variation with frequency or in terms of radiation parameters. The acceptable interval for determining the bandwidth of a particular antenna configuration should be ($1 \leq VSWR \leq 2$) which is obtained by proposed design.

CONCLUSIONS

A multiband/broadband antenna has been designed from rectangular microstrip patch antenna using stepped cut at four corner technique with enhanced performance. The simulated gain and return loss performance were obtained well than previous design for 1.5, 2.4 and 2.6 GHz. AT 2.6 GHz; the gain is 6.1 dBi which is 1.5 dB higher. The proposed antenna achieved resonance at 3.5 GHz with gain of 5.9 dBi and return loss -17 dB. The operating frequencies of this design covers from 900MHZ to 3.5 GHz which can be used for GSM (900MHz/1.5GHz), WiFi (2.4GHz), LTE (2.6GHz) and WiMax (3.5 GHz) applications.

REFERENCES

[1] Yue Li, Jianfeng Zheng and Zhenghe Feng “Latest Progress in MIMO Antennas Design” INTECH Open Access Publisher, pp.1-6, 2012.

[2] Shivani Chourasia and Dr. Soni Changlani” Design and Analysis of I-Shaped Microstrip Patch Antenna for Low Frequency,” IJIRST -International Journal for Innovative Research in Science and Technology. Vol. 1.No. 6, November 2014.

[3] Anindya Kumar Kundu, MD. Tofael Hossain Khan, Md. Ashikur Rahman, Md. Osman Goni and Kazi Abul Barket,” Design and Performance Analysis of a 4×1 MIMO Inverted F- Shaped Patch Antenna Array for X-Band Applications and Link Budget Optimization,” International Conference on Electrical Information and Communication Technology (EICT), pp. 1-5, Feb. 2014.

[4] Alishir MoradiKordalivand,and Tharek A. Rahman" broadband modified rectangular microstrip patch antenna using stepped cut at four corners method" Progress In Electromagnetics Research, Vol. 137, pp. 599-619, 2013.

[5] Tara Ali-Yahiya “Understanding LTE and its Performance” Springer Science and Business Media, 2011.

[6] M. K. A. Nayan, M. F. Jamlos and M. A. Jamlos” Circularly polarized MIMO antenna array for point-to-point communication,” Microwave and Optical

ARPN Journal of Engineering and Applied Sciences

Technology Letters, vol.57, no. 1, pp. 242-247, Jan 2105.

[7] Atser A. Roy, Joseph M. Môm, Gabriel A. Igwue" Enhancing the Bandwidth of a Microstrip Patch Antenna usingSlots Shaped Patch" American Journal of Engineering Research (AJER). Vol -02, pp. 23-30, 2013.