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BANDWIDTH ENHANCEMENT OF WIDE BAND RECTANGULAR MICROSTRIP PATCH ANTENNA USING RECTANGULAR CUT AND L SHAPE CUT ON THE PATCH FOR KU BAND APPLICATIONS

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ABSTRACT

This paper presents bandwidth enhancement of a rectangular microstrip patch antenna which is designed [1][2] for RADAR applications for operating range Ku band. The proposed antenna gives bandwidth of 12.36-16.73GHz for $S_{11} < -10\text{dB}$. The Bandwidth is increased by using square cut and L shape cut on the patch. The antenna is simulated by Ansoft High Frequency structure Simulator (HFSS) software which is finite element method based simulator. After simulation the antenna performance characteristics such as, input impedance, return loss, impedance bandwidth, percentage bandwidth and Voltage Standing Wave Ratio (VSWR) are obtained.

Keywords: Rectangular patch antenna, FR4 Substrate, Input impedance, Return loss, Ansoft High Frequency structure Simulator (HFSS).

INTRODUCTION

Ku band primarily used in satellite communications most notably for broadcast services and for specific applications for NASA. Ku band are also used for backhousles and particularly for satellite from remote location back to a television network studio for editing and broadcasting. The wireless communication market has been greatly expanded and the demands of Ku band are increasing. The current fastest and robust microwave towers, mobile service, mobile satellite service, radio location service and radio navigation operate in the Ku band which can provide reliable high-speed connectivity between personal organizers and other wireless digital appliances.

The proposed antenna can operate from 12.36-16.73GHz making it suitable for wideband application. This small printed monopole antenna can be used in the vehicle speed detection.

Antennas play a very important role in the field of wireless communications [3] some of them are parabolic reflectors, patch antennas, slot antennas, and folded dipole antennas with each type having their own properties and uses. It is perfect to classify antennas as the backbone and the driving force behind the recent advances in wireless Communication technology [4]. 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 weight, 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 dielectric substrate which has a ground plane on the other side as Shown in Figure 1. 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 [5]. Therefore, the antenna can be fed by a variety of methods. These methods can be Classified into two categories- contacting and non-contacting. 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. In my design microstrip feeding method is used.

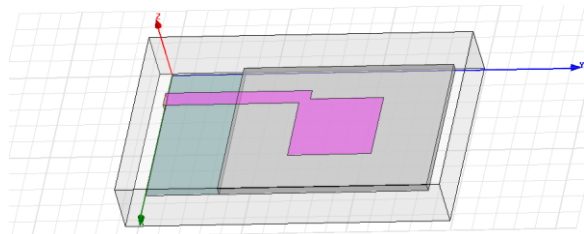


Figure (1): Rectangular patch antenna1 without cut on the patch.

Antenna Design Parameters

For a rectangular patch, the length L of the patch is usually $0.333 \lambda_0 < L < 0.5 \lambda_0$, where λ_0 is the free-space wave length [6]. The patch is selected to be very thin such that $t \ll \lambda_0$ (where t is the patch thickness) [7]. The height h of the dielectric substrate is usually $0.003 \lambda_0 \leq h \leq 0.05 \lambda_0$.

Physical Parameters of Antenna

The geometry of the proposed antenna is showed in Fig.1. It consists of a printed rectangular patch antenna on FR4 substrate of thickness 0.8 mm and a relative permittivity 4.4. The substrate has a length of $L=20$ mm and the width of $W=15$ mm. The dimensions of the partial conducting ground plane are $15\text{mm} \times 7$ mm. The patch dimension are $L=7\text{mm}$ and $W=8\text{mm}$. The excitation is launched

through a 50 Ohm microstrip feed line, which has the length 14mm and the width 1.5mm.

Table (1): Dimensions of all part of the proposed antenna without cut on the patch

Sub position(X,Y,Z)	0mm_7mm_0mm
FR4Substrate(X,Y,Z)	15mm_20mm_0.8mm
Gnd position(X,Y,Z)	0mm_0mm_0mm
Ground Plane (X, Y)	15mm_7 mm
Patch position (X,Y,Z)	4mm_13mm_0.8mm
RectangularPatch(X,Y)	7mm_8 mm
Feed position(X,Y,Z)	3mm_0mm_0.8mm
Feed Line (X, Y)	1.5mm_14 mm

In this paper, the patch is cut in rectangular shape to increase bandwidth of antenna 1 in order to cover the entire 12.56-16.64GHz band is shown in below fig 2. The dimensions of all part of the proposed antenna 2 are given in table. (2).

Table (2): Dimensions of all part of the proposed antenna with 3mmby4mm cut on the patch.

FR4Substrate(X,Y,Z)	15mm_20mm_0.8mm
Feed position(X,Y,Z)	3mm_0mm_0.8mm
Feed Line (X, Y)	1.5mm_13 mm
Ground Plane (X, Y)	15mm_7 mm
Patch position (X,Y,Z)	4mm_13mm_0.8mm
RectangularPatch(X,Y)	7mm_8 mm
Cut position(X,Y,Z)	6mm_15mm_0.8mm
Cut(X,Y)	3mm_4mm

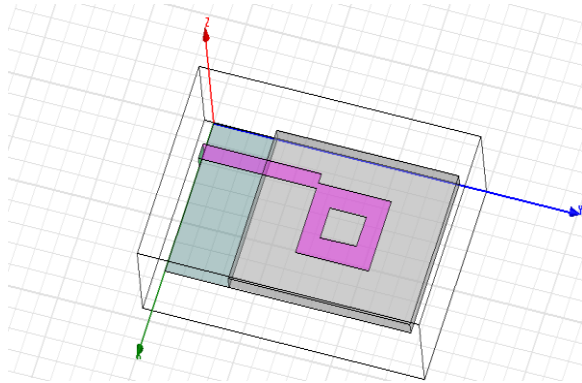


Figure (2): Rectangular patch antenna2 with 3mmby4mm cut on the patch.

If the patch is cut in L shape then the bandwidth again increase and cover bandwidth 12.36-16.73GHz with centre frequency 13.79GHz. The structure of the antenna is shown in below fig. (3) And the antenna dimensions are shown in table (3).

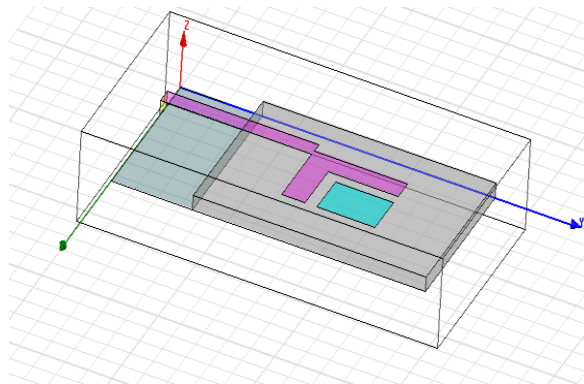


Figure (3): Rectangular patch antenna3 with L shape cut on the patch.

Feed point location

A microstrip line type feed is used in this design. The feed point must be located at that point on the patch, where the input impedance is 50 ohms for the resonant frequency. Hence, a trial and error method is used to locate the feed point. For different locations of the feed point, the return loss (R.L) is compared and that feed point is selected where the R.L is most negative. There exists a

point along the length of the patch where the R.L. is minimum.

Table (3): Dimensions of all part of the proposed antenna with L shape cut on the patch.

FR4Substrate(X,Y,Z)	15mm_20mm_0.8mm
Feed position(X,Y,Z)	3mm_0mm_0.8mm
Feed Line (X, Y)	1.5mm_13 mm
Ground Plane (X, Y)	15mm_7 mm
Patch position (X,Y,Z)	4mm_13mm_0.8mm
RectangularPatch(XY)	7mm_8 mm
Cut position(X,Y,Z)	6mm_15mm_0.8mm
Cut(X,Y)	6mm_5mm

Simulation Setup and Results

The software used to model and simulate the microstrip patch antenna is HFSS software. HFSS software is a full-wave electromagnetic simulator based on the finite element method. It analyzes 3D and multilayer structures of general shapes. It has been widely used in the design of MICs, RFICs, patch antennas, wire antennas, and other RF/wireless antennas. It can be used to calculate and plot the S parameters, VSWR, current distributions as well as the radiation patterns.

DISCUSSION

Return loss is important parameter for calculating the bandwidth of the antenna. The center frequency is selected as the one at which the return loss is minimum. The bandwidth can be calculated from the return loss (RL) plot..The bandwidth of the antenna can be said to be those range of frequencies over which the RL is greater than -10 dB (-10 dB corresponds to a VSWR of less than 2 which is an acceptable figure.

In the first case, when the antenna 1 is designed without cut on the patch then Impedance bandwidth is achieved 3.6879GHz and return loss -44.62db and VSWR is 1.011 with operating range

12.51-16.20GHz and percentage bandwidth 13.23%. The return loss, VSWR, and smith chart are shown in fig(1a), fig(1b) and fig(1c) respectively.

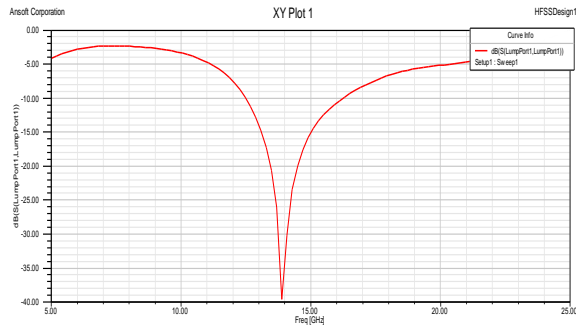
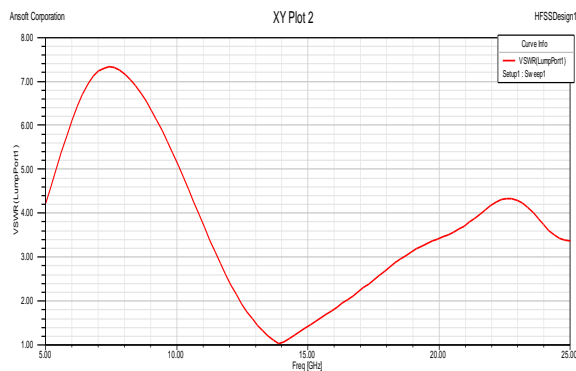


Figure (1a): Return loss vs. frequency plot



Fig(1b). VSWR Vs Frequency

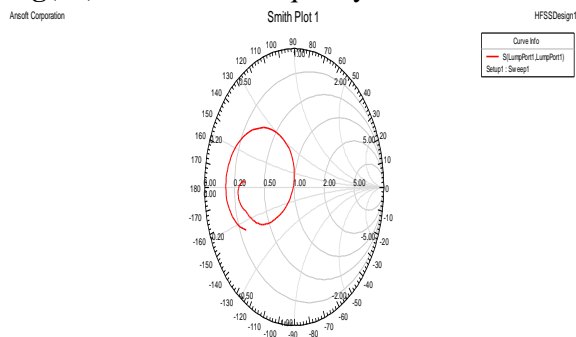


Figure (1c): Scattering parameter S11 versus frequency on the Smith chart

In the second case, when the patch is cut in rectangular shape then return loss achieved - 34.50db, VSWR 1.03 and increased impedance bandwidth 4.07GHz, percentage bandwidth 14.70% and operating range 12.56-16.64GHz with

centre frequency 13.85GHz. The return loss, VSWR, and smith chart are shown in fig(2a), fig(2b) and fig(2c) respectively.

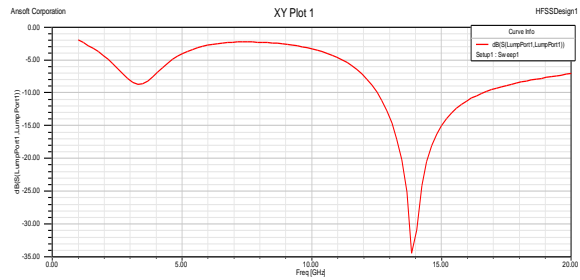


Figure (2a): Return loss vs. frequency plot

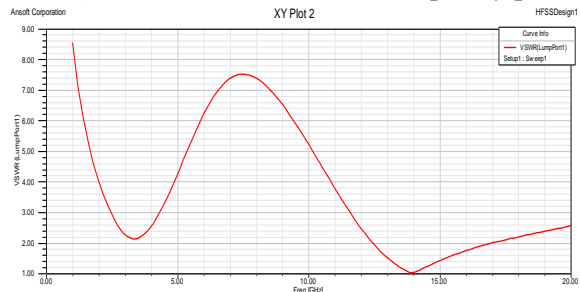


Fig (2b). VSWR Vs Frequency

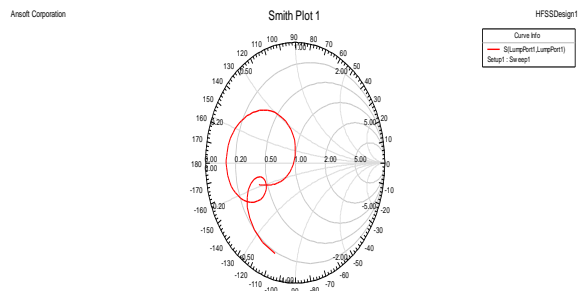


Figure (2c): Scattering parameter S11 versus frequency on the Smith chart

In the third case, when the patch is cut in L shape then return loss achieved -30db, VSWR 1.06 and increased impedance bandwidth 4.36GHz, percentage bandwidth 15.83% and operating range 12.6-16.73GHz. The return loss, VSWR, and smith chart are shown in fig (3a), fig (3b) and fig (3c) respectively.

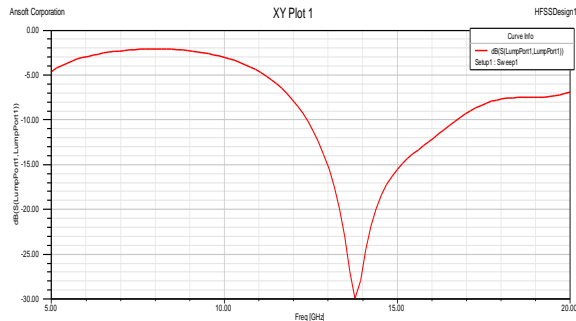


Figure (3a): Return loss vs. frequency plot

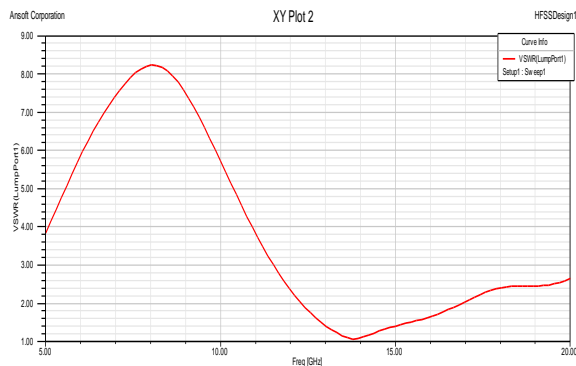


Fig (3b). VSWR Vs Frequency

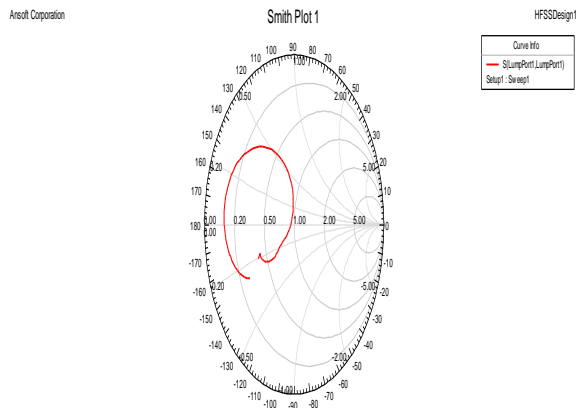


Figure (3c): Scattering parameter S11 versus frequency on the Smith chart

The impedance bandwidth and percentage bandwidth are calculated by following formulas.

$$\text{Impedance BW} = fh - fl$$

$$\text{Percentage BW} = (fh - fl) * 100/2fc,$$

Where,

fh = upper cutoff frequency,

fl = lower cutoff frequency and

fc = resonant frequency.

Using above formulas the impedance bandwidth and percentage bandwidth are calculated and result are shown in below table (4)

Table (4) shows that the impedance bandwidth and percentage bandwidth are increased in each cases.

Table (4) Calculation and comparison of result for three cases.

Antenna/Parameter	Return Loss (DB)	VSWR	Impedance Bandwidth (GHz)	Percentage Bandwidth.
Antenna 1	-44.62	1.0	3.68	13.23%
Antenna 2	-34.50	1.0	4.07	14.70%
Antenn3	-30	1.0	4.36	15.83%

CONCLUSION

It is shown that the simulations results obtained by HFSS simulator show good agreement. The proposed rectangular patch antenna can be good candidate for Ku band applications, and wideband applications [8], due to its miniature size, and its good performances. Thus by this idea the Bandwidth of antenna can be increased.

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