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Microstrip Patch Slot Antenna with Two Parasitic Patches

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ABSTRACT

A Microstrip patch antenna with two parasitic patches and a slot is made onto the parasitic patches have been presented for bandwidth enhancement .At first, an antenna using Microstrip feed (with dimensions in mm, x: 2, y: 5, z: 0) is designed. Parametric analysis of the patches has been studied for the verification of bandwidth enhancement. An example of the proposed antenna with two parasitic patches is designed and tested. The measured bandwidth with |s_11|<-10 dB ranges from 8.23 to 15.14 GHz (54.2%). Additionally two slots are inserted into the parasitic patch of the above proposed antenna. The antenna bandwidth can be broadened with the addition of slots onto the parasitic patches. This antenna is designed and tested as well, which achieves a measured 10-dB impedance bandwidth of 63.25% from 8.21 to 15.11 GHz.

Index terms: *Bandwidth Enhancement, Patch Slot Antenna, Parasitic Patches.*

1. Introduction

With the wide spread advance in wireless communication technology in recent years, the requirement of compact size, low profile and broad bandwidth antenna has increased considerably. To meet up with this requirement, the Microstrip patch antennas have been proposed. Microstrip patch antennas are attaining prominent publicity due to its many appealing characteristics such as light in weight, low volume, low cost, low profile, small dimensions and ease of fabrication and conformity etc. Microstrip patch antennas are extremely valuable and have better prospects as compared to other conventional antennas. Moreover, the Microstrip patch antennas can provide frequency agility, broad band-width and feed line flexibility. Microstrip antennas are used in numerous applications, ranging from biomedical diagnosis to wireless communications but in spite of many advantages, one major problem of gain and bandwidth is concerned. Significant research work has been reported till now on increasing the gain and bandwidth of Microstrip antennas e.g. probe fed stacked antenna, Microstrip patch antennas on electrically thick substrate, slotted patch antenna, air gap, parasitic patch and stacked shorted patch have been proposed and investigated. The widespread use of Microstrip patch antenna can be due to its several beneficial features, even though it suffers from the problem of low gain and narrow bandwidth. To surpass these limitations several methods have been proposed to widen the bandwidth and increase the gain of such antennas. Numerous wireless applications like WLAN [1] and mobile telephony require multiple resonances, which is very simply met by Microstrip patch antennas. A rectangular patch antenna is compared and analysed by introducing parasitic patches along with the main patch of the antenna in [2]. The parasitic elements cause the wide-banding of the antenna leading to the formation of some resonance frequencies that appear near the main element [3].Also, parasitic elements bring better impedance matching and radiation characteristics of antenna [4]. Therefore, several methods have been presented to enhance the bandwidth of the Microstrip patch antennas [5]-[17]. One of the most popular ways is to introduce some slots into the patch radiators [5]-[7], which can yield extra controllable resonances for the bandwidth enhancement. This approach has the advantage of simple antenna structures without introducing additional sizes, however, the radiation patterns may be affected in some degree. Another widely used method is adding parasitic strips or patches for gap-coupling to the main patch radiators [8-11]. For instance, a Microstrip antenna with gap-coupled sectoral patch has been designed in [8], which results in a bandwidth increase from 1.6% to 12.3%. In [11], a multilayer antenna structure is used for improving the impedance bandwidth. Although the multilayer dielectrics and patches can achieve an enhanced impedance bandwidth of over 20%, it pays a heavy price for the increased profile and cost. Additionally, inserting shorting vias into the dielectric substrate is one of the prevailing approaches used by researchers recently [12]-[17]. In [12], a triangular patch antenna using shorting vias and V-shaped slot is proposed, where a wider bandwidth is obtained with the help of the shorting vias, having great influence on the resistance and reactance of the antenna. Similarly, in [13]-[17] the shorting vias are inserted in order to expand the impedance bandwidths of the antennas.

2. System model

Designing the Microstrip patch antenna includes the substrate with dimensions of 16 x 18x 1.6mm.The rectangular patch and trace is drawn on the top face of the substrate. Two rectangular patches has dimensions L_1= 9mm; W_1= 5.74mm andL_2=9mm;W_2=5.76mm . Air box is drawn on starting from the bottom of the substrate with the same length and width. The height of the air box can be any value here the dimensions are taken to be 11.4x12.9x4.2mmand also an Air box is drawn below the substrate of dimensions11.4x12.9x4.2 mm. In the patch1 a hexagonal slot of side 4mm is made and in the patch 2 a rectangular slot of length L=5mm and width W=2mm is made. A waveport should be defined .To do so a rectangle is drawn on the XZ plane of dimensions such that it covers the trace. Select the XZ Plane from the menu. Select the substrate to assign material and assign a User defined material with a relative permittivity of 4.4 and dielectric loss tangent of 0.028 to the substrate. Select the bottom face of the substrate and assign the PerfectE boundary to it. Assign the Radiation boundary to the top and bottom air boxes. Assign PerfectE boundary to the rectangular patch and the trace. Assign wave port excitation to the rectangle on the XZ plane. Set up an Adaptive solution at 7.5GHz, with 20 passes and delta as .001 and also set up a Sweep solution from 7-18GHz with a step size of 0.1. To analyze the results Plot the S matrix in dB to check if the designed Antenna resonates at the specified 7.5Ghz and Plot the Magnitude of Zo to check if the Input Impedance is 50Ohm as designed.

3. Proposed work

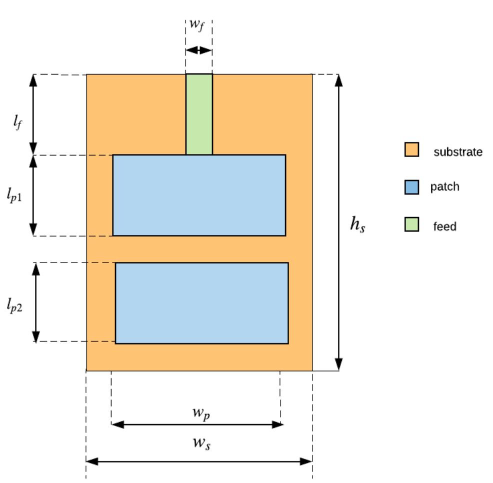

Fig.1(a) ANT_1

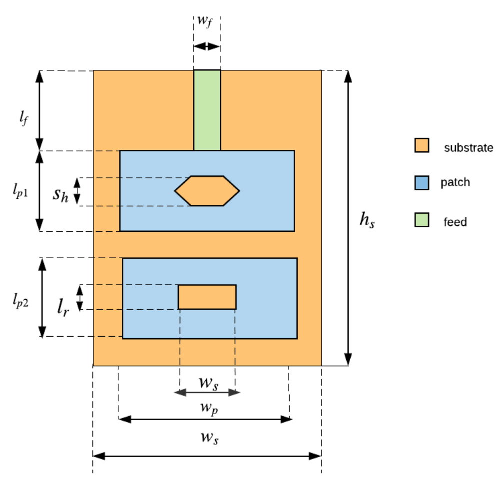

Fig.1(b) ANT_2

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Initially, a Microstrip patch antenna is designed with two parasitic patches which is shown in fig.1(a). An mictrostrip patch antenna with two parasitic patches and slots are made onto the patches is proposed for the bandwidth enhancement. The above proposed antenna is designed and tested using HFSS 13.0.The substrate is formed with the dimensions of 16 x 18x 1.6mm.Two rectangular patches has dimensions of L_1= 9mm; W_1= 5.74mm and L_2=9mm;W_2=5.76mm.In the patch1 a hexagonal slot of side 4mm is made and in the patch 2 a rectangular slot of length L=5mm and width W=2mm is made. This antenna is designed and tested as well, which achieves a measured 10-dB impedance bandwidth of 63.25% from 8.21 to 15.11 GHz .It is shown in fig.1(b)

4. Simulation and results

Initially, a Microstrip patch antenna with two parasitic patches is designed and analysed. The measured bandwidth of the antenna with two parasitic patches and $|s_{11}|$<-10 dB ranges from 8.23 to 15.14 GHz (54.2%).The simulated results are shown in 2(a).

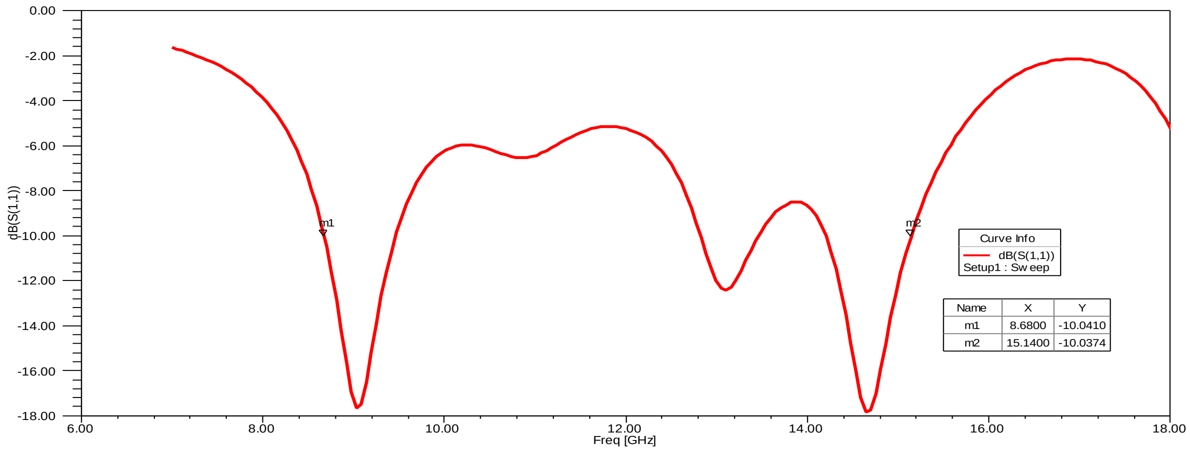

Fig.2(a)

Additionally two slots are inserted into the parasitic patch of the above proposed antenna. The antenna bandwidth can be broadened with the addition of slots onto the parasitic patches. This antenna is designed and tested as well, which achieves a measured 10-dB impedance bandwidth of 63.25% from 8.21 to 15.11 GHz which is shown in fig.2(b)

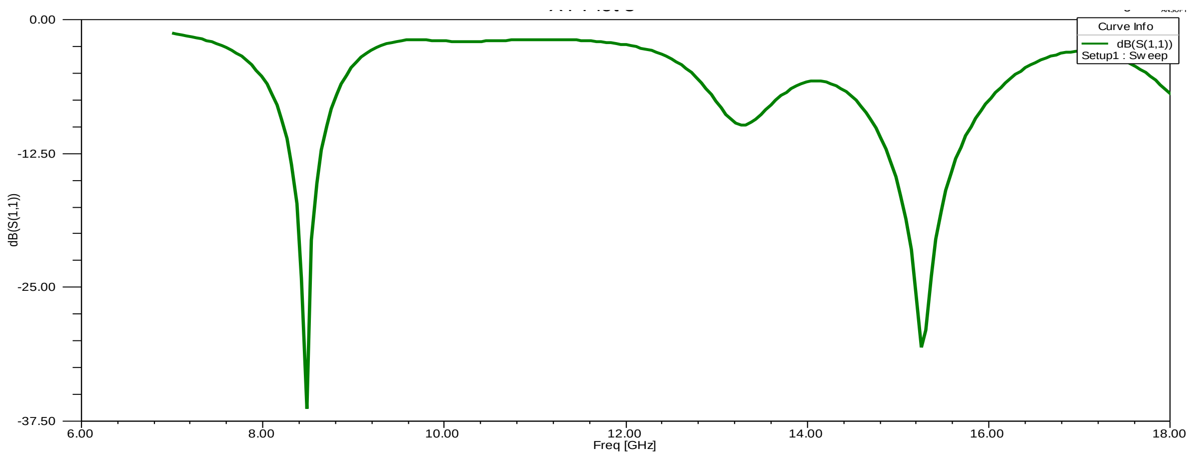

Fig.2(b)

Comparison of the both ANT_1 & ANT_2 is made .It is very clear from the comparison plot that the antenna with slots on the parasitic patch have enhanced bandwidth. The simulated results are shown in fig.3(a)

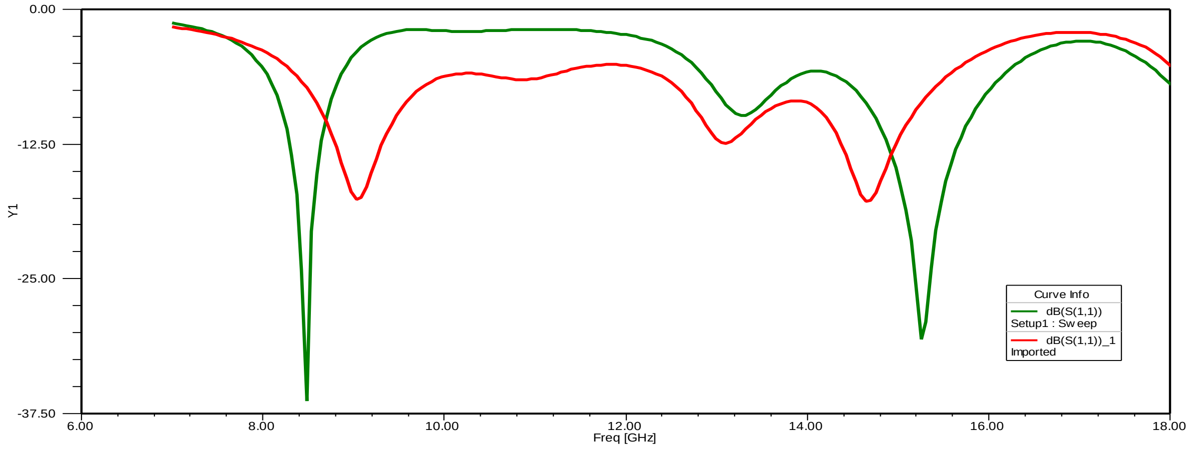

Fig.3(a)

Now let us consider the case where the patch size is increased and the bandwidth is calculated. Initially the size of the patch1 is increased having dimensions (10mm*5.835mm) and the size of the patch2 is increased to (10mm*6.165mm). It is found is not enhanced in this case than the actual result. The bandwidth of the antenna with increased patch size is 45%.. Then the size of the patch1 is increased further having dimensions of (10.5mm*5.835mm) and the size of the patch2 is increased to (10.5mm*6.165mm). It is found the bandwidth is not enhanced in this case also. Here the bandwidth of the antenna is calculated with increased patch size is 45.4%.So we can say that the bandwidth cannot be enhanced by increasing the patch size. The simulated results are shown in fig.3(b)

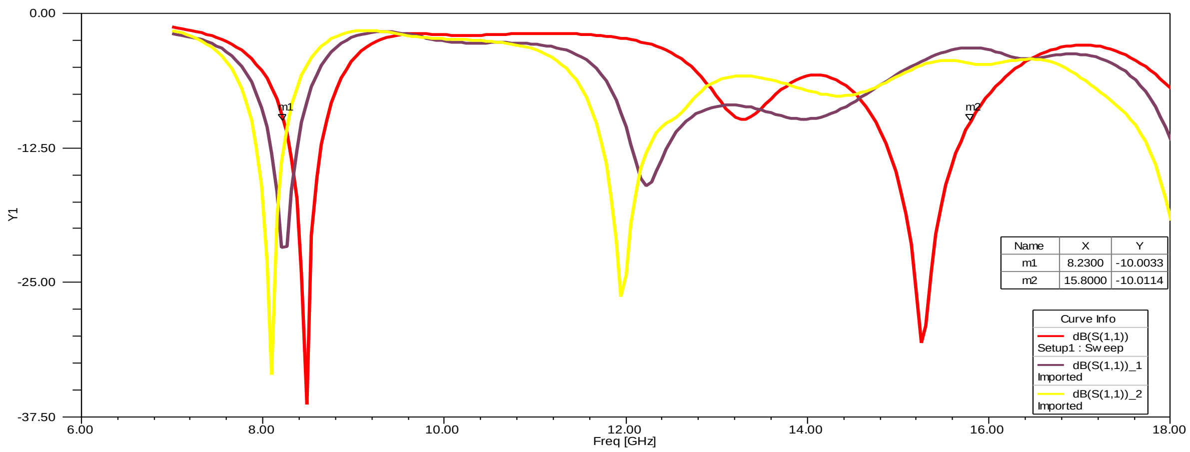

Fig.3(b)

So let us consider another case , It is found from the simulation result that the bandwidth is further enhanced by increasing the slot size. Now the side of the hexagonal slot is increased from 4mm to 5mm and the length and width of the rectangular slot is increased from (5mm*1mm) to (5mm*2mm). Now the bandwidth is found to be 67% ranges from 8.04GHz to 16.47GHz. Now the side of the hexagonal slot is further enlarged to 5.1mm and the length and width of the rectangular slot is enlarged to (5mm*2.5mm). Now the bandwidth is found to be 68.7% ranges from 8.03GHz to 16.47GHz.

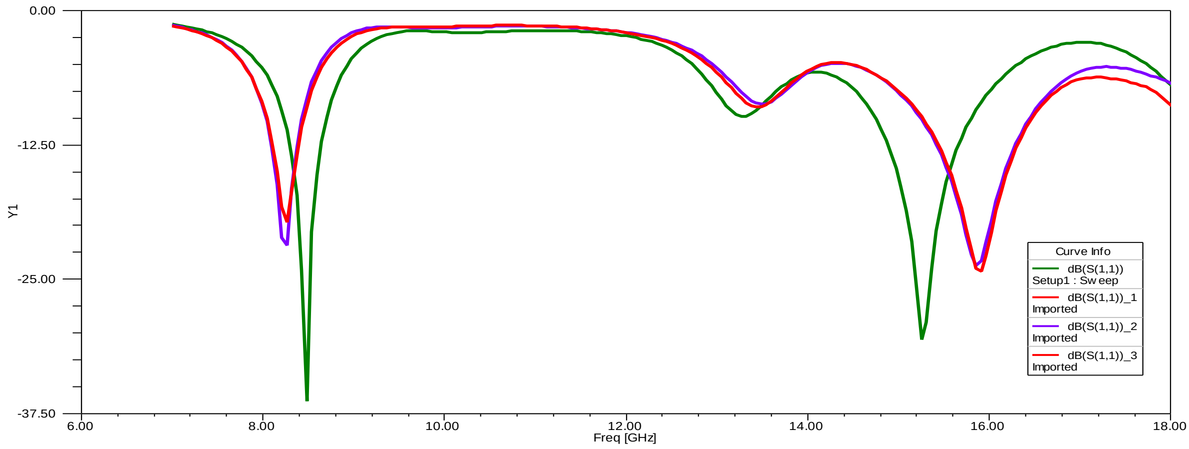

Fig.3(c)

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