academicJournals

Vol. 9(15), pp. 661-667, 15 August, 2014
DOI: 10.5897/SRE2014.5927
Article Number: 63B667B46679
ISSN 1992-2248 ©2014

http://www.academicjournals.org/SRE

Scientific Research and Essays

Full Length Research Paper

Performance analysis of bandwidth and gain improvement of printed wide slot antenna using parasitic patch

Prachi Gupta[1] and Brajlata Chauhan[2]

[1]Dehradun Institute of Technology, Dehradun, UK, India.
[2]Uttarakhand Technical University, Dehradun UK India.

Received 11 April, 2014; Accepted 24 July, 2014

Here, a printed micro strip line fed wide slot antenna with rotated square slot resonator is presented. This article deals with design, modeling and simulation of slotted antenna. A parasitic patch is introduced to improve the gain along with the bandwidth. For bandwidth enhancement, a slotted approach is used in ground of antenna along with rotation in patch and a simple 50 Ώ microstrip line fed is used to excite the slot in the antenna. The proposed antenna exhibits the return loss (S11) below -10 dB for the frequency mentioned and the effects of design antenna parameters such as slot width and patch width have been investigated. Results shows that a good amount of bandwidth (approximately 3 GHz) and gain (approximately 8 dB) is achieved ranging from 2.23 to 5.4 GHz which shows its application in world interoperability for microwave access (WIMAX) and wireless local area network (WLAN) bands.

Key words: High frequency structure simulator (HFSS), microstrip patch antenna (MSA), parasitic patch, wide-slot antenna.

INTRODUCTION

Nowadays, the demand for large bandwidth antennas is on rise as ultra wideband becomes more wide spread. Printed slot antennas are widely used in variety of communication systems because of wide-slot antenna as the two orthogonal modes in wide slot antennas are merged to create a wide impedance bandwidth (Kahrizi et al., 1993). By coupling between the feeding structure and slot, wide bandwidth is obtained. A printed wide slot antenna with fork like tuning stub fed by micro strip line provides good bandwidth (Sze and Wong, 2001). Wide slot antennas have various properties like low profile, ease of integration, light weight, wider bandwidth, less interaction via surface waves and negligible radiation from feed network (Stutzman and Thiele, 1998; Girish and Ray, 2003). Wider is the antenna slot, wider is the impedance bandwidth. The impedance bandwidth has been broadened rapidly from 58 to 130% by using combination of different feed shapes and wide slots have been reported (Qu et al., 2006). In literature (Jan and Su, 2005), significant bandwidth is achieved just by rotating slot around centre of square slot. By etching a wide slot as fractal shapes can also improve bandwidth in proposed

*Corresponding author. E-mail: prachig048@gmail.com

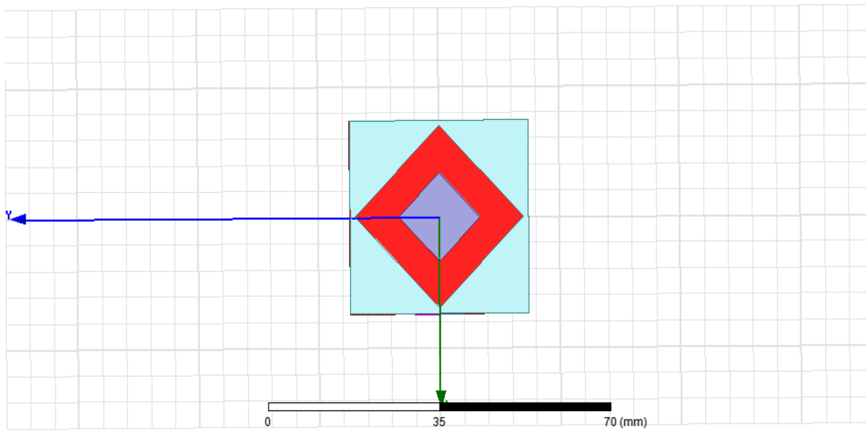

Figure 1. Design of slot antenna with parasitic patch.

slot antenna (Chen et al., 2009).

Use of parasitic patch is intended for gain maximization as well as bandwidth. Analysis of rotation of parasitic patch is also produced which satisfies that the gain and bandwidth are maximized at an angle of 45°. By use of parasitic patch in slot center, it is shown that f1 (lower resonant frequency) is decreased and f2 (higher resonant frequency) is increased thus, broad band characteristic is obtained. Then, by use of the parasitic patch printed symmetrically to the feeding line, the bi-directional radiation feature is changed into unidirectional with enhanced gain. UWB antennas helped in obtaining multi-standard functionality and higher data rate as compared to any other narrow band antenna.

From the simulated results, the achieved impedance bandwidth (determined from 10-dB reflection coefficient) of the proposed antenna can operate from 2.2 to 5.4 GHz covering the wireless local area network (WLAN) bands and world interoperability for microwave access (WIMAX) bands. By optimization, the dimensions of ground reduces from 70 to 37 mm for bandwidth and gain maximization along with reduced area constraint that is, about 72%. Both the mechanisms of high gain and bandwidth of some key parameters of the structure are also given and discussed in this paper. The proposed antenna is simulated using HFSS which is based on FEM.

ANTENNA GEOMETRY AND DESIGN

Proposed design of micro strip parasitic patch antenna is shown in the Figure 1. Yagi-Uda antenna offers a concept for improving antenna gain. In this approach, parasitic patches are printed on suitable position in the antenna and the effects on the gain are investigated. The proposed antenna has a simple geometry, consist of square slot and parasitic patch with some angle of rotation. The printed square slot antenna's dimensions are 24.7×24.7 mm^2 which is printed on FR-4 substrate having thickness 1.6 mm and relative permittivity 4.4. The ground dimensions are taken as 37×37 mm^2. The square slot is fed by 50 Ω micro strip line which is printed on substrate. The feed line shown in figure is having the dimensions of 3×31.5 mm^2.

For bandwidth maximization, the square slot rotation is performed at an angle of 45° and parasitic patch is applied having the dimensions of 12×12 mm^2 and for gain maximization, the parasitic patch is also rotated at angle of 45°. Thus, angle of rotation of parasitic patch provides us gain improvement.

Parametric study

Here a parametric study is carried out to understand the effects of design parameters such as slot width and parasitic patch width on the bandwidth. Figure 2 shows the simulated reflection coefficient for the proposed antenna with different widths of slot in the ground plane. The dimensions of proposed antenna are as follows: ground G = 37 mm, FR4 substrate, parasitic patch p=12mm and slot dimensions as length of slot remains 24.7 mm and width t in the ground plane varies from 17 to 26 mm. As the width of slot decreases, the bandwidth increases up to 3.6 GHz. The bandwidth however does not increase any further when the width of slot is below 18 mm. When t = 18 mm and all other dimensions are same, the bandwidth of antenna obtained through simulation is 3.61GHz ranging from 2.45 to 6.06 GHz and gain so obtained in this case is about 3.56 dB. Thus, the shape of slot which is rotated at angle 45° changes from square to rectangular as shown in Figure 5. The return loss so obtained in this case is -49.6 and -30.04 dB at two resonant frequencies at 5.5 and 2.6 GHz as shown in Figure 4.

Figure 3 shows the simulated reflection coefficient for the proposed antenna with different widths of parasitic patch. In this case, the length of patch remains same that is, 12 mm and width of patch varies from 10 to 16 mm and all other dimensions are same as given in antenna geometry and design and square slot is to be considered.

The bandwidth of proposed antenna obtained through simulation and parametric is 3.2 GHz when width of patch a = 12 mm that is, square parasitic patch which is also rotated at an angle 45° and the gain so obtained in this case is 8.81 dB.

By applying parametric, the proposed antenna shows extreme bandwidth that is, 3.6 GHz when square parasitic patch is introduced in the rectangular slot and both are rotated at an angle 45° and gain is 3.35 dB. This is the case when bandwidth is the only criteria but when square parasitic patch is centered in the square wide slot with 45° rotation, the bandwidth so obtained is 3.2 GHz and gain is 8.81 dB. This is the case when both bandwidth and

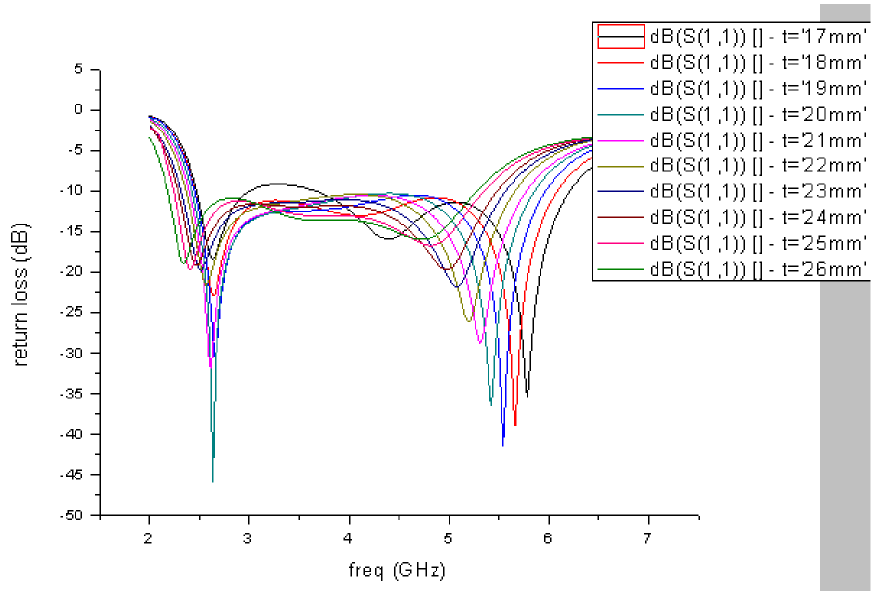

Figure 2. Simulated reflection coefficient of proposed antenna with different widths.

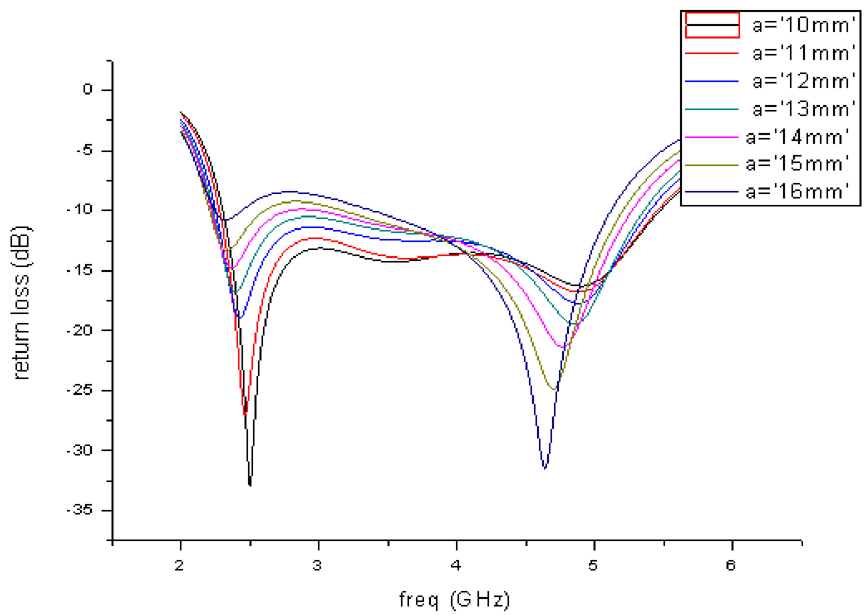

Figure 3. Simulated reflection coefficient of proposed antenna with different widths of parasitic patch.

gain is the criteria.

RESULTS AND DISCUSSION

The proposed antenna is simulated on EM solver Ansoft HFSS (High Frequency Structure Simulator) and various parameters such as return loss, bandwidth and gain are discussed in this section.

Return loss of proposed antenna

Return loss is a measure of how well antenna matching is done. The return loss of proposed antenna when both patch and slot is square is approximately 19 dB as shown

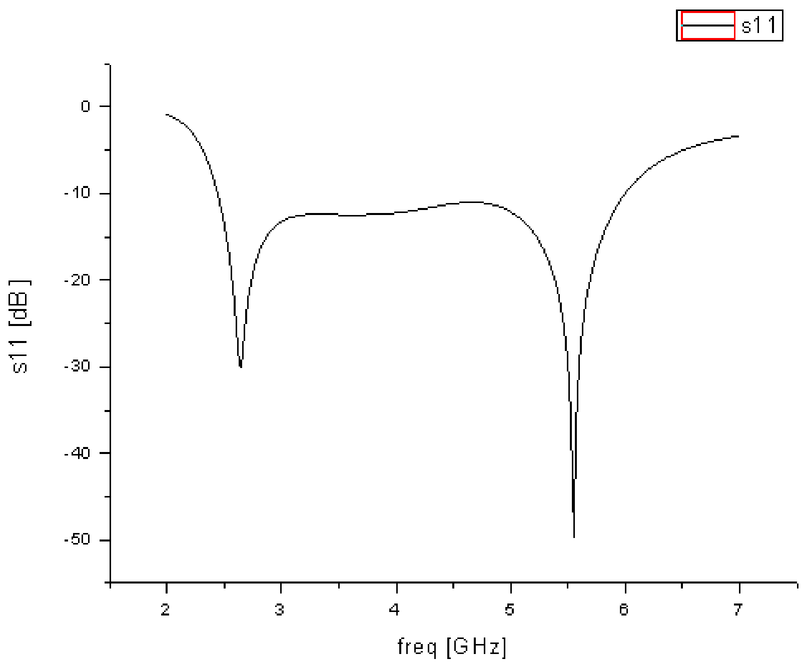

Figure 4. Simulated reflection coefficient of rectangular slot antenna with parasitic patch.

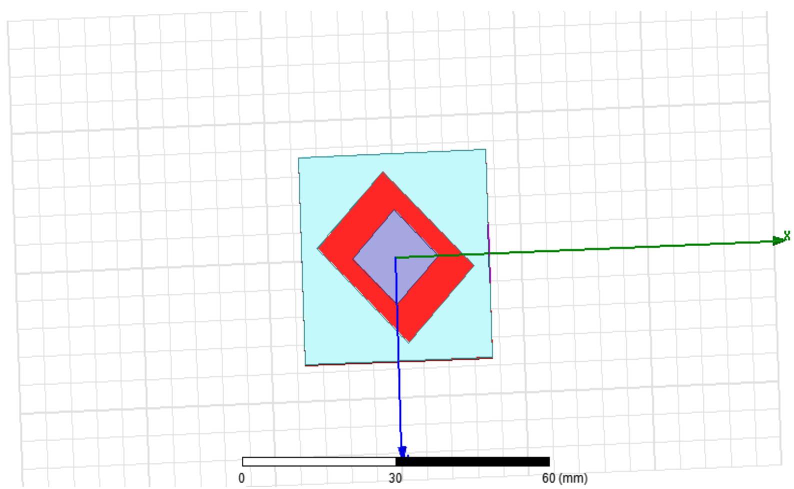

Figure 5. Design of rectangular slot antenna with parasitic patch.

in Figure 6.

Bandwidth of proposed antenna

Bandwidth describes the range of frequencies over which the antenna can properly radiate or receive energy. We can see that on changing the values of ground plane have effect on the bandwidth of proposed antenna. Substrate thickness is another important parameter in achieving wide band performance. The impedance bandwidth obtained from the simulation results ranging from 2.2 to 5.4 GHz at 10 dB return loss, that is, 3.2 GHz bandwidth is achieved as shown in Figure 6.

Gain of proposed antenna

Gain is defined as the ability of antenna to concentrate energy in a narrow angular region (a directive beam). The results on the basis of rotation of parasitic patch are shown in Table 1. The gain so obtained at angle 45° is

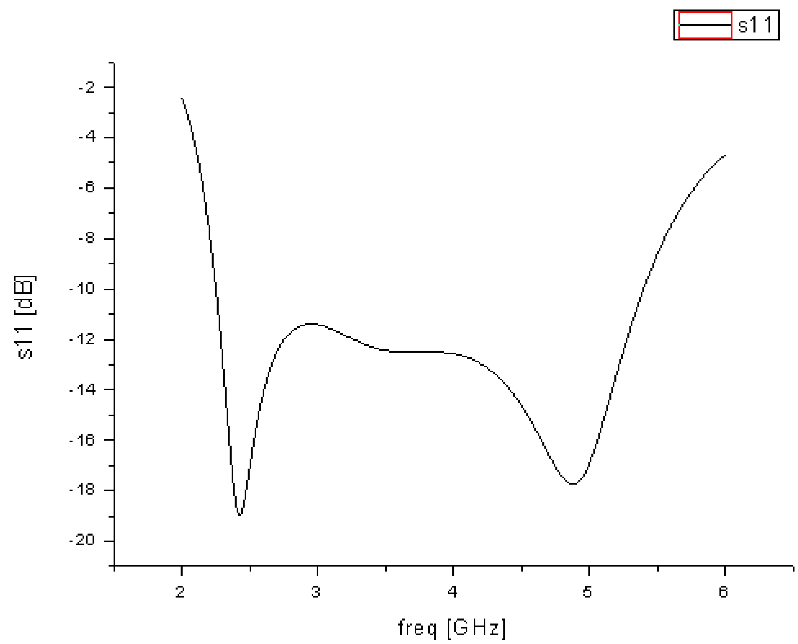

Figure 6. Return loss.

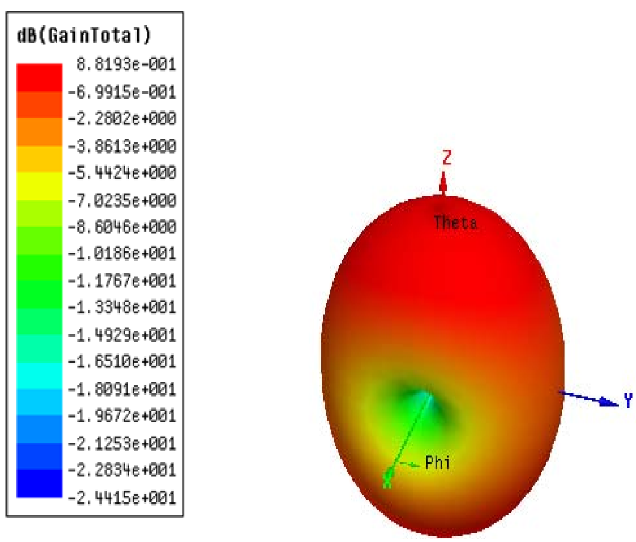

Figure 7. Gain.

Table 1. Results on the basis of rotation of parasitic patch.

Angle	Fr (GHz)	Bandwidth (GHz)	Gain (dB)
0°	2.4 &4.7	5.3-2.3	2.47
10°	2.4&4.7	5.3-2.3	2.47
20°	2.4&4.8	5.4-2.2	-9.67
30°	2.4&4.8	5.4-2.2	1.9
40°	2.4&4.8	5.4-2.2	1.27
45°	2.4&4.8	5.4-2.2	8.81
50°	2.4&4.8	5.4-2.2	1.36
60°	2.4&4.8	5.3-2.2	1.24
70°	2.4&4.8	5.3-2.2	-6.31
80°	2.4&4.8	5.3-2.2	-2.52

maximum that is, 8.81 dB and is verified by the table as shown in Figure 7.

Comparison analysis

The comparison has been made between without parasitic patch and with parasitic patch on the basis of return loss, bandwidth and gain in square wide slot antenna. The reference antenna that is, without parasitic patch has ground dimensions of 70×70 mm^2 and with parasitic patch has dimensions of 37×37 mm^2 thus, area is reduced up to 72%.The return loss of reference antenna is -39 dB at resonant frequency of 3.8 GHz is shown in Figure 9 which shows very good impedance matching. The bandwidth so obtained is about 2 GHz (5.4 - 3.4 GHz). The gain so obtained in this case is about 5.4 dB as shown Figure 10. The design of reference antenna without parasitic patch is shown in Figure 8.

The proposed antenna that is, with parasitic patch has ground dimensions of 37×37 mm^2. The variations are in the dimensions of ground and all other parameters are

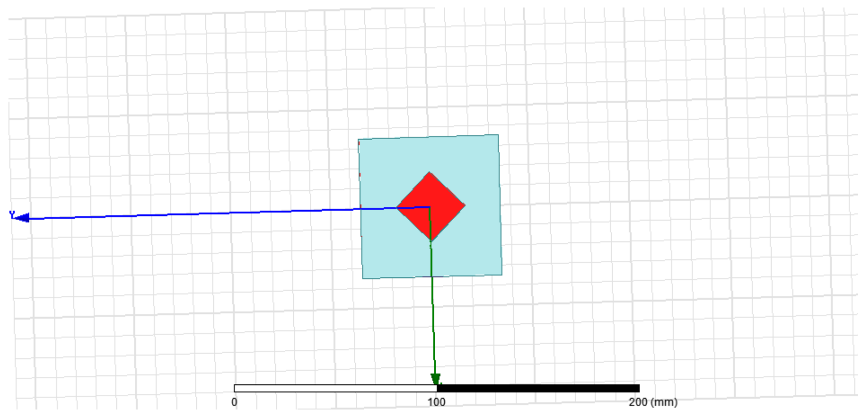

Figure 8. Without parasitic patch.

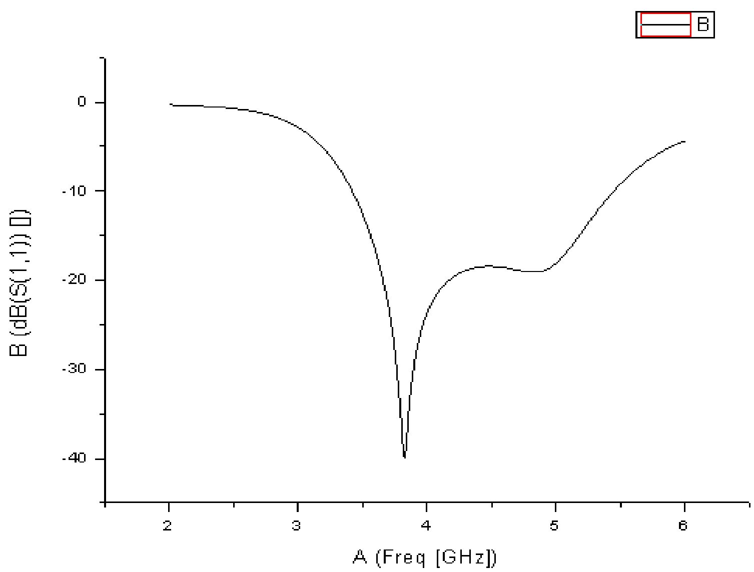

Figure 9. Return loss of reference antenna.

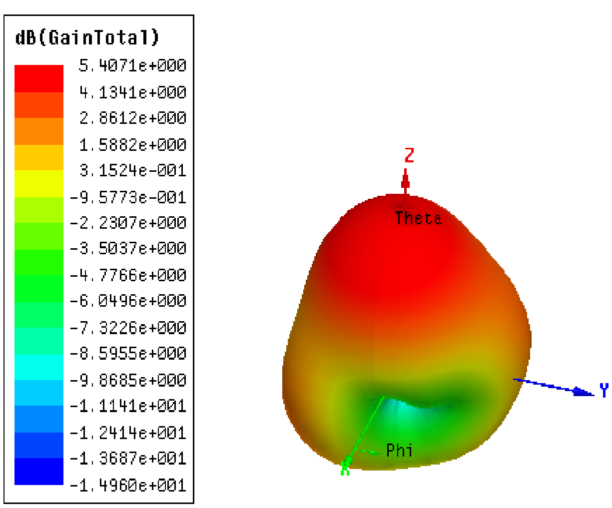

Figure 10. Gain of reference antenna.

same as given in design methodology. The return loss of proposed antenna is about -19 dB and the bandwidth so obtained is about 3.2 GHz which is far better than reference antenna. The results of gain are about 8.8 dB which is far better than reference antenna only by rotating the parasitic patch.

Conclusion

A printed wide slot antenna with parasitic patch has been implemented and studied in this work. By analyzing parametric, we can say that bandwidth increases from 3.2 GHz to 3.6 GHz by decreasing width of slot in ground plane that is shape of slot changes from square to rectangular. On rotating the parasitic patch at different angles and is centered in the square slot, the gain is enhanced up to 8.8 dB and when compared with and without parasitic patch, the antenna performance is improved. The proposed antenna is applicable for WIMAX and WLAN bands. Furthermore, we are trying to do miniaturization of this antenna so that it will use comparatively lesser area for fabrication.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

Chen WL, Wang GM, Zhang CX (2009). "Bandwidth enhancement of a microstrip-line-fed printed wide-slot antenna with a fractal-shaped slot,"IEEE Trans. Antennas Propag. 57(7): 2176-2179. http://dx.doi.org/10.1109/TAP.2009.2021974

Girish K, Ray KP (2003)."Broadband Microstrip Antennas", Artech House pp. 3-5.

Jan JY, Su JW (2005). "Bandwidth enhancement of a printed wide-slot antenna with a rotated slot,"IEEE Trans. Antennas Propag. 53(6):2111-2114. http://dx.doi.org/10.1109/TAP.2005.848518

Kahrizi M, Sarkar TK, Maricevic ZA (1993). "Analysis of a wide radiating slot in the ground plane of a microstrip line,"IEEE Trans. Antennas Propag. 41(1):29-37.

Qu SW, Ruan C, Wang BZ (2006). "Bandwidth enhancement of wide slot antenna fed by CPW and microstrip line,"IEEE Antennas Wireless Propag. Lett. 5:15-17. http://dx.doi.org/10.1109/LAWP.2005.863616

Stutzman WL, Thiele GA (1998). "Antenna Theory and Design". John Wiley Sons, Inc, PMid:10026767

Sze JY, Wong KL (2001). "Bandwidth enhancement of a microstrip line-fed printed wide-slot antenna," IEEE Trans. Antennas Propag. 49(7):1020-1024. http://dx.doi.org/10.1109/8.933480