

# UNIVERSITY OF BIRMINGHAM

## Research at Birmingham

### Simple methods for enhancing bandwidth of a rectangular microstrip patch antenna

Ghafouri-Shiraz, Hooshang; Rabbani, Muhammad

DOI:

[10.1049/ic.2014.0184](https://doi.org/10.1049/ic.2014.0184)

License:

Other (please specify with Rights Statement)

*Document Version*

Peer reviewed version

*Citation for published version (Harvard):*

Ghafouri-Shiraz, H & Rabbani, M 2014, Simple methods for enhancing bandwidth of a rectangular microstrip patch antenna. in 2nd IET Annual Active and Passive RF Devices Seminar. 2nd IET Annual Active and Passive RF Devices Seminar , Institution of Engineering and Technology, pp. 5-9, Active and Passive RF Devices Seminar, 2nd IET Annual, United Kingdom, 29/10/14. <https://doi.org/10.1049/ic.2014.0184>

[Link to publication on Research at Birmingham portal](#)

#### **Publisher Rights Statement:**

© 2014 IEEE. Personal use of this material is permitted. Permission from IEEE must be obtained for all other uses, in any current or future media, including reprinting/republishing this material for advertising or promotional purposes, creating new collective works, for resale or redistribution to servers or lists, or reuse of any copyrighted component of this work in other works

Rabbani, M.S. and Ghafouri-Shiraz, H., 2014, October. Simple methods for enhancing bandwidth of a rectangular microstrip patch antenna. In Active and Passive RF Devices Seminar, 2nd IET Annual (pp. 1-4). IET.

#### **General rights**

Unless a licence is specified above, all rights (including copyright and moral rights) in this document are retained by the authors and/or the copyright holders. The express permission of the copyright holder must be obtained for any use of this material other than for purposes permitted by law.

- Users may freely distribute the URL that is used to identify this publication.
- Users may download and/or print one copy of the publication from the University of Birmingham research portal for the purpose of private study or non-commercial research.
- User may use extracts from the document in line with the concept of 'fair dealing' under the Copyright, Designs and Patents Act 1988 (?)
- Users may not further distribute the material nor use it for the purposes of commercial gain.

Where a licence is displayed above, please note the terms and conditions of the licence govern your use of this document.

When citing, please reference the published version.

#### **Take down policy**

While the University of Birmingham exercises care and attention in making items available there are rare occasions when an item has been uploaded in error or has been deemed to be commercially or otherwise sensitive.

If you believe that this is the case for this document, please contact [UBIRA@lists.bham.ac.uk](mailto:UBIRA@lists.bham.ac.uk) providing details and we will remove access to the work immediately and investigate.

# SIMPLE METHODS FOR ENHANCING BANDWIDTH OF A RECTANGULAR MICROSTRIP PATCH ANTENNA

M. S. Rabbani\* and H. Ghafouri-Shiraz\*\*

School of Electronic Electrical and Computer Engineering, University of Birmingham, 52 Pritchatts Road Edgbaston, B15 2TT, UK

\*[saqibrabbani05@hotmail.com](mailto:saqibrabbani05@hotmail.com) and \*\*[ghafourh@bham.ac.uk](mailto:ghafourh@bham.ac.uk)

**Key words:** Microstrip antenna, bandwidth, filtering patch antenna

**Abstract:** In this paper we have introduced two methods namely (i) taper matching and (ii) quarter wavelength width extension to increase the bandwidth (BW) of a rectangular microstrip patch antenna (RMPA). Also we have studied the effect of applying both methods on the antenna performance. Simulation and experimental results on a 5GHz patch antenna using these methods have been presented.

## 1. Introduction

A typical microstrip antenna has a very narrow BW of about 4% [1]-[2]-[3]. In the recent decade, a considerable amount of work has been done to increase the BW of RMPA [4]-[5]-[6]. In Ref. [1] antennas having ultra wide BW have been reported [1]. However, the problem with the available techniques for BW improvement is that either a complex geometrical pattern or a complex patch shape should be used. This may cause difficulties in the antenna fabrication (especially at frequencies above 30GHz) and produces some unwanted variations in the antenna's far field pattern. These issues have been addressed in this paper. Furthermore, usually a band pass filter is required to be incorporated with the transmitting and receiving antennas. In recent years, many attempts have been made to design a microstrip antenna with a built in band pass filter [6]-[7]-[8]-[10]-[11]. Also, in this case the band pass filter (BPF) is constructed either by employing a complex pattern on the patch antenna or by making the BPF separately using microstrip transmission lines and then matching the filter with the antenna. Either method may require complex design or may need more space to accommodate both the antenna and filter together. This problem may be rectified by the proposed methods easily without any necessity to have extra design or complex geometry.

## 2. Bandwidth Enhancement of Patch Antenna

The following methods have been proposed to improve the band width of a RMPA.

### 2.1 Taper Matching

A patch antenna operating at 5GHz was designed using the conventional design equations available in the literature [1]. In the 1<sup>st</sup> design (antenna a) we used a quarter wavelength long rectangular microstrip transmission line (TL) for impedance matching. The antenna substrate was RT/Duroid 5880 with  $\epsilon_r = 2.2$ ,  $h = 3.175$  mm and  $t = 0.035$  mm so that we can get large antenna's dimensions (see Fig.1), high gain and high bandwidth. The original calculated length 'L' and width 'W' were 18.1mm and 23.7mm, respectively whereas the optimised values of L, W and the transmission line dimensions 'L<sub>T</sub>' and 'W<sub>T</sub>' were 17.6mm, 23.7mm,

10.67mm, and 2.84mm, respectively. Also as shown in Fig.1 the substrate length 'L<sub>g</sub>' and width 'W<sub>g</sub>' were, respectively, 37.15mm and 42.75mm.

In the 2<sup>nd</sup> (antenna b) design we used a tapered shape quarter wavelength long TL (L<sub>T</sub>) on the original design (i.e. L=18.1mm, W=23.7mm) to improve the matching and bandwidth. The optimised taper widths 'W<sub>fe</sub>' and 'W<sub>f</sub>' were 0.3mm and 8.33mm, respectively, which corresponds to the 50Ω standard input impedance.

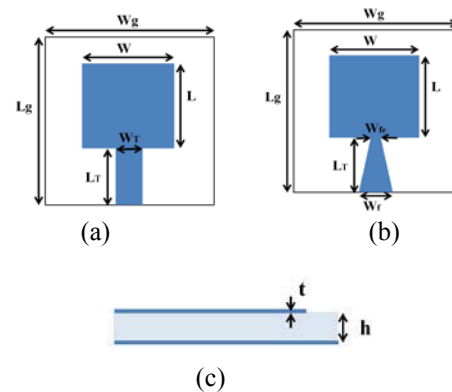


Figure 1: Antenna dimensions (a) rectangular quarter wavelength matching (b) taper matching (c) side view of the antenna

### 2.2. Quarter Wavelength Width Extension

For this method, firstly, the antennas dimensions are calculated from the conventional formulas as described in section 2.1. When the patch antenna's width 'W' is increased by let say  $\Delta W \leq \lambda / 4$  (where  $\lambda$  is the guided wavelength), a second resonance starts appearing at a higher but close to the original resonance frequency. However, as  $\Delta W$  approaches to  $\lambda / 4$  the second resonance starts merging with the first one which ultimately gives a considerable increase in the antenna bandwidth. In our design (antenna b) the new value of the antenna width (i.e.  $W + \Delta W$ ) becomes 34.38mm. Also as the antenna width increases the input impedance of the antenna decreases, so W<sub>T</sub> (see Fig.1a) is increased to flatten the ripple in the pass band. Both the antenna length and width can be adjusted to finely control the edges of the S<sub>11</sub> response. The antenna bandwidth and pass band flatness of

$S_{11}$  can all be controlled by  $\Delta W$  and  $W_T$  which give enough flexibility to create the desired response.

### 2.3. Width Extension and Taper Matching

This method is basically a combination of the two methods as described in sections 2.1 and 2.2. The patch antenna used in section 2.2 with  $W = 34.38$  mm is redesigned to operate at 5GHz using tapered matching.

The values of input ( $W_f$ ) and output ( $W_{fe}$ ) taper widths were optimised to increase the antenna bandwidth. These optimised values are  $W_f = 6$  mm and  $W_{fe} = 7$  mm which gives the widest and deepest response around 5GHz.

### 3. Results and Discussions:

**Taper Matching:** Two samples of rectangular and tapered matching for each designed patch antenna have been fabricated and tested (see Figs 2a and 3a). The measured and simulation results for the two matching methods are shown in Figs 2 and 3.

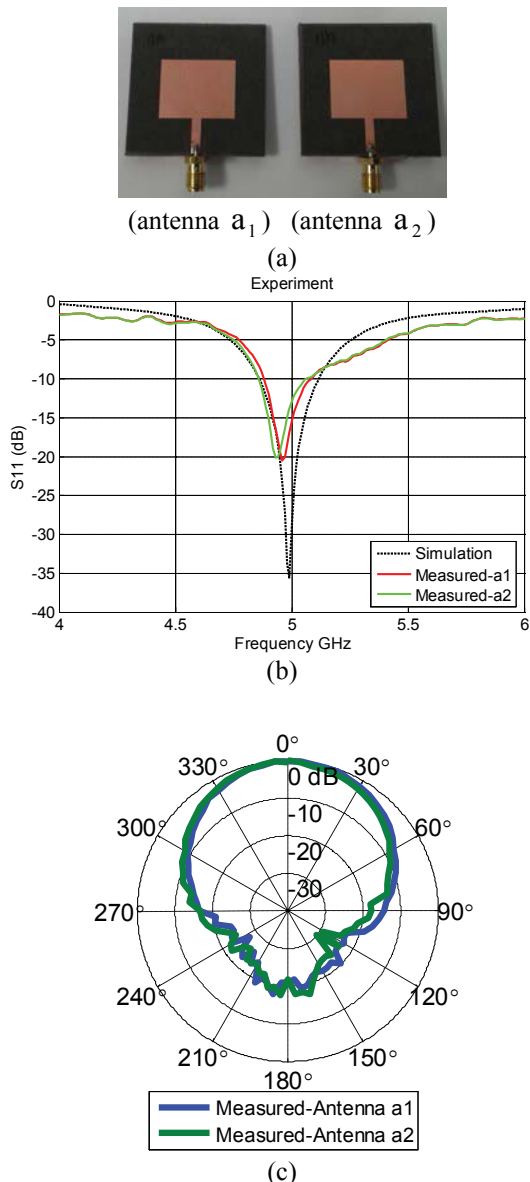


Figure 2. Test results for Antenna a (a) fabricated antennas (b) results (c) measured far-field pattern

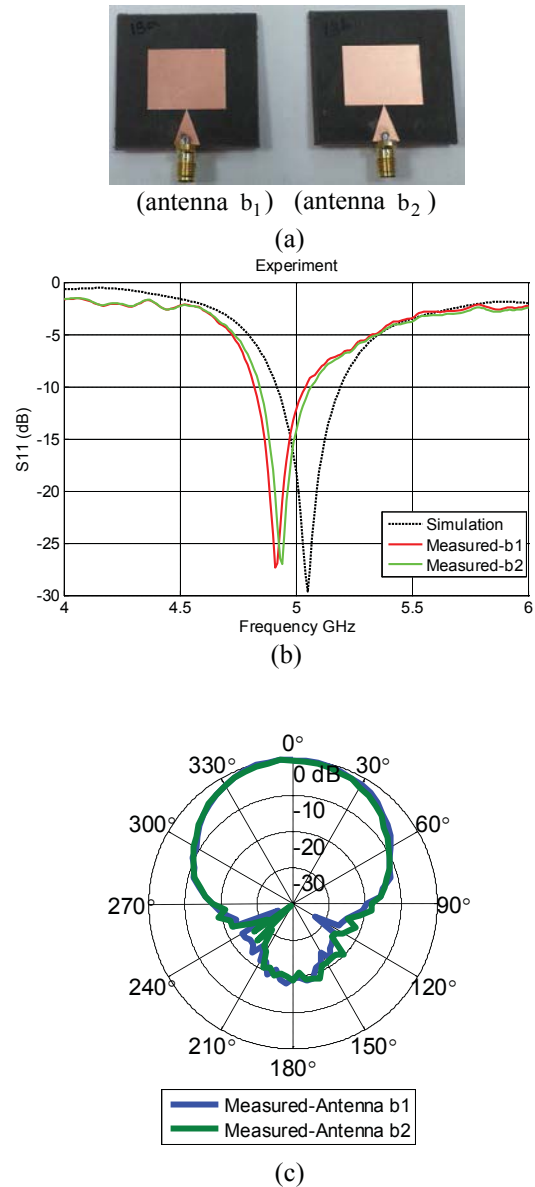


Figure 3. Test results for design b (a) fabricated antennas (b) results (c) measured far-field pattern

The measured bandwidths of the antennas shown in Figs.2 and 3 are, respectively, 202MHz (4.05% at  $f_0 = 4.982$  GHz) and 220MHz (4.46% at  $f_0 = 4.93$ GHz), where  $f_0$  is the centre frequency. The results clearly show that the taper matching gives 18 MHz wider bandwidth and also the  $S_{11}$  parameter is 5dB lower as compared with the conventional quarter wavelength matching.

**Quarter Wavelength Width Extension:** Various patch antennas with fixed  $W = 33$ mm and different  $W_T$  were fabricated. Figure 4 shows the simulation and measured results for the optimised one (see Fig.4a) which has  $W_T = 8$ mm (Fig.4a). The results show that the  $S_{11}$  response (Fig.4b) is quite flat in the pass band and gives a bandwidth of 1.18GHz (i.e. 22.18% at  $f_0 = 5.32$ GHz). The far- field pattern of the antenna at this frequency is shown in Fig.4c.

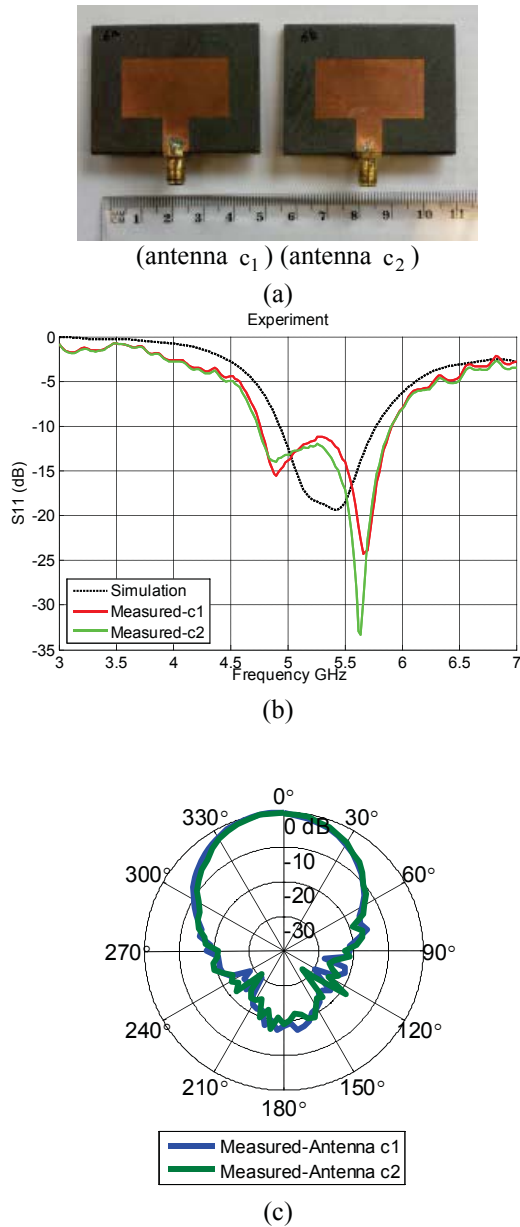


Figure 4. (a) The fabricated antenna, (b) simulation and measured results and (b) measured far-field pattern

**Width Extension and Taper Matching:** Two fabricated samples of the antenna that are fabricated by this method are shown in Fig.5a. Figures 5b shows both the simulation and measured  $S_{11}$  responses which are in good agreement and Fig.5c shows the designed antenna far-field pattern. The measure bandwidth is 1.018GHz (i.e. 19.52% at  $f_0 = 5.21$ GHz) which is about 5 times larger than a typical patch antenna.

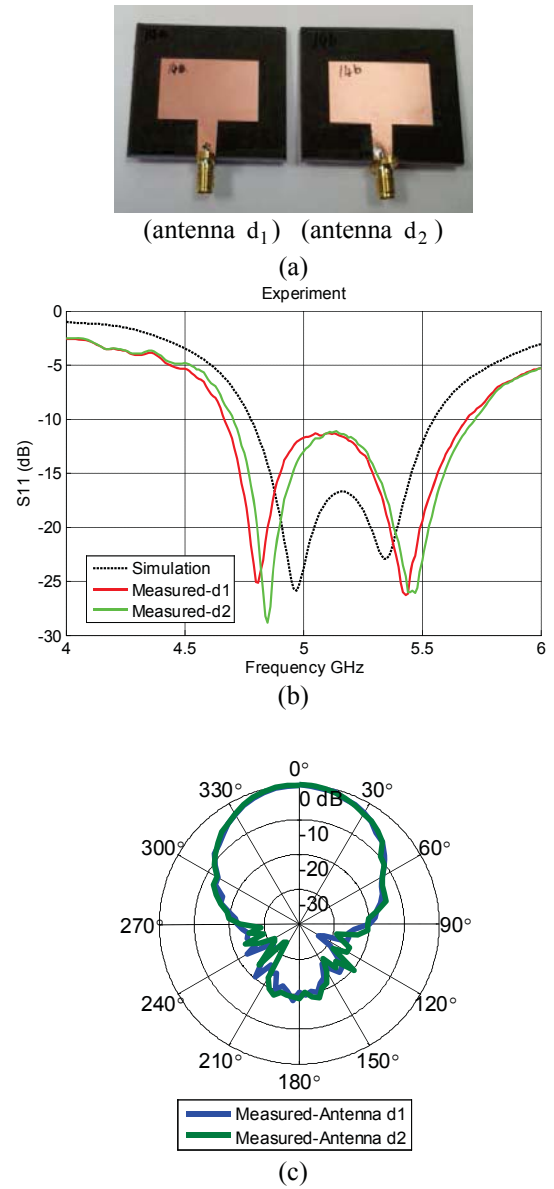


Figure 5. (a) Fabricated antennas (b)  $S_{11}$  response (c) Far-field pattern

#### 4. Conclusion

Two methods namely (i) taper matching and (ii) quarter wavelength width extension have been proposed to increase the bandwidth of a rectangular microstrip patch antenna. The taper matching is a simple method to improve the patch antenna bandwidth and impedance matching. With quarter wavelength width extension a large increment in bandwidth (i.e. 22.18%) is measured. With the combination of these two methods, again, a considerable bandwidth improvement (i.e.19.52%) is achieved. All tested antennas have given a typical patch antenna radiation pattern and their measured directivities range from about 10dBi to 11.43dBi.

## References:

- [1]. Bancroft, R.: 'Microstrip and printed antenna design', The Institution of Engineering and Technology, 2009.
- [2]. Balanis, C. A., ed.: 'Modern antenna handbook', John Wiley & Sons, 2011.
- [3]. <http://www.antenna-theory.com/antennas/patches/antenna.php#fringing>, Accessed August 2014
- [4]. Kandwal, A, Rakesh S, and Sunil K. K.: "Bandwidth Enhancement Using Z-Shaped Defected Ground Structure for a Microstrip Antenna." *Microwave and Optical Technology Letters* 55.10 (2013): 2251-2254.
- [5]. Chaudhary, Raghvendra K., Kumar V. Srivastava, and Animesh B.: "A Practical Approach: Design of Wideband Cylindrical Dielectric Resonator Antenna with Permittivity Variation in Axial Direction and its Fabrication using Microwave Laminates." *Microwave and Optical Technology Letters* 55.10 (2013): 2282-2288.
- [6]. Sathamsakul, S.; Anantrasirichai, N.; Benjangkprasert, C.; Wakabayashi, T., "Rectangular patch antenna with inset feed and modified ground-plane for wideband antenna," *SICE Annual Conference, 2008* , vol., no., pp.3400,3403, 20-22 Aug. 2008
- [7]. Xinwei, C., Fengxian, Z., Liyun, Y., and Wenmei Z.: "A Compact Filtering Antenna With Flat Gain Response Within the Passband," *Antennas and Wireless Propagation Letters, IEEE* , vol.12, no., pp.857,860, 2013
- [8]. Chin-Kai, L., Shyh-Jong C.: "A Filtering Microstrip Antenna Array," *Microwave Theory and Techniques, IEEE Transactions on* , vol.59, no.11, pp.2856,2863, Nov. 2011
- [9]. Zuo, Shaoli, Wei-Jun W., and Zhi-Ya Zhang. "A Simple Filtering-Antenna with Compact Size for WLAN Application." *Progress In Electromagnetics Research Letters* 39 (2013): 17-26.
- [10]. Hizan, H. M., Hunter, I. C., and Abunjaileh, A. I., "Integrated SIW filter and microstrip antenna," *Microwave Conference (EuMC), 2010 European* , vol., no., pp.184,187, 28-30 Sept. 2010
- [11]. Abbaspour-Tamijani, A., Rizk, J., and Rebeiz, G.: "Integration of filters and microstrip antennas," *Antennas and Propagation Society International Symposium, 2002. IEEE* , vol.2, no., pp.874,877 vol.2, 2002