



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 6, June 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

 9940 572 462

 6381 907 438

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Bandwidth Enhancement of Microstrip Patch Antenna for Communication System

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ABSTRACT: - Several strategies exist to enriched bandwidth of the antenna. In the present undertaking, in this manner, the author has made an effort to design and analyze the parasol shape geometries of MSA for bandwidth upgrade. Commonly rectangular, circular or square shapes are selected because of the ease of investigation, however, they have limited bandwidth of operation. The entire effort focused on the area in order to obtain an improved bandwidth by numerous ways like loading of slot and notch, using defected or partial ground plane structures, etc. Which help to get rid of bandwidth constrain of microstrip patch antennas. A parasol shaped foam spacer has been used to provide mechanical support to the optimized substrate. The proposed antenna offers about 2.16 GHz of frequency compared to previous 2.16 GHz frequency. In addition to the enhanced bandwidth characteristics, the proposed antenna also reveals an increase in the gain approximately 6.3 dB throughout the operating frequency band.

KEYWORDS:-Microstrip Antenna, Partial ground plane, Ultra-wide band.

I. INTRODUCTION

In daily life routine, due to excessive utilization of the wireless devices the progress of modern wireless communications has increases. The use of wireless local area network, cellular phones, global positioning system and satellite telephones increases the field of wireless communication. In communication system, the efficient transmission and reception of electromagnetic waves are done through an antenna. An antenna is a transition apparatus in which electromagnetic photons converted into currents as well as it converts energy from circuits into photons radiated into free space. Maxwell proposed an electromagnetic equation for time varying electric fields and magnetic fields. After that, Hertz proposed another field called 'antenna' using a half wave dipole and square loop as transmitter and receiver respectively. Moreover, the demand of modern portable wireless communication systems has led to miniaturization of the antenna so that it may be effortlessly implemented on printed circuit board. This led to the advancement of microstrip patch antenna. Deschamps has been described the concept of microstrip antenna and radiator [1, 2].

At that time, development has been accelerate by the accessibility of fine substrate having minimum loss tangent, notable mechanical as well as thermal properties, better photolithographic methods along with improved theoretical models by various scientists and researchers [3, 4]. Since then, a numerous microstrip patch antennas have been studied and broad research and development of patch antennas has been performed. The aspire of such things was exploiting their various advantages such as conformal configuration, little volume, light weight, compatibility with integrated circuits, less cost and many more [5].

The elementary configuration of microstrip antenna is made known in Fig. 1. One side of it having a radiating patch and the other side a metallic plate of infinitely extends to form the ground plane. In between, there is dielectric substrate whose dielectric constant ϵ_r may be less than 10. The radiating patch, usually of gold or copper may presume virtually several shapes, but for easy analysis and performance prediction, regular shapes are generally used.

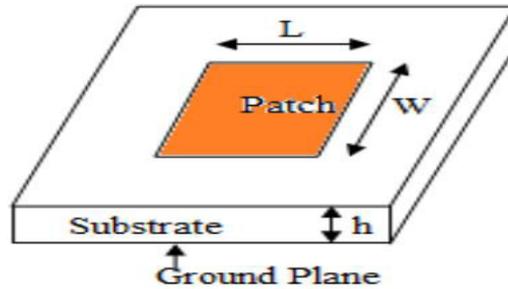


Fig. 1: Microstrip antenna configurations

Generally, microstrip patch antennas are made of metallic patch of larger width and low dielectric substrate with greater the height of substrate. Ideally, to improve the fringe fields for the account of radiation of patch antenna, the relative permittivity ϵ_r of the dielectric substrate have to be low that is ϵ_r less than 2.5. With 50 Ω co-axial connector or microstrip line as feed, the patch is excited and establishment of charge distribution has been done among the radiated patch and the ground level surface. At that particular moment, the radiated patch and the ground level surface are positively charged and negatively charged respectively [6, 7].

II. FEEDING TECHNIQUES AND MODELING

Selection of feeding method depends on numbers of factors. Impedance matching among the radiating structure and the feed structure is one of them by which efficient power has been transferred. The effect of spurious radiation on radiation pattern and minimization of spurious radiation itself is another important factor for the evaluation of feed. The different types of feeding method are as follows [8, 9]

- (1) Co-axial probe feed
- (2) Microstrip line feed
- (3) Proximity Coupling feed or Electromagnetic coupling
- (4) Aperture coupling feed
- (5) Coplanar waveguide feed

With the help of either co-axial probe or strip line feed, the microstrip antenna may be excited directly. It may also be excited indirectly, by means of aperture coupling, coplanar waveguide and proximity coupling feed, where there is lack of through connection of metal among the stripline feed and patch. Feeding methods are a significant design parameter, which influences the characteristics and antenna input impedance.

Co-axial probe feed/Probe coupling

Fig. 2 shows the co-axial probe feed configuration. For microwave power transmission, coupling of power using a probe is one of the essential process. The probe is an inner conductor of a co-axial line and using this with a hole in the ground plane, power can transfer from a strip line to a microstrip antenna. The co-axial connector is connected to the reverse face of radiating patch and after passing through the substrate material, it is soldered with the patch metallization.

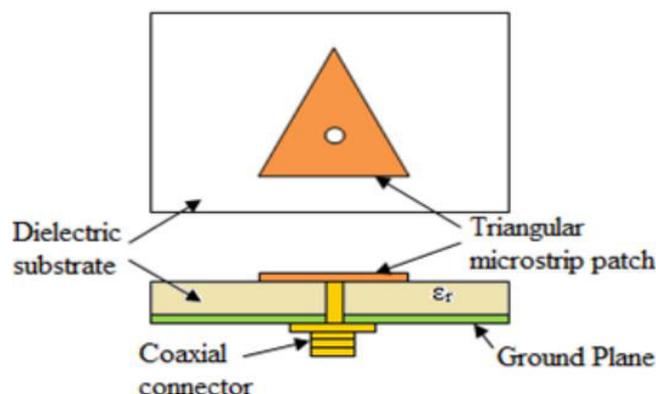


Fig. 2: Co-axial probe feed for microstrip antennas

Coplanar waveguide feed

The CPW (coplanar waveguide) feed is also a method to excite the microstrip antenna, shown in Fig. 3 [10, 11]. For (MMICs) microwave monolithic integrated circuits, CPW is preferred transmission line. Since, both the microstrip antennas and CPW belong to the planar structure therefore, microstrip antenna is feed with the CPW to integrate microstrip antennas with MMICs. The CPW is etched and coupling is accomplished using slot on the antenna ground plane. CPW feed has an advantage that it has negligible radiation from the feed structure due to excitation of the CPW in the coupled slot odd mode.

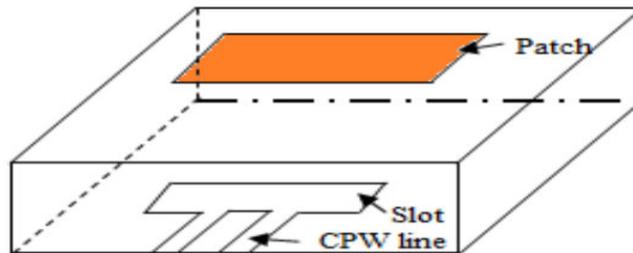


Fig. 3: Coplanar waveguide feed for microstrip antennas

III. PARAMETRIC OPTIMIZATION

The design parameters that govern the input impedance are substrate height, feed-point location and gap width.

3.1 Effect of Feed Point Location

For three different feed-point locations from the center of the patch, there is variation in the VSWR with frequency, shown in Fig. 4. With increase in frequency, the input impedance moves in a clockwise direction in the smith chart [7, 8]. As x moves from 1mm (feed-point is shifted to the edge), the input impedance loci shifts in the right direction on the smith chart implying that the impedance is increasing. A perfect match of 50 ohm feed-line is obtained for 4.75 mm along -x direction, which gives a bandwidth of 3.21 GHz for VSWR 2.

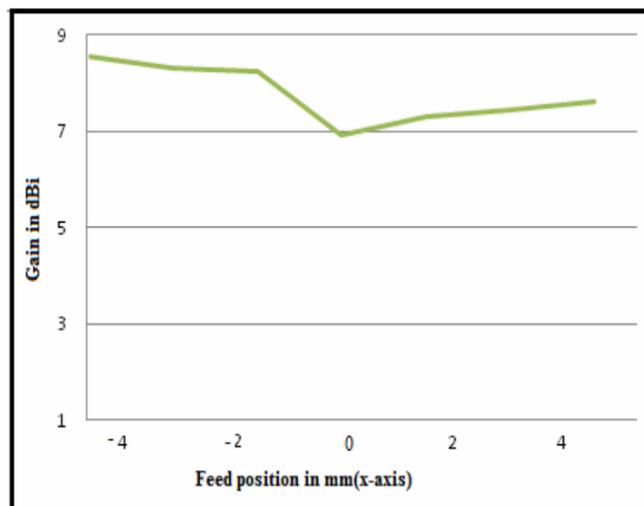


Fig. 4: Gain variations of microstrip antenna

3.2 Effect of Gap Width

Gap width governs the interaction between the coupled patch and the main patch. Increase in the gap width decreases the size of the impedance loci, because the interaction between the resonators decreases. Also the impedance loci shift toward the left side of the smith chart is shown in Fig. 5(a) and (b). Further increase in the gap width decreases the size of the impedance loci and the loop disappears for larger gap width. In this case, the gap width is varied from 0.0073 to 0.033. The optimized value of 0.0073 gives good bandwidth thereby increasing the interaction between the co-patch and the main patch [9].

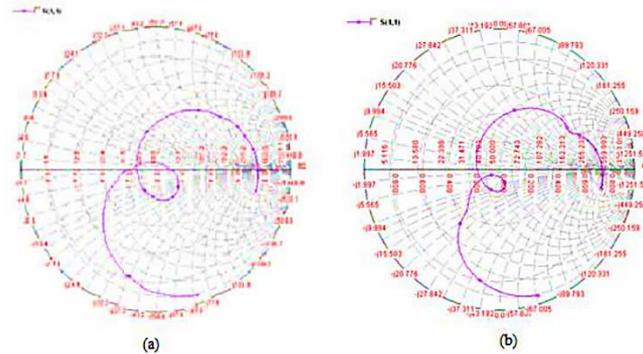


Fig. 5: (a) Smith chart for optimized gap width (b) Smith chart for increased gap width

3.3 Effect of Height, h

With increase in height h , from 0.083 to 0.093 the fringe fields from the edges increase, which increases the extension length and hence the effective length, thereby decreasing the resonance frequency. The bandwidth of the antenna increases from 1.575 GHz to 3.21 GHz, for the optimized height 0.093. The increase in the probe inductance of the feed moves the input impedance in clockwise, thereby introducing inductive shift [12].

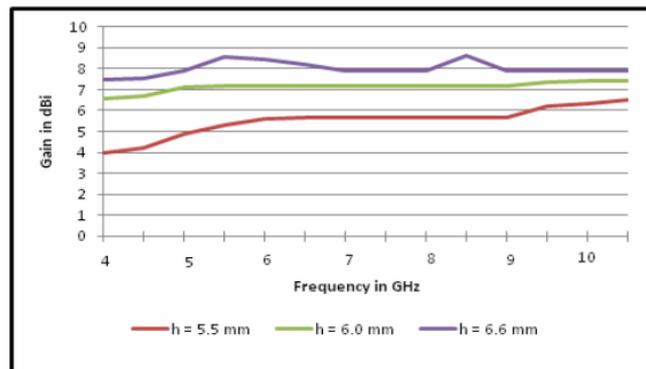


Fig. 6: Gain variations of microstrip antenna

IV. ANTENNA DESIGN

In an aperture coupling feed (ACF) microstrip patch antenna, separate dielectric substrate is used for the feed network and the patch antenna. Since all layers adhere to conformal printed circuit technology, fabrication is thus made simple. However, alignment between layers and correct selection of aperture size and position will be critical in controlling the antenna impedance. The natural existence of small gaps between the layers of dielectric substrate can significantly change the input impedance values.

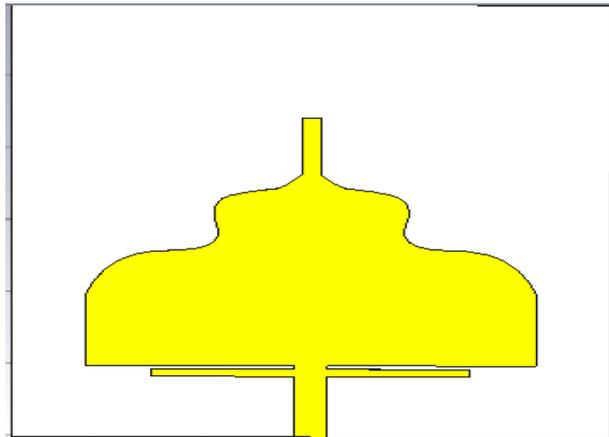


Fig. 7: Parasol Design of Microstrip Antenna

Absence of abrupt current discontinuities in ACF makes it relatively easy to design the antenna accurately. The design of the central strip and substrate takes a major part in deciding antenna parameters.

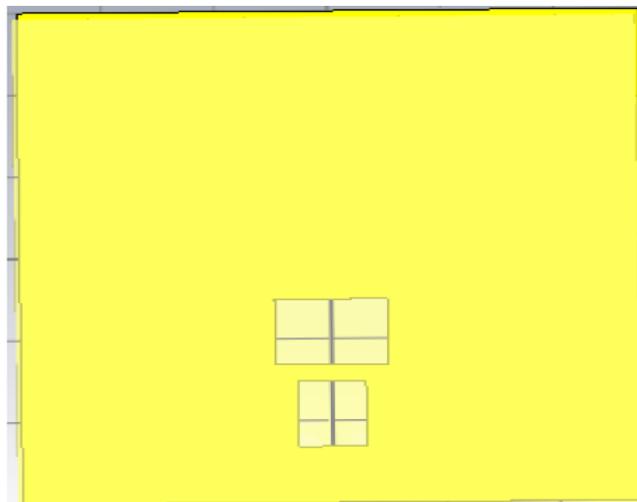


Fig. 8: Bottom View of Parasol Design

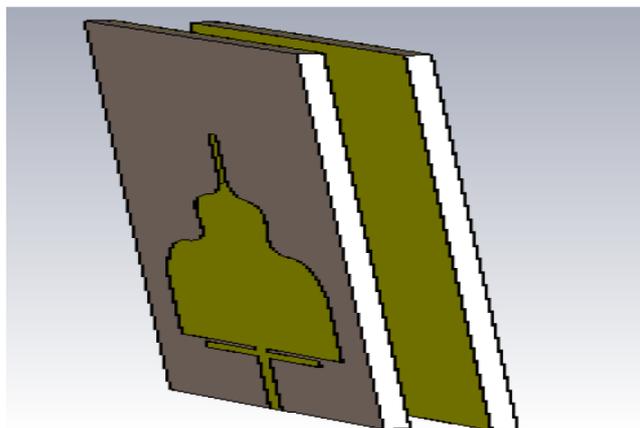


Fig. 9: Design Reflector of Parasol Design



V. RESULTS AND DISCUSSION

Return loss:- Return loss is a measure of how well devices or lines are matched. A match is good if the return loss is high. A high return loss is desirable and results in a lower insertion loss.

Directivity:- Directivity of an antenna is defined as the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions.

Antenna Directivity (D) = $4 \pi(\text{maximum radiation intensity})/\text{total radiation power}$

Gain:- The gain of an antenna in a given direction is defined as the ratio of the intensity, in a given direction, and the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically.

Gain of an antenna (G) = Antenna efficiency * Antenna directivity (D)

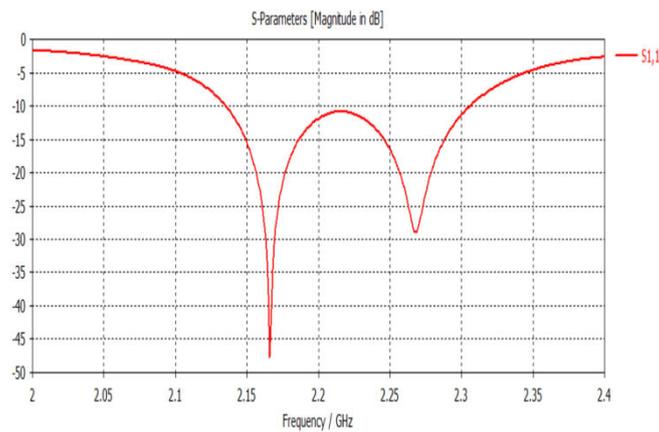


Fig. 10: Return loss vs frequency plot

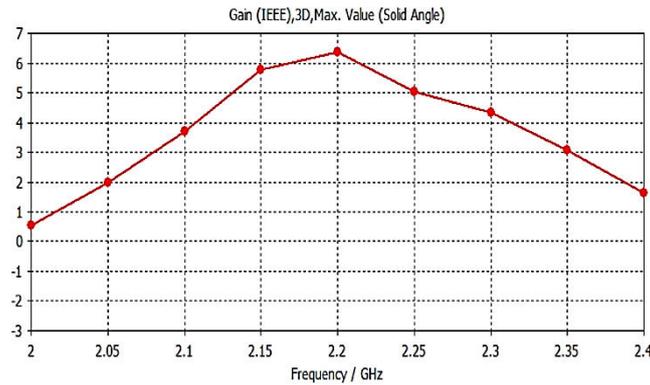


Fig. 11: Gain vs frequency plot

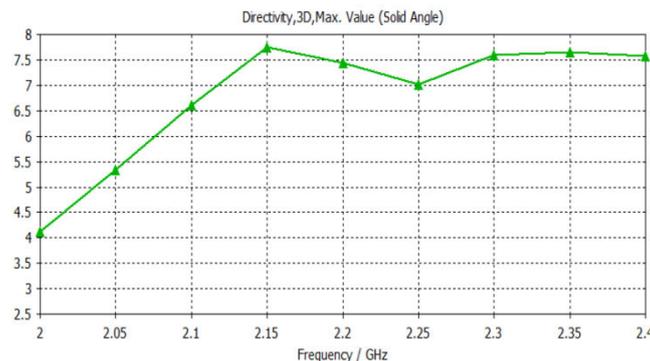


Fig. 12: Directivity vs frequency plot

Table 1: Comparison of Previous and Proposed Technique

Design	fr(GHz)	S ₁₁ (dB)	G(dB)	D(dBi)	η	VSWR	BW(MHz)
Base paper	2.45	-28	5.4	7.7	0.58	1.082	44.7
Presented	2.16	-50	6.3	7.75	0.85	1.05	170

VI. CONCLUSION

The previous design of 44.7 MHz bandwidth, the improved BW of the offered microstrip antenna is accomplished by selecting proper positions of symmetrical slots and equilateral arms inverted U-slot on the partial ground and patch, individually. The previous technique is analysis frequency 2.45 GHz, The decrease resonant frequencies is controlled. The previous design is 1.082 voltage standing wave ratio (VSWR) and 5.4 dB gain, the enhanced VSWR and gain feature of the antenna bandwidth is achieved by selecting the appropriate position of an upper half-circular disk. For additional improvement in the available bandwidth, a rectangular slit is loaded on the top of the radiating element.

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