VOL. 7, NO. 1, JANUARY 2012 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

ENHANCEMENT BANDWIDTH OF MICROSTRIP ANTENNA USING TAPERED SINGLE SLOT

Ali A. Dheyab Al-Sajee
Department of Electronic and Communication, College of Engineering, Al-Nahrain University, Iraq
E-Mail: alidiab70@yahoo.com

ABSTRACT

A modified rectangular patch antenna design has been proposed in this paper, the bandwidth of this antenna is enhancement using the tapered slot with type of feeding (probe feed). This design is simulated with microwave office 2008 software package. This method is employed for analysis at the frequency band of (2 GHz - 3 GHz), when it is changed the location and dimensions of tapered slot. It gives a good VSWR less than (2), return losses (RL) less than (- 10 dB) and impedance bandwidth of the order of (13.1%) at the frequency band of (2.2921GHz- 2.6063) GHz of [2-3] GHz.

Keywords: microstrip antenna, bandwidth, tapered slot, performance, VSWR.

1. INTRODUCTION

Although microstrip antennas have many attractive advantages, it has a narrow bandwidth. Many techniques have been used to enhance the bandwidth. Among these techniques are using thick foam or air substrates. Other techniques for enhancing the bandwidth of a single-layer single-patch microstrip antenna include the designs with single tapered slot with probe feed [1].

In this paper, the technique for extending the bandwidth is studied. The first is loading the rectangular patch by tapered slot, its width are not equal, the tapered slot has three parameters that have effect on the antenna performance, the primary width, the secondary width and the length of the slot as shown in Figure-1.

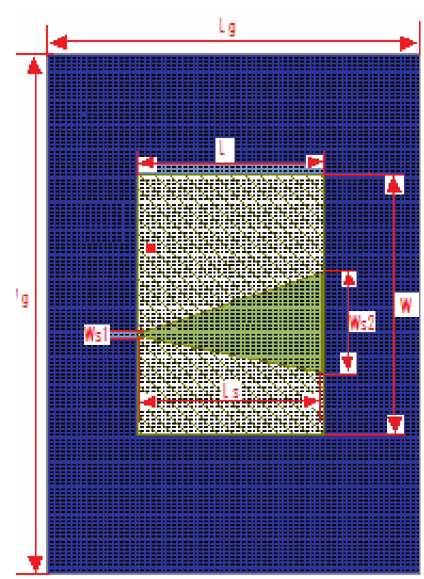


Figure-1. Configuration of the proposed Single tapered slot antenna.

It took the different locations and dimensions of tapered slot and tested them in this simulation. It analyzed the performance of rectangular microstrip antenna with single tapered slot.

This technique is used to design microstrip antenna working in the (2-3) GHz range frequency.

The design was simulated using the 2008 microwave package. It was found that for loading the antenna with tapered slot in the rectangular patch gives the widest bandwidth.

2. IMPORTANT DESIGN PARAMETERS OF RMSA

A-The characteristics of dielectric substrate

To produce microstrip antennas, it is necessary to select a material that is mechanically and electromagnetically stable. This choice of substrate is based on the fact that the permittivity range is from 1.2 to 13 and that these materials are either in use today or are expected to be in use for millimetre wave antenna systems in the future [2].

B-Length and width of patch

For an efficient radiator, a practical width that leads to good radiation efficiencies is [3]; with proper excitation one may choose a patch width W greater than patch length. It has been suggested that $1 < W/L < 2$ [4].

3. DESIGN GUIDEDINES

A variety of approximate models have been proposed for the calculation of input impedance for a probe-fed patch, this work presents the use of transmission line method to analyze the rectangular microstrip antenna [5].

RMPA operating of resonance frequency (2.4GHz) for TM10 mode, with the coaxial probe feed used the antenna is matched by choosing the proper feed position [6].

In this model the MSA can be represented by two slots of width (W) and height (h) separated by transmission line of length (L).

The width of the patch can be calculated from the equation by [7].

For a known value of (εr) and dielectric thickness we can calculate the effective dielectric constant (εeff)

and thus the length of resonance of a microstrip patch of given width [8].

The dimensions of ground plane (Lg and Wg) are given by [9]. MSAs have narrow BW, typically 1-5%, which is the major limiting factor for the widespread application of these antennas. Increasing the BW of MSAs has been the major thrust of research in this field [9, 10].

The MSA can be excited directly either by a coaxial probe or by a microstrip line. It can also be excited indirectly using electromagnetic coupling or aperture coupling and a coplanar waveguide feed, in which case there is no direct metallic contact between the feed line and the patch [9-12].

Feeding technique influences the input impedance and characteristics of the antenna, and is an important design parameter. The centre conductor of the coaxial connector is soldered to the patch. The main advantage of this feed is that it can be placed at any desired location inside the patch to match with its input impedance [13].

The disadvantages are that the hole has to be drilled in the substrate and that the connector protrudes outside the bottom ground plane, so that it is not completely planar. Also, this feeding arrangement makes the configuration asymmetrical [13].

The main limitation in the ever-increasing applications of these antennas is their narrow BW. Fortunately, the BW can be increased by using a thick substrate with a low dielectric constant [13].

To further increase the BW, a tapered slot is used, it has three parameters that have effect on the antenna performance, the length of the slot, the primary width and the secondary width.

4. ANTENNA GEOMETRY

The geometries of Design is shown in Figure-2, the FR4-based substrate having $\varepsilon r = 4.4$ is h = 6mm in thickness, 27.6 mm along the *x*-axis and 38mm along the *y*-axis. The feed probe (coaxial) has a characteristic impedance of 50 ohms.

The patch is a rectangle that is 27.6 mm along the x-axis and 38 mm along the y-axis. The rectangular part of the ground plane is (55.2 mm×76 mm).

A coaxial probe is used to connect the inset microstrip at its centre axis and away from the patch edge.

Where the input impedance is nearly 50 ohm then Yf = 19 mm along the length, and Xf = 7.174 mm along the width. It was found that the best impedance match at feed point location is (10.6875mm) of the left edge of the patch, the distance (1.725mm) is of the upper of the length patch, at an input impedance of (50 + j 2.01) ohms.
The vertical distance (Fd) between the probe feed and the tapered slot is (12 mm).

The microwave office software is used for the simulation. It sets with the following specifications: the number of divisions is 64 divisions, X cell size = 0.56cm and Y cell size = 0.406cm, x-division = 128 and y-division = 128.

A single tapered slot with dimensions (Ws1=1.1875mm, Ws2= 4.751mm and Ls= 19.873mm) as shown in Figures 2(a), 2(b).

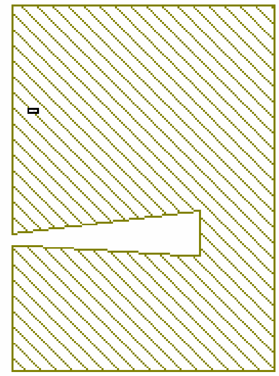


Figure-2(a) one- dimension of single tapered slot antenna.

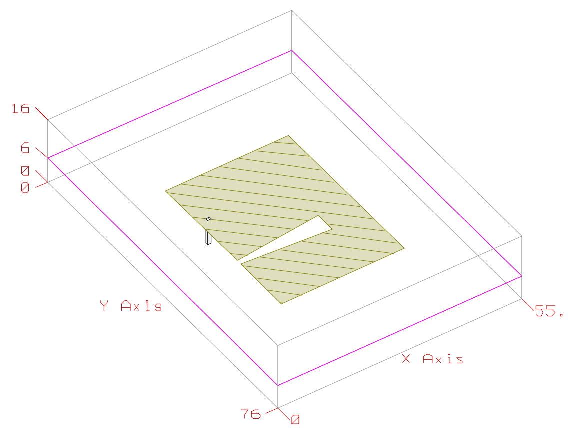


Figure-2(b) three - dimension of single tapered slot antenna

Figure-2. Single tapered slot of microstrip antenna.

Single tapered slots with different dimensions and locations were set in the package to get the best results compute in Table-1.

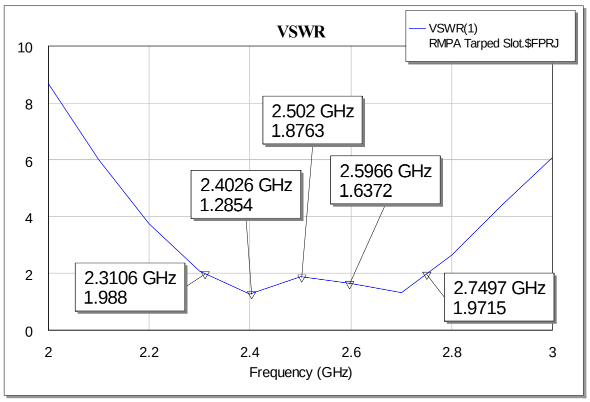
Table-1. different dimensions and locations of single slot for rectangular microstrip antenna.

It	Ws1 mm	Ws2 mm	Ls Mm	Fd mm
1	0.5937	4.1562	24.5813	8.25
2	1.1875	2.375	25.4433	8.9062
3	0.5937	1.7812	24.4455	6.5312
4	1.1875	2.375	25.4507	9.5
5	1.1875	4.75	19.873	12

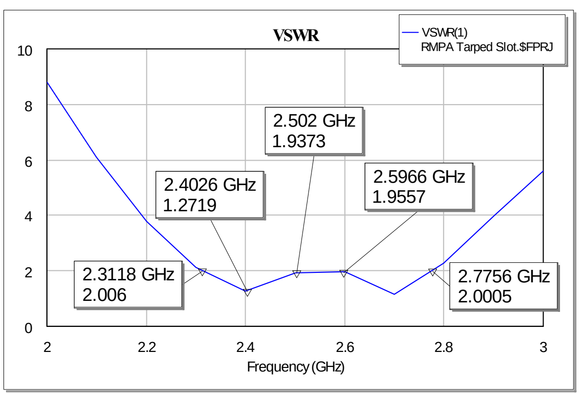
ARPN Journal of Engineering and Applied Sciences

5. RESULTS

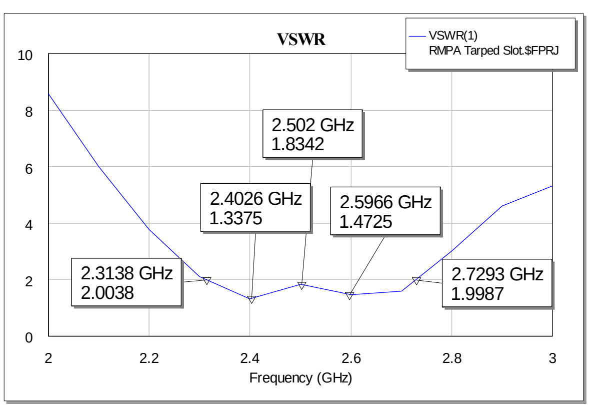
The microwave office package computed returns losses S11 ≤ -10, the VSWR is given in Figures (4a, 4b, 4c and 4d) the bandwidth of design for VSWR ≤ 2 are (460, 464, 416, 414 and 314) MHz, respectively.



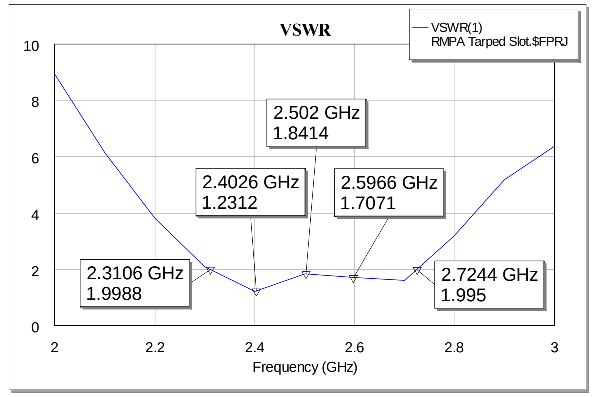
(a)



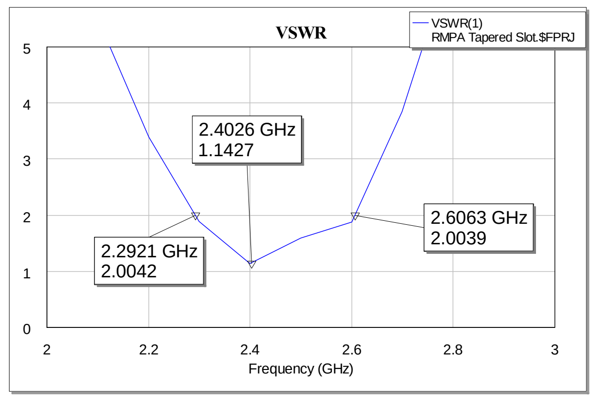
(b)



(c)



(d)

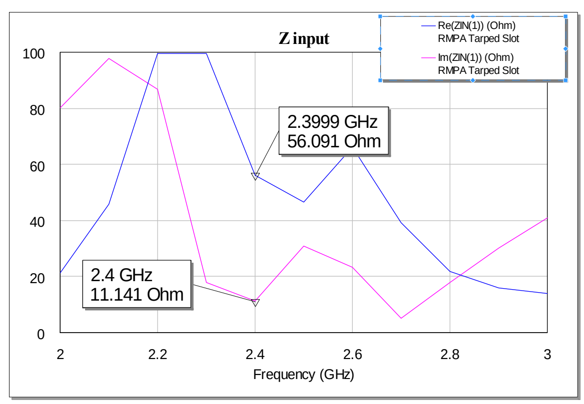


(e)

Figure-4. VSWR of the antenna with different dimensions and locations of single slot.

The microwave office-computed input impedance of the design is depicted in Figures (5a, 5b, 5c and 5d), respectively

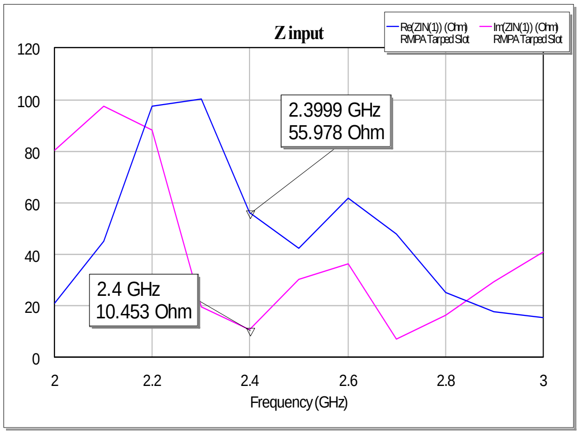
The real part of the impedance is closer to 50 ohm and the imaginary part to 2.1 ohm.



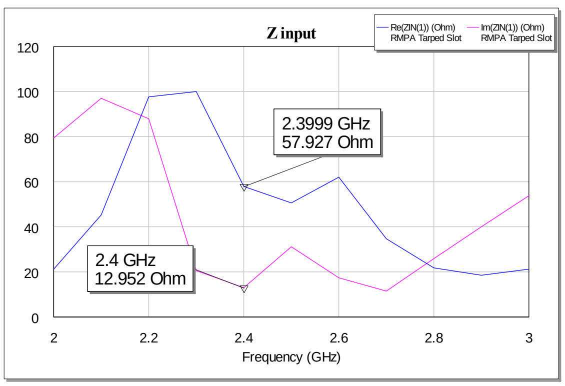
(a)

VOL. 7, NO. 1, JANUARY 2012 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

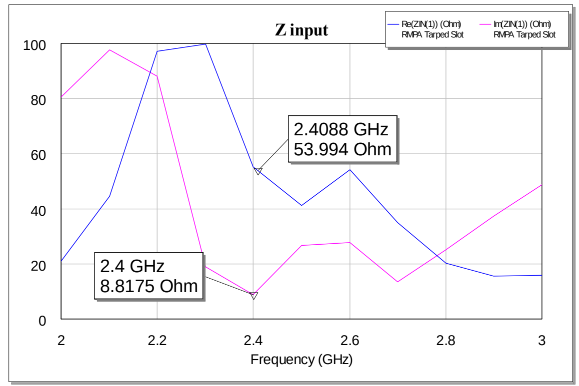
www.arpnjournals.com



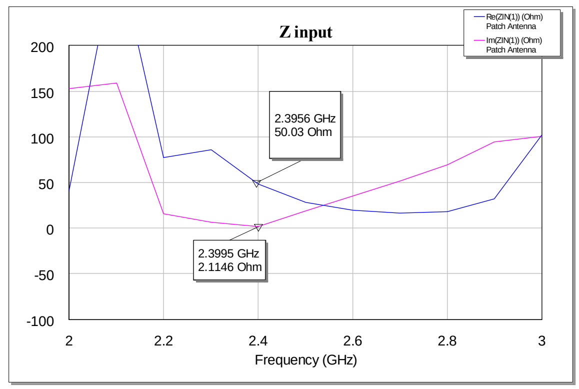
(b)



(c)



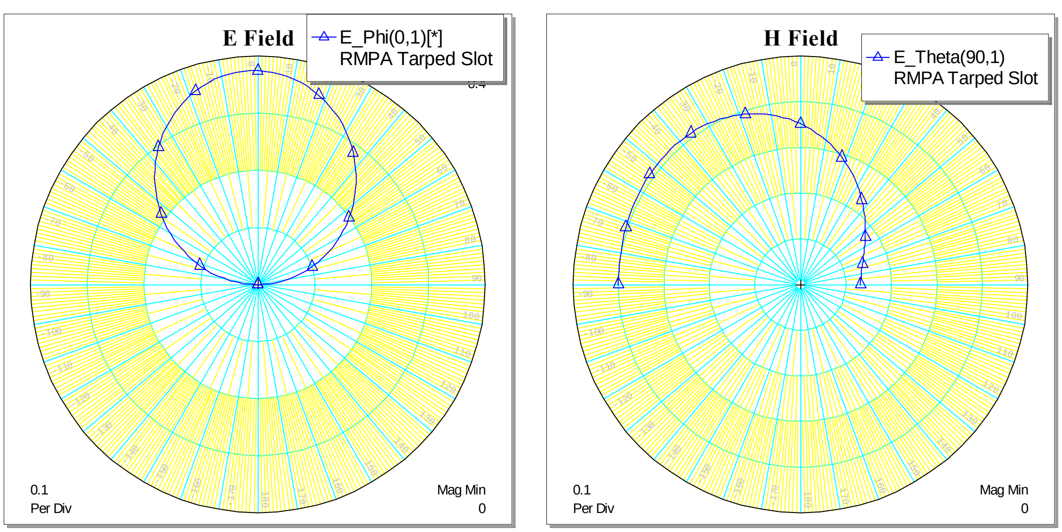
(d)



(e)

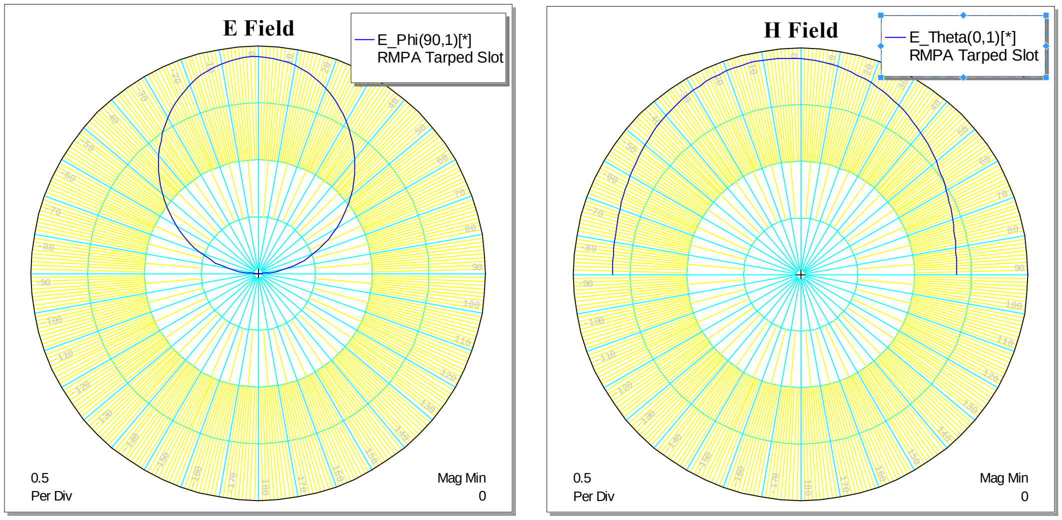
Figure-5. The input impedance of the antenna with different dimensions and locations of single slot.

The microwave office-computed the radiation patterns of design in the x-z plane (E-plane) and y-z (H-plane) in Figures (6a, 6b, 6c and 6d), respectively.

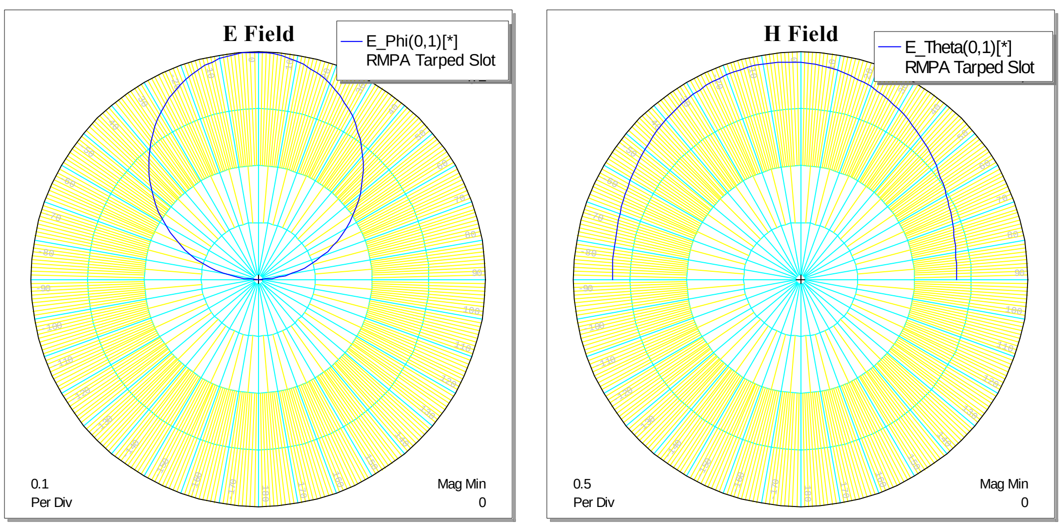


(a)

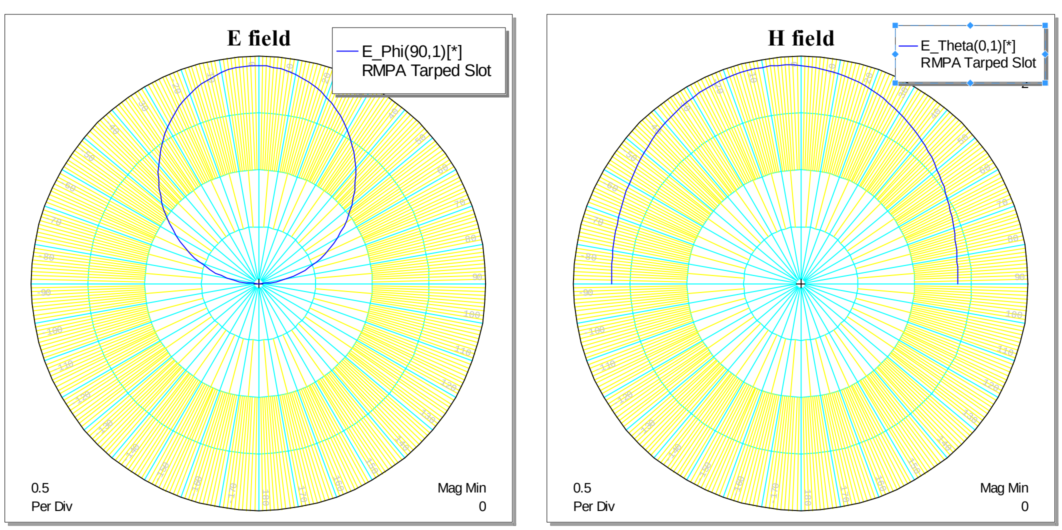
ARPN Journal of Engineering and Applied Sciences



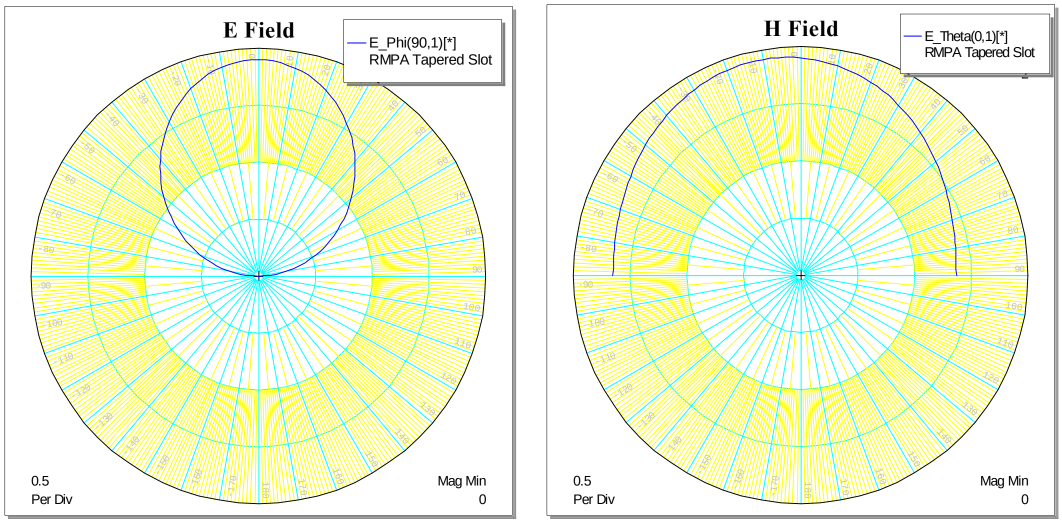
(b)



(c)



(d)



(e)

Figure-6. The radiation pattern of microstrip with different dimensions and locations of single slot.

The bandwidth can be calculated from the VSWR plot, from Figures 4(a, b, c, d, f and e). In Figure-4(a), the simulated impedance bandwidth of (460 MHz 18.25%) from (2.3106) GHz to (2.7497) GHz is achieved at (-10dB) return losses (VSWR ≤ 2). In Figure-4(b), the simulated impedance bandwidth of (464 MHz 19.31 %) from (2.3118) GHz to (2.7756) GHz is achieved at - (10dB) return losses (VSWR ≤ 2). In Figure-4(c) the simulated impedance bandwidth of (416MHz 17.31%) from (2.31138) GHz to (2.7293) GHz is achieved at (-10dB) return losses (VSWR ≤ 2). In Figure-4(d), the simulated impedance bandwidth of (414 MHz 17.23%) from (2.3106) GHz to (2.7244) GHz is achieved at - (10dB) return losses (VSWR ≤ 2).

In Figure-4(d), the simulated impedance bandwidth of (310MHz 13.07%) from (2.2921) GHz to (2.6063) GHz is achieved at - (10dB) return losses (VSWR ≤ 2).

Table-2. The effect of dimensions and locations of tapered slot on the performances of microstrip antenna.

It	Ws1 mm	Ws2 mm	Ls mm	Fd mm	Fo GH	BW GH	BW %
1	0.5937	4.1562	24.5813	8.25	2.4	460	18.25
2	1.1875	2.375	25.4433	8.9062	2.4	464	19.31
3	0.5937	1.7812	24.4455	6.5312	2.4	416	17.31
4	1.1875	2.375	25.4507	9.5	2.4	414	17.23
5	1.1875	4.75	19.873	12	2.4	310	13.07

6. CONCLUSIONS

In this work, the MW-office 2008 package is used to determine the proper location of a proper feed and tapered single slot. The simulations results for tapered slot have dimensions [Ws1 = 1.1875 mm], [Ws2 = 4.75mm] and [Ls = 19.873] at locations [23.75 mm] from upper edge of rectangular patch and distance from feed probe is (Fd) =12 give a good (VSWR ≤ 2) at (-10dB) return losses and good impedance bandwidth of the order of (13.07%) at the frequency band of (2.2921- 2.6063) GHz of [2 - 3] GHz.

REFERENCES

[1] N. Herscovici A. 1998. A wide-band single layer patch antenna. IEEE Trans. Antennas Propagat. 46: 471-473, Apr.

[2] Kao-Cheng Huang and David J. Edwards. 2008. Millimetre Wave Antennas for Gigabit Wireless Communications A Practical Guide to Design and Analysis in a System Context. United Kingdom, John Wiley and Sons Ltd.

[3] I. J. Bahl and P. Bhartia. 1980. Microstrip Antennas. Artech House, Dedham, MA.

ARPN Journal of Engineering and Applied Sciences

[4] Komsan Kanjanasit. 2003. Novel Design of a Wide and Improved U-Slot on Rectangular Patch Using Additional Loading Slots.

[5] Yi Huang and Kevin Boyle. 2008. Antennas from the Theory to Practice. United Kingdom, John Wiley and Sons Ltd.

[6] Zhi Ning Chen and Kwai-Man Luk. 2009. Antennas for Base Stations in Wireless communications. United State America, McGraw-Hill Companies.

[7] Lorena I. Basilio. 2001. The Dependence of the Input Impedance on Feed Position of Probe and Microstrip Line-Fed patch Antennas. IEEE Transaction on Antennas and Propagation. 49(1).

[8] Garg R., Bhartia P. and Ittipiboon A. 2001. Microstrip Antenna Design Handbook. Artech House, Inc.

[9] C. A. Balanis. 1997. Antenna Theory, Analysis and Design. John Wiley and Sons, New York, USA.

[10] Lee H. F. and W. Chen. 1997. Advances in Microstrip and Printed Antennas, New York: John Wiley and Sons.

[11] Sainati R. A. 1996. CAD of Microstrip Antennas for Wireless Applications, Norwood, MA: Artech House.

[12] Pozar D. M., and B. Kaufman. 1987. Increasing the Bandwidth of a Microstrip Antenna by Proximity Coupling. Electronics Letters. 23(8): 368-369.

[13] Girish Kumar and K.P. Ray. 2003. Broadband microstrip antennas, London, Boston: Artech House.