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Performance Analysis of Slotted Rectangular Patch Antenna using Co-axial and Strip line Feed

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Abstract

A slotted rectangular microstrip patch antenna for bandwidth enhancement which is excited by two different feeding methods is presented in this paper. The feeding methods are microstrip line feed and coaxial probe feed. The rectangular slot excited by microstrip line feed gives an impedance bandwidth of 33.54% and return loss of -30.35dB at center frequency of 14.28 GHz. An impedance bandwidth of 56.83% and return loss of -34.39dB at 19.92 GHz is obtained when the rectangular microstrip slot antenna is excited by a coaxial probe feed. The bandwidth and the radiation patterns are measured by using HFSS software.

Keywords: *Coaxial feed, Impedance bandwidth, Microstrip line feed, microstrip slot antenna, returns loss.*

1. Introduction

Microstrip patch antennas are widely used in wireless communication systems because it has various advantages like low profile, small in size, ease of fabrication, low cost, light in weight, and easily integrate with monolithic microwave integrated circuits (MMIC). Narrow bandwidth is the major drawback of microstrip patch antennas [1, 2]. Therefore, various designs have been proposed in the literature to improve their bandwidth such as using different patch shapes [3, 4] and using thicker substrate [13], using stacked patch and shorted patch antenna [5-7]. Several broadband slot antennas are also presented for broadband operation which is more useful in wireless communication systems [8-12]. Slot antennas with different configurations such as H-slot, T-slot, E-slot, triangular slot, U- slot, wide rectangular slot with U shaped tuning stub, and open L-slot are presented for the bandwidth enhancement along with reduction in size. A bandwidth enhancement technique of rectangular microstrip slot antenna with two different excitation methods is presented in this paper. Proposed antenna gives an impedance bandwidth of 33.54% and 56.83% when the rectangular microstrip slot antenna is excited by microstrip line feed and coaxial probe feed respectively, and it can operate at center frequencies of 14.28 GHz and 19.92GHz for radar, satellite, and WLAN communication applications.

Microstrip antennas have various feeding techniques. They can be divided based on how power is transferring from feed line to patch. Section 2 focuses on the design of a slotted rectangular microstrip antenna. The proposed antenna is simulated using Ansoft's HFSS and result analysis of slotted rectangular microstrip antenna by applying two well-known and mostly used feeding techniques such as co-axial feeding and the strip line feeding is described in section 3 and 4.

2. Design of Slotted Patch Antenna

The configuration of the proposed antenna is shown in Fig.1. It is composed of a Microstrip feed line and a ground plane. The ground plane is split into two parts by the square slot and a rectangular slot cut in the center of the ground plane.

The essential parameters for the design of a slotted rectangular patch are:

- Length (**L**): The two sides are selected to be of equal length and are 76.4mm each.
- Width (**W**): The two sides are selected to be of equal width and are 76.4 mm each.
- Frequency of operation (f_o): The resonant frequency of the antenna must be selected appropriately.
- Dielectric constant of the substrate (ε_r): The dielectric material selected for our design has a dielectric constant of 2.2. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.
- Height of dielectric substrate (**h**): For the Microstrip slot antenna the height of the dielectric substrate is 1.6mm. The substrate used is RT Duroid 5880.

- Square Slot Length along the axis ($\mathbf{L_x}$): The length of slot along the axis was adjusted to be 66 mm in order to obtain better results.
- Slot Width ($\boldsymbol{w}$): The width of all the four slots was selected to be 1 mm.
- Rectangular Slot Length along the axis ($\mathbf{L_{x1}}$): The length of slot along the axis was adjusted to be 30 mm in order to obtain better results.
- Slot Width (w_1): The width of all the slot was selected to be 6 mm.

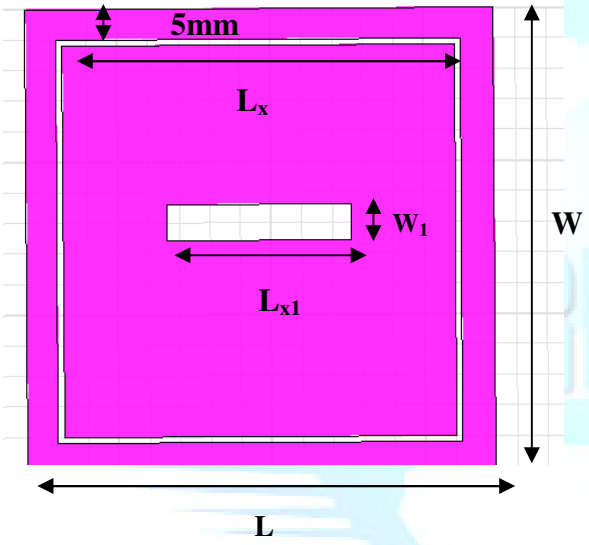

Fig.1 Geometry of Rectangular Slot Antenna (Top view)

3. Results and Analysis of Slotted Patch with Microstrip Line Feed

Microstrip line feed is one of the simplest methods of feeding the microstrip antennas and also it is easy to fabricate because it is a just a conducting strip connecting to the patch. Surface wave and spurious feed radiation increases as the substrate thickness increases which limit the bandwidth. This is the disadvantage of strip line feed. Fig. 2 shows the geometry of rectangular slot antenna with microstrip line feed.

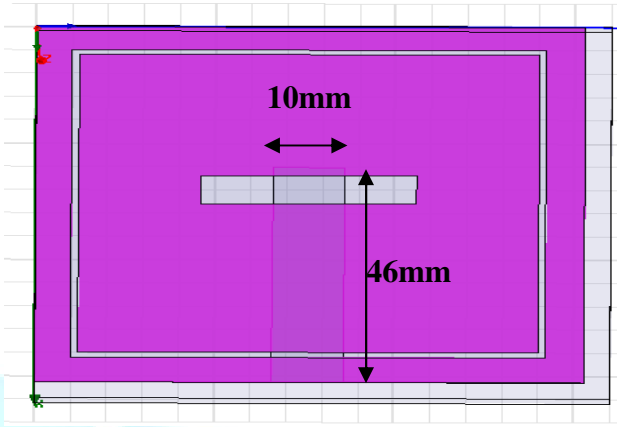

Fig. 2 3D Geometry of Rectangular Slot Antenna (Top view)

Here the Microstrip feed line is perpendicular to the rectangular slot. From the figure, it shows that a very wide bandwidth is achieved because of the various resonant modes that are generated between the slotted ground plane and the Microstrip feed line. The return loss curve for the rectangular slot antenna by using microstrip line feeding is shown in Fig. 3.

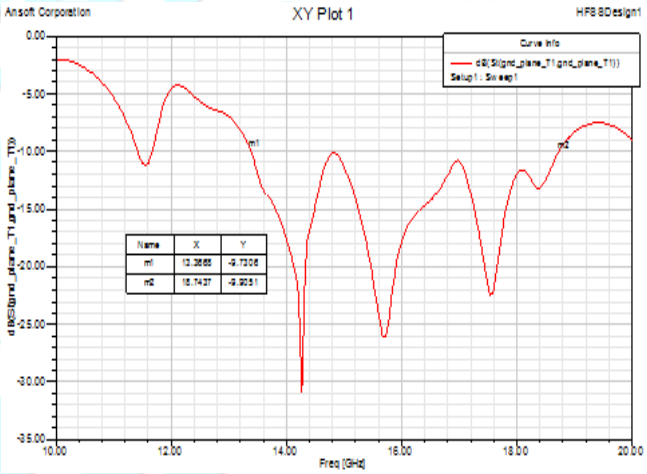

Fig. 3 Return Loss curve for strip line feed

The operating frequency for the proposed antenna is chosen at 14.28 GHz. From the Fig 3, the return loss of 30.35dB is obtained between 18.74 GHz to 12.28 GHz band of frequencies with center frequency 14.28 GHz. The impedance bandwidth for the proposed antenna is 33.54%.The radiation pattern for the rectangular slot antenna with the microstrip line feed is shown in Fig 4.

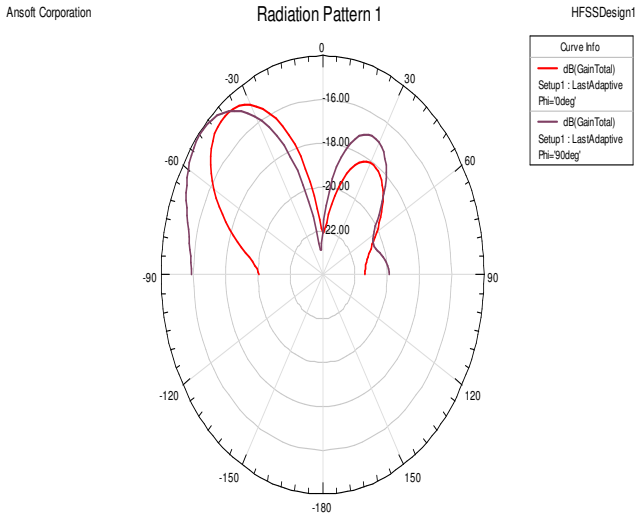

Fig. 4 Radiation pattern for strip line feed

4. Results and Analysis of Slotted Patch with Co-axial Probe Feed

In co-axial probe feeding, the inner conductor of the co-axial is attached to the radiation patch of the antenna while the outer conductor is connected to the ground plane. The main advantages of this method are easy to fabricate, easy to match and low spurious radiation and hence more bandwidth compared to microstrip line feed. But it is some what difficult to fabricate compared to microstrip line feed.

The same rectangular microstrip slot antenna is fed by a co-axial probe feed to improve the bandwidth and the feed can be placed at any desired position inside the patch. The design of the co-axial probe feed is shown in the Fig. 5. The design parameters of the patch are same similar to that of rectangular slot antenna with a microstrip line feed.

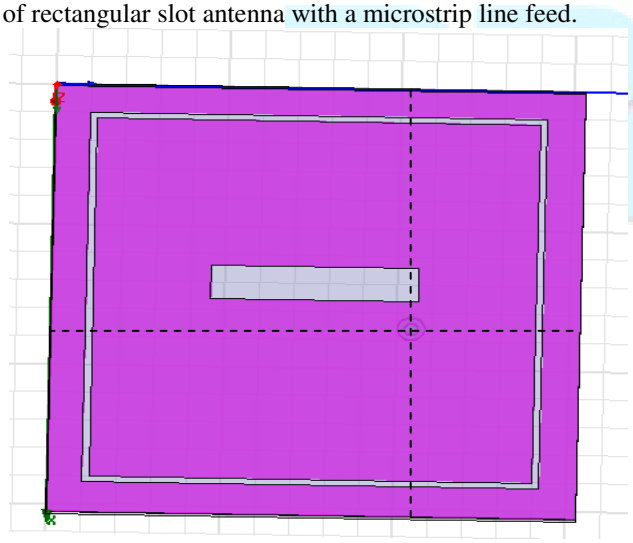

Fig. 5 Rectangular slot Antenna with probe feed along the axis

The outer cylinder (coax) is of radius 2mm and height -5mm. The inner cylinder (co-axial probe) is of radius 1mm. The probe is of 1mm radius and height 1.5.

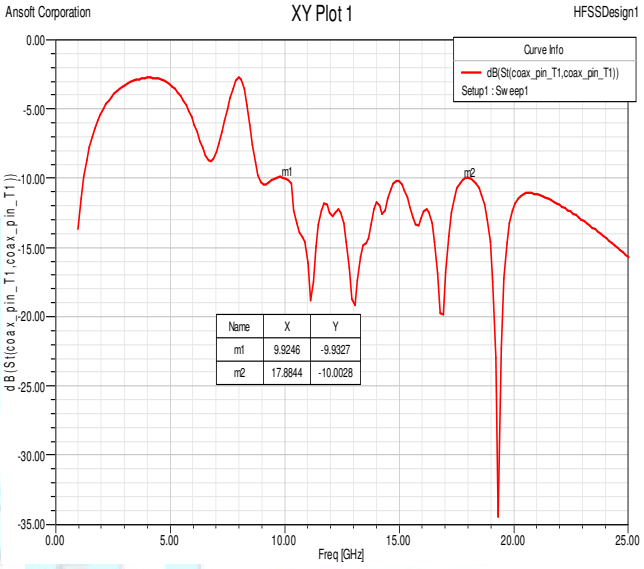

Fig. 6 Return Loss curve for probe feed

The return loss curve for the square patch antenna by using co-axial feeding is shown in Fig. 6. The operating frequency of the proposed antenna is chosen at 19.92 GHz. The impedance bandwidth achieved is 56.83% between frequencies 17.88 GHz to 9.92 GHz. From the Fig. 6 the return loss of -34.39dB is obtained at 19.92 GHz. The radiation pattern for the rectangular slot antenna with the co-axial probe feed is shown in Fig. 7.

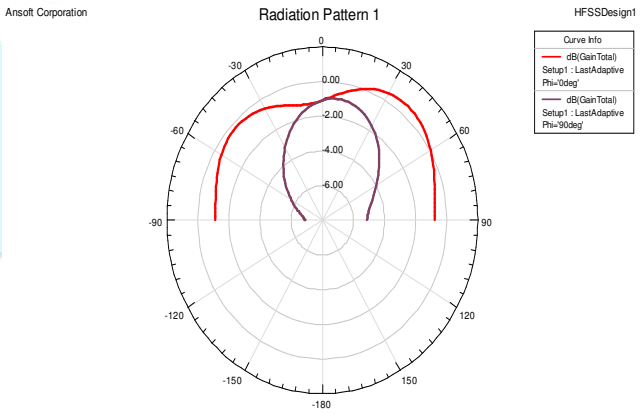

Fig. 7 Radiation pattern for probe feed

From the above results, it is observed that the co-axial probe feed technique achieves bandwidth of 23% more than that of microstrip line feed technique for same design parameters.

4. Conclusions

Performance analysis of slotted rectangular microstrip patch antenna is presented in this paper. The proposed antenna is simulated using HFSS software. Performance of proposed antenna is analyzed with two different feeding techniques such as strip line feed and probe feed. Comparative study of simulated parameters like impedance bandwidth, radiation pattern have been presented. Co-axial feeding technique achieves better impedance bandwidth over a microstrip line feeding. Simulated and measured results show that a 56.83% fractional impedance bandwidth is achieved with respect to the center frequency of 14.28GHz for a Co-axial probe feed. The proposed antenna is more suitable for radar, satellite, and WLAN communication applications.

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