ISSN 2229-5518

A Novel design approach Microstrip Patch Antenna Design for Ultra wideband Applications

Prashant Sarode, Shashikant S. Patil, Sachin Sonawane, Girish Patil

Abstract— There are various types of Microstrip antennas that can be used for many applications in communication systems. This paper proposes the design of a Bevel Shape rectangular Microstrip patch antenna to operate in a frequency range of 1.55 GHz to 2.2 GHz. We have designed the antenna, based on a thickness of 1.6 mm, Flame Retardant 4 substrate with a dielectric constant of approximately 4.4, is a probe feed and has a partial ground plane. After mathematical design and simulation tool results, the antenna performance characteristics such as antenna VSWR and Return Loss are substantially improved. The simulation was done using Hyperlink 3D simulator software

Index Terms— Microstrip Antenna, Bevel Shape, Partial Ground Plane, Operating Frequency Range, Antenna Performance Characteristics, Hyperlink 3D Simulator.

1 Introduction

Antennas play a very important role in the field of wireless communications. Some of them are parabolic reflectors, patch antennas, slot antennas, and folded dipole antennas with each type having their own properties and usage. It is perfect to classify antennas as the backbone and the driving force behind the recent advances in wireless communication technology.

Microstrip antenna technology began its rapid development in the late 1970s. By the early 1980s basic Microstrip antenna elements and arrays were fairly well establish in term of design and modeling. In the last decades printed antennas have been largely studied due to their advantages over other radiating systems, which include: light weightiness, reduced size, low cost, conformability and the ease of integration with active device. A Microstrip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The patch is generally made of conducting material such as copper or gold. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a Microstrip line or probe feed. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the Microstrip line and the radiating patch this includes proximity feeding and aperture feeding [11].

A Microstrip patch antenna is a radiating patch on one side of a dielectric substrate, which has a ground plane on the underside. The EM waves fringe off the top patch into the substrate, reflecting off the ground plane and radiates out into the air. Radiation occurs mostly due to the fringing field between the patch and ground. The radiation efficacy of the patch antenna depends largely on the permittivity of the dielectric .Ideally a thick dielectric, has low permittivity and low insertion loss is preferred for broadband purpose. The advantage of Microstrip antenna that are low cost, light weight and low profile .Disadvantage of Microstrip antenna is narrow bandwidth, low gain and polarization purity is hard to achieved.

Microstrip antennas are characterized by a larger number of physical parameters than conventional microwave antennas. They can be designed to have many geometrical shapes and dimensions but rectangular andcircular Microstrip resonant patches have been used extensively in many applications. In this paper, the design of probe feed rectangular Microstrip antenna is for satellite applications is presented and is expected to operate within 1GHz - 3GHz frequency span. This antenna is designed on a double sided Flame Retardant (FR-4) epoxy and its performance characteristics which include Return Loss and VSWR are obtained from the simulation [11][12].

2 Basic Configuration

In the basic configuration of the Microstrip antenna, illustrated in Fig. 1, the basic parameters like length (L) and width (W) of a Microstrip patch antenna for a required resonant frequency or vice versa and substrate parameters (ε_r and h) are decided. The (L/W) ratio is expected to be approximately equal to unity then radiation pattern is symmetric but may not provide resonant input impedance and hence, value for W is required to be derived accordingly. W is one of the constraints for the input impedance at radiating edges [3] [12].

The antenna is design on FR4 substrate with thickness 1.6 mm and dielectric constant 4.4. The MSA is designed of primary patch with beveled shape. The beveled shape rectangular patch of dimension 30 mm x 30 mm is design on one side of FR4 substrate of thickness 1.6 mm and by following the standard model, ground plane is placed on the opposite side of substrate. The standard coaxial probe (50 Ω) is preferred to feed the input signal to antenna. This feeding technique produces low spurious radiation. Out of three patch strips of variable length; middle strip is rectangular step shaped fractal having length 11 mm and width of 4 mm, the shorter patch is connected to the feed line. Accompanying strips behave like parasitic elements and are of equal width but reducing length. Monopole antenna is generally a quarter of wavelength; hence the minimum operative frequency can be approximated by [2] [7].

ISSN 2229-5518

3 Antenna Geometry

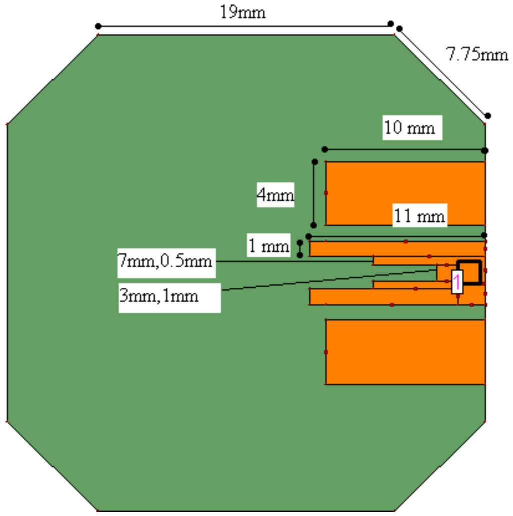

Fig. 1. Geometry of Antenna.

The optimized parameters are summarized in following Table 1.

Table 1: Optimized Parameters of Antenna

Parameter	Dimension (mm)	Description
L_{patch}	30	Length of side of square patch.
S_{patch}	7.75	Length of cut slope at corner of ground plane.
W_{patch}	4	Width of radiating patch side strip line.
LR_{patch}	11	Length of radiating patch side strip line.
$L1_{frac}$	11	Length of fractal.
$W1_{frac}$	1	Width of fractal.
$L2_{frac}$	7	Length of fractal.
$W2_{frac}$	0.5	Width of fractal.
$L3_{frac}$	3	Length of fractal.
$W3_{frac}$	1	Width of fractal.

4 Simulation Result and Discussion

4.1 Voltage Standing Wave Ratio (VSWR)

Fig. 2 illustrate simulated and measured VSWR against frequency. Based on simulated result, the VSWR value ranges from 1 to 2 throughout frequency range.

For frequency region from 1.55 GHz to 2.2 GHz the VSWR is 2. This indicates a good value and level of mismatch between probe and strip is not very high. The VSWR use to describe the performance of an antenna when attached to transmission line. It is the ratio of maximum to minimum RF voltage along transmission line.

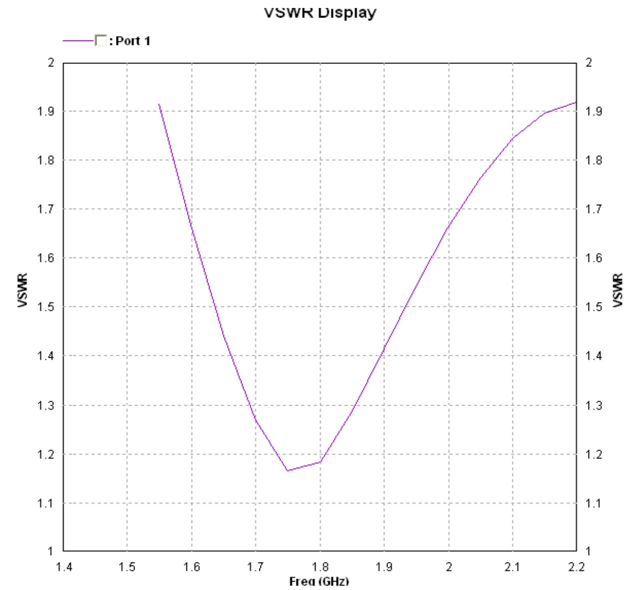

Fig. 2. VSWR Vs. Frequency.

4.2 Return Loss

The return loss of antenna obtained is -10 dB at center frequency 650 MHz as shown in Fig. 3.This indicates that 90 % of power is transmitted. Thus bandwidth obtained from the return loss result is 34.66 % which signifies 650 MHz.

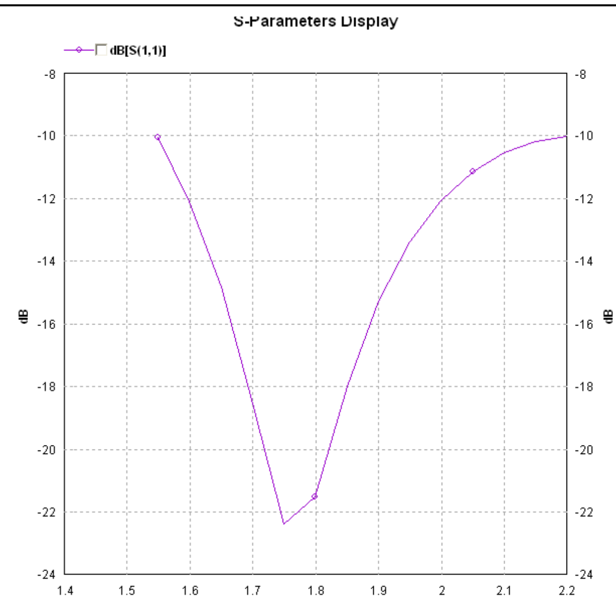

Fig. 3. Return Loss.

ISSN 2229-5518

4.3 Gain Vs. Frequency

The antenna gain in entire UWB band is increasing shown in Fig. 4 which shows good performance in UWB band.

The gain of antenna is the radiation intensity in given direction divided by radiation intensity that would be obtained if the antenna radiates all of the RF power delivered to it equally in all directions.

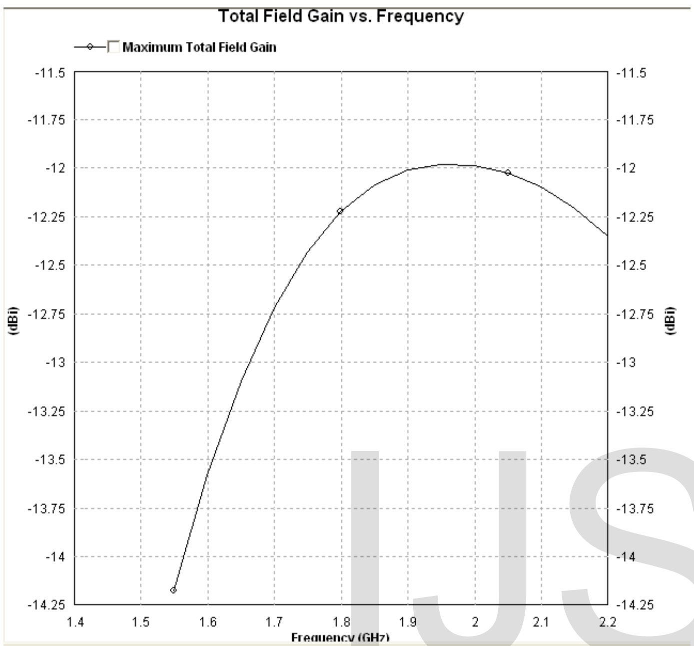

Fig. 4. Gain Vs. Frequency.

4.4 3D Antenna Radiation Pattern

The radiation pattern is the representation of the gain of an antenna for all direction. Since this is a three dimensional description of power density, it is difficult to display or use. The radiation pattern is an important indicator of antenna performance as shown in Fig. 5. The radiation pattern significantly changes it shape at higher frequency.

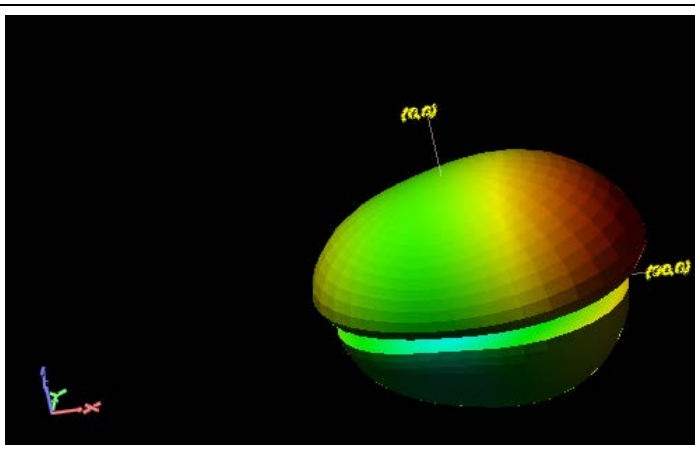

Fig. 5. 3D Antenna Radiation Pattern.

Variation in the dimension of MSA influences a significant change in the important parameters like the Bandwidth, Efficiency and Gain

TABLE 1
EFFECT OF CHANGE IN SUBSTRATE THICKNESS

Thickness (*h*), mm	Efficiency %	BW MHz, %	Gain (dB)
15.0	98.60	670.0, 30.6	12.1
15.2	98.64	662.8, 30.32	12.2
15.4	98.60	636.5, 28.7	12.2
15.6	98.55	684.4, 31.1	12.3

4.5 Effect of Change in Substrate Thickness

The above table reflects effect of change in the substrate thickness (h). It allows 'h' to be increased up to a certain level with similar flow of efficiency but thereafter efficiency gradually decreases due to increased cross polar level. The fringing field also become more effective and extends length ΔL; this decreases the value of resonant frequency. At the same time W/h ratio reduces which in turn decreases ε_{reff}.

TABLE 2
EFFECT OF CHANGEIN PROBE RADIUS

Radius (r) mm	Efficiency %	BW MHz, %	Gain (dB)
0.75	98.70	686.1, 31.2	12.3
0.8	98.71	691.0, 31.6	12.3

4.6 Effect of Change in Probe Radius

As the probe radius (r) increases, the probe inductance decreases with rest all parameters constant. It reduces the input impedance and resonant frequency. However, the ideal value of the impedance of a coaxial probe can be found by all primary constants and X_C between the patch and ground plane [4].

5 Conclusion

In this paper a rectangular patch antenna is designed and simulated. It operates in frequency range of 1.55 GHz to 2.2 GHz.

The antenna has suitable size and Omni-directional radiation pattern which allow us to use at UWB applications.

The performance of antenna meets the desired requirement in terms of return loss and VSWR which are equal to -10 dB and 2 respectively. Adding to this the performance of Microstrip antenna is strongly depends on several factors such as feeding technique, type of substrate, the thickness and dielectric constant of substrate respectively..

ACKNOWLEDGMENT

We would like to pay our gratitude to our Honorable Chancellor Shri. Amrish R Patel, Joint President Shri. Bhupesh Patel, Managing Committee Member Shri. Rajgopal Bhandari, who provided us an excellent platform for studies and research activities. We are also thankful to our Honorable VC, Dr. Rajan Saxena, Pro-VC Dr. M. N. Welling, for this explicitly knowledgeable work.

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