Salud, Ciencia y Tecnología. 2022;2(S2):197
doi: 10.56294/saludcyt2022197

ORIGINAL ARTICLE

Patch Antenna with Slots for L and S - Band Communication

Antena de parche con ranuras para comunicaciones en bandas L y S

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Citar como: Borah MC, Saikia P, Bordoloi AK, Sarma B. Patch Antenna with Slots for L and S - Band Communication. Salud Cienc. Tecnol. 2022;2(S2):197. https://doi.org/10.56294/saludcyt2022197

Submitted: 28-11-2022 **Revised:** 15-12-2022 **Accepted:** 22-12-2022 **Published:** 31-12-2022

Editor: Fasi Ahamad Shaik

ABSTRACT

A slot loaded rectangular antenna is designed to resonate at three distinct frequencies. Initially, a simulation software (CST Microwave Studio) was used to design the antenna. This device was assembled by introducing one slot near the center and the remaining slots on both sides of the central slot, placed diagonally, to observe frequency variation leading to tuning the designed frequency. The addition of slots on the patch with variations in feed point location shows multiband frequency tuning behavior at three resonant frequencies. Variations of the slots distance with respect to each other along with changing the feed point locations are studied with tuning of the resonant frequency within the same band (L and S-Band). The RL values are not degraded for both simulated and measured results, thus antenna performance is not disturbed by multiband frequency behavior.

Keywords: Multiband Frequency; Microstrip Patch; Slot Loaded; L and S-band.

RESUMEN

Se diseñó una antena rectangular cargada con ranuras para que resuene a tres frecuencias distintas. Inicialmente, se utilizó un software de simulación (CST Microwave Studio) para diseñar la antena. Este dispositivo se montó introduciendo una ranura cerca del centro y el resto de las ranuras a ambos lados de la ranura central, realizadas en diagonal, con el fin de observar la variación de frecuencia que lleva a sintonizar la frecuencia diseñada. La adición de ranuras en el parche con variaciones en la ubicación del punto de alimentación muestra un comportamiento de sintonización frecuencial multibanda en tres frecuencias de resonancia. Las variaciones de la distancia de las ranuras entre sí junto con el cambio de la ubicación de los puntos de alimentación se estudiaron en conjunto con la sintonización de la frecuencia de resonancia dentro de la misma banda (L y S-Band). Los valores de RL no se degradaron tanto en los resultados simulados como en los medidos, por lo que el rendimiento de la antena no se ve perturbado por el comportamiento de la frecuencia multibanda.

Palabras clave: Frecuencia Multibanda; Parche Microstrip; Cargado con Ranura; Banda L y S.

INTRODUCCIÓN

The microstrip patch antenna is primarily used in communication applications, and its bandwidth can be increased by making the antenna smaller. Size reduction[3, 9] bandwidth enhancement[1, 4] and good tuning capability are becoming the main design considerations for practical applications of microstrip patch antennas. Several researchers have designed slot and slit loaded antennas[2, 5, 7, 8] to investigate their effect on frequency/frequencies. In this paper, the antenna has been fabricated using a copper clad FR4 substrate, and its dielectric constant is 4,8 (εr) with a substrate thickness (h) of 1,5 mm. A simple basic patch antenna was designed in the L and S bands, and modification of the patch was carried out by adding diagonal slots to study the effect on resonant frequency. The performance of the antenna was studied by measuring the return loss and radiation pattern of the antenna.

ANTENNA DESIGN

A. Basic antenna design

A basic rectangular microstrip patch antenna that resonates at two frequencies in the L and S bands was designed. Feed point location for best matching in terms of return loss with resonant frequencies was investigated for the design. The length of the ground plane is 58 mm, the width of the ground plane is 70 mm, and the length and width of the patch are Lp=38 mm and Wp=50 mm, respectively. Table 1 summarizes the overall dimension of the patch.

Table 1. Overall dimension of Patch Antenna

Parameter	Value
Length of ground plane (Lg)	58 mm
Width of ground plane (Wg)	70 mm
Patch width (Lp)	38 mm
Patch length (Wp)	50 mm
Height of the substrate (h)	1,5mm
Dielectric constant (ε_r)	4,8
Feed point location from edge	11 mm

B. Selection of feed point location:

Multiple iterations were carried out to connect a port to the patch antenna, and the optimized value was selected. Feed point location was varied in steps of 1 mm towards the edge which shows the antenna resonating at frequencies of 1,717 GHz and 2,653 GHz with good return loss values of -27,235 dB and -26,959 dB, respectively, with the feed point location at 11 mm from the center towards the radiating edge along the X axis. Variations of feed point locations with enhanced RL values in relation to frequency shifts in both lower and upper frequencies for all feed points (1mm to 12mm) were plotted and shown in Figure1.

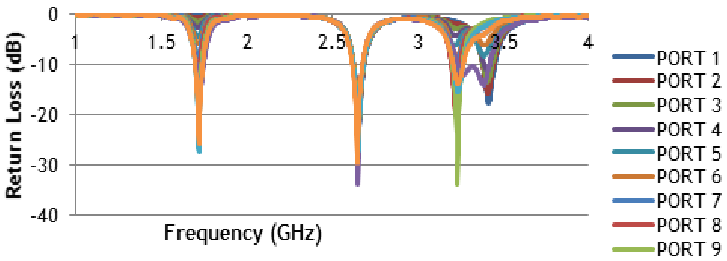

Figure 1. Frequency vs Return loss values for all feed point locations

The simple patch antenna was loaded with slots (length=20mm, width=2mm) in such a way that one slot was fixed near the center and other slots on both sides of the central slot were placed diagonally and moved to observe frequency variation, leading to tuning the antenna in both upper and lower frequencies. Return loss variation with designed structures (Structure 1-9) for different resonant frequencies was plotted and shown in Figure 2.

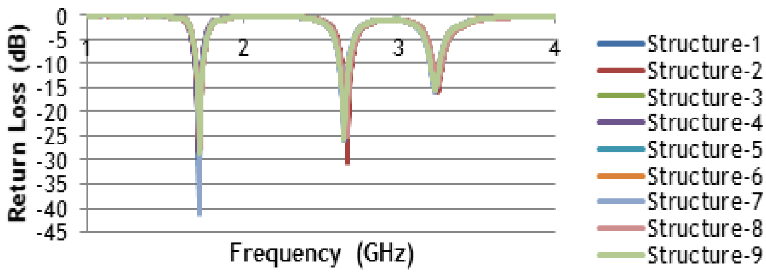

Figure 2. Frequency vs Return loss values for slot loaded patch antenna structures

According to the results (Fig. 2) , the three slots position varied along the diagonal, the structure 7 for feeding point at 11 mm along the +ve X axis towards radiating edge, the best result with a return loss value of -40.87 dB at frequency 1,717 GHz and return loss values -24,682 dB, -15,611 dB at frequencies 2,644 GHz and 3,226 GHz, respectively, was obtained for the upper and lower slot positions from the centre slots, which are 4 mm and 10 mm away respectively, for the structure 7. For these frequencies, the measured VSWR (1,018, 1,124 and 1,143) are within an acceptable range. Figure 3 depicts the geometrical diagram of structure 7 for best matching.

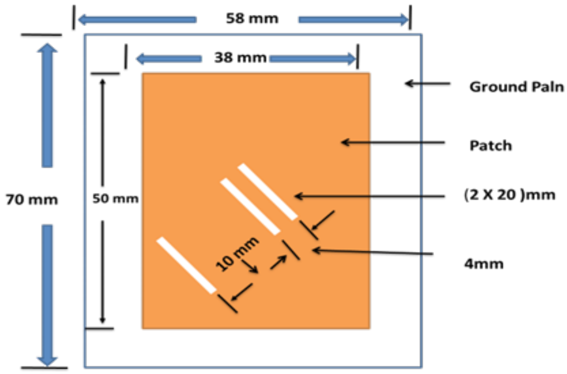

Figure 3. Geometrical diagram of designed slot loaded Patch Antenna (Structure 7)

The slot loaded antenna was fabricated as shown in figure 4 for the struture 7

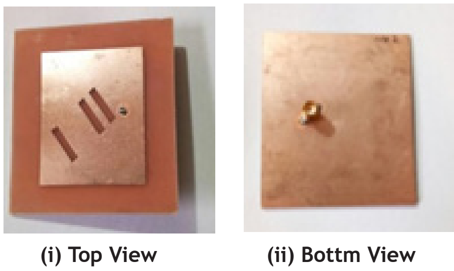

Figure 4. Fabricated patch antenna of structure 7

Figure 4 shows the (i) top view and (ii) bottom view of the fabricated patch antenna of structure 7.

EXPERIMENTAL RESULT

Measurements were carried out on the fabricated antenna (Fig. 4) using the Vector Network Analyzer (Agilent make, PNA Network Analyzer E8362C, 10MHz- 20 GHz). Figure 5 compares the return loss (in dB) versus frequency (in GHz) of the simulated and measured results of the fabricated antenna with port locations at 11 mm, and the results are presented in Table 2.

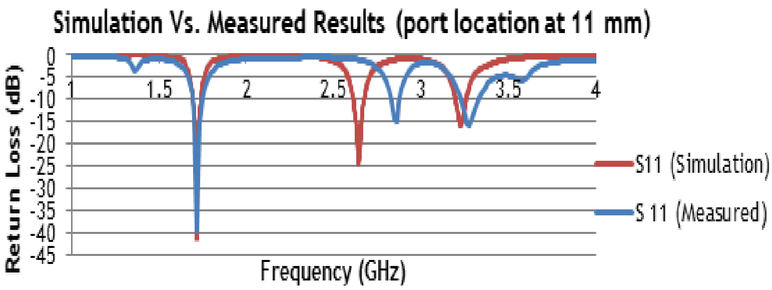

Figure 5. Comparison plot for measured and simulated results

Taking the results as a whole - fig 5, table 2- it is observed that, for both lower and higher frequencies, the feeding point location at 11 mm towards the radiating edge along the X axis results in a slight shift in resonant frequency in measurement when compared to the simulated value. At frequencies of 1,72 GHz, 2,860 GHz, and 3,265 GHz, respectively, there is a shift in frequencies of 3 MHz, 216 MHz, and 39 MHz, with return loss values of -39,479 dB, -14,92 dB, and -15,628 dB.

https://doi.org/10.56294/saludcyt2022197

TABLE 2. Simulated Vs. Measured results

Feed point at 11mm	Frequency1 (GHz)	RL1 (dB)	Frequency2 (GHz)	RL2 (dB)	Frequency3 (GHz)	RL 3 (dB)
Simulated result	1,717	-40,875	2,644	-24,68	3,226	-15,611
Measured result	1,720	-39,479	2,860	-14,92	3,265	-15,628

Radiation Pattern

Radiation pattern plots for the antenna at both lower and higher frequencies (1,717 GHz, 2,644 GHz, and 3,265 GHz) were measured. These plots also indicate a broadside radiation pattern having directivity 6 dBi and 7,97 dBi (sinulated), respectively and measured gain were 4,72 dB, 5,92 dB and 8,1 dB at the center frequencies 1,72 GHz , 2,86 GHz and 3,265 GHz respectively for the fabricated antenna (Figure 6)

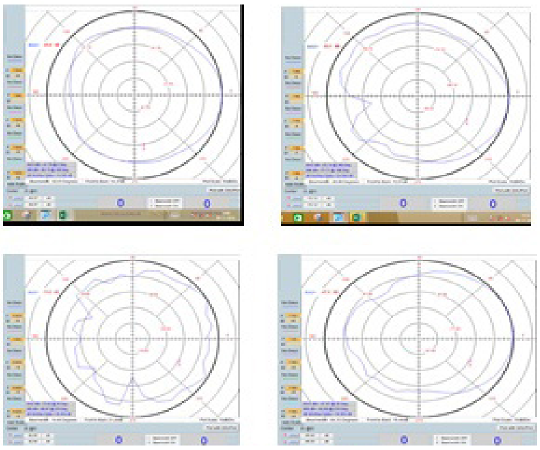

Figure 6. Radiation pattern plot at 1,72 GHz, 2,86 GHz and 3,265 GHz (Measured)

CONCLUSION

According to our research, the maximum return loss is found by aligning the three slots diagonally, increasing the return loss from -27,23 dB at frequency 1,717 GHz (without slots) to -40,875 dB (with slots). From the fabrication of the antenna, the measured RL value is -39,479 dB at frequency 1,72 GHz with 3 MHz of frequency variation from the simulated frequency, and other return loss values are -14,90 dB at frequency 2. Simulated and measurement results show a good agreement with slight shift in frequencies, which might be due to fabrication tolerance. For these frequencies, the measured VSWR is found to be around 1. Thus, the proposed antenna exhibits multi frequency responses at these three distinct resonant frequencies in L and S bands with acceptable VSWR and measured gain are 4,72 dB, 5,92 dB and 8,1 dB, respectively with broadside radiation pattern. The antenna designed in the present investigation can be used as a potential candidate for multi band frequency applications (in the L and S bands).

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ACKNOWLEDGEMENT

I would like to express my deep, unbound gratitude and appreciation to Dr. Anup Kumar Bordoloi and Dr. Bhairab Sarma for their precious guidance during the entire period of my work and preparation of the paper and my co-author Ms Parimita Saikia for her support and help in finalizing the work. I am also expressing my gratitude to the faculty members of the Computer Science and Electronics Department, University of Science and Technology, Meghalaya, for providing me with the platform to carry out my research work.

CONFLICTS OF INTEREST

None.

FINANCING

None.

AUTHORSHIP CONTRIBUTION

Conceptualization: Manik Chandra Borah, Parimita Saikia, Anup Kr Bordoloi, Bhairab Sarma.
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Writing - Review & Editing: Manik Chandra Borah, Parimita Saikia, Anup Kr Bordoloi, Bhairab Sarma.