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E-Shaped Multiband Microstrip Patch Antenna Design for C and X Bands Wireless Applications

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Abstract: In this paper, a six band microstrip patch antenna design for wireless applications is proposed and simulated. The proposed antenna resonates at (4.084-4.185GHz), (5.857-6.043GHz), (6.218-6.407Hz), (6.784-6.976GHz), (9.553-10.46GHz), and (10.474-11.24GHz) with a minimum return loss of-35.99dB (5.94 GHz). The FR-4 material is used to isolate ground and patch with a 4.3 dielectric constant and 1.6 mm thickness and uses a microstrip transmission line. In this design, the return loss is minimized by adding an extra three rectangular blocks to the patch. CST microwave studio simulation software is used for the design and simulation of this proposed antenna. The design is simple geometry and provides good bandwidth with appreciable gain. The proposed antenna can be used for different applications in the C, X bands of wireless communications.

Keyword:- FR-4, CST, E-shap, square slot, rectangular block.

I. INTRODUCTION

In the present scenario, every electronic device communicates in a wireless manner. In all electronics industries, researchers try to develop small size, minimal return loss; high gain, high efficiency, and Omni directional patch antennas which should support different wireless standards. In the patch antenna design process, the ground plane and feed patches are isolated by a dielectric material. There are many substrates available with $2.2 < \varepsilon_r < 12$ dielectric constants to use as a dielectric for designing a patch antenna. With a lower dielectric constant and thick substrate, a patch antenna provides better efficiency and larger bandwidth [1]. A single device communicates with multiple devices simultaneously at a different-different frequency; a multiband patch antenna can be used in this device. A single device communicates with multiple devices at different-different frequencies via multiple patch antennas. A multiband patch antenna can be used in place of multiple antennas in these devices. In microstrip antenna literature A lot of techniques are available to design multiband operation of microstrip antenna that can be used in wireless communication. The most common, easy to fabricate and low-cost technique is slot cut in the feed patch of the antenna. This same antenna can provide double, triple, or multi-band resonance [2]. A patch antenna is cheap and with the FR-4 Substrate material, it can be easily fabricated with a small effort. Less bandwidth and poor gain are major demerits of microstrip patch antennas. To avoid these demerits and attain the multiband operation, different approaches can be used, like cutting a slot in the patch, fractal geometry, parasitic patch, shorting and DGS (Defected Ground structure) [3].Due to a slot on the antenna patch, the path of the surface current is changed into a circular function. Owing to the path converts the resonant band shift towards the lower band from the designed resonance band, here it is clear a slot can reduce the overall size of the patch antenna [4]. Microstrip antenna designs with the traditional methods such as the use of slots, defected ground structure (DGS), high permittivity dielectric materials and ceramic substrate, etc, have limitations which are a complex structure and low radiation performance for miniaturization. The use of metamaterial is a new design methodology by which this antenna can produce high miniaturization. [5]. A multiband microstrip patch antenna is used for different wireless applications when it provides appropriate frequency band resonance for standards like Wi-Fi, WLAN bands, CDMA, UMTS bands [6]. In [7] an antenna has been proposed which is capable of operating at three different frequency bands. In the proposed design, an L-shape is etched in a rectangular patch to achieve multiband operation. In [8] a Microstrip feed triple-band circular patch antenna design was proposed. In this design I shaped a slot etched on the patch and DGS used. In [9] a staked microstrip antenna design was proposed with a swastika slot etched on a parasitic patch where the simulation results confirmed good return loss. In [10] a proposed design, multiple L-frame slots etched on slots and by simulation describe the gain of antenna increases by these slots.

II. ANTENNA DESIGNED

In this paper, a L×W×h rectangular microstrip antenna design on CST microwave studio fig 1 (a). The proposed design is fed by a microstrip transmission line with impedance characteristics of 50.As a dielectric material, an FR-4 substrate with ε_r =4.3 and a thickness of 1.6mm is used to isolate the ground plane from the feed path. By this design, get four resonance bands with less than -20dB return loss. To improve some parameters of the antenna, like a reduction in return loss, some extra two rectangular blocks were added to this proposed antenna. Now the proposed antenna converts into

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an E-shape antenna which is shown in fig 1(b). After cutting two 5×5×0.035mm slots in the patch of this E-shape antenna, one more resonance band was added.

The width (W) of the patch is calculated using the following equation [1].

$$W = \frac{C}{2f_r\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \tag{1}$$

Where, C = speed of light in free space,
f_r = resonant frequency, and
ε_r = value of the dielectric substrate

The Length (L) of the patch is calculated using the following equation [1].

$$L = L_{eff} - 2\Delta L \tag{2}$$

Where, ΔL = Extended electrical length

The effective length (L_{eff})of the antenna is determined by equation [3] [4],and [5]:

$$L_{eff} = \frac{C}{2f_r\sqrt{\varepsilon_{reff}}} \tag{3}$$

The effective refractive (ε_{reff}) index value of substrate material is an important parameter for the patch antenna, and it is determined by equation [4].

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}} \tag{4}$$

Where, h = thickness of the substrate

Now the extended electric length (ΔL) is determined by equation [5] :

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \tag{5}$$

To achieve good performance, the antenna size of the ground plane should be greater as compared to patch.
The width of the ground plane is determined by equation [6]:

$$W_g = 6h+W \tag{6}$$

The length of the ground is determined byequation[7]:

$$L_g = 6h+L \tag{7}$$

Table 1 Parameters of Antenna

S.No.	Parameter	Dimensions	Material
1	Ground Plane	W_g = 40mm, L_g = 40mm, h_g =0.035mm	Copper
2	Substrate	W_s = 40mm, L_s = 40mm, h_s =1.6mm	FR-4 (4.3)
3	Patch	W = 30mm, L = 32mm h_p =0.035mm	Copper

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4	Feed Line	W_f = 3mm, L_f = 8mm, h_t =0.035mm	Copper
5	Extra rectangular blocks	W_{er} = 5mm = L_{er} = 5mm, h_{er} =0.035mm	Copper
6	Rectangular slots on the patch	5mm×5mm×0.035mm	---
6	Rectangular slots on the patch	5mm×5mm×0.035mm	---

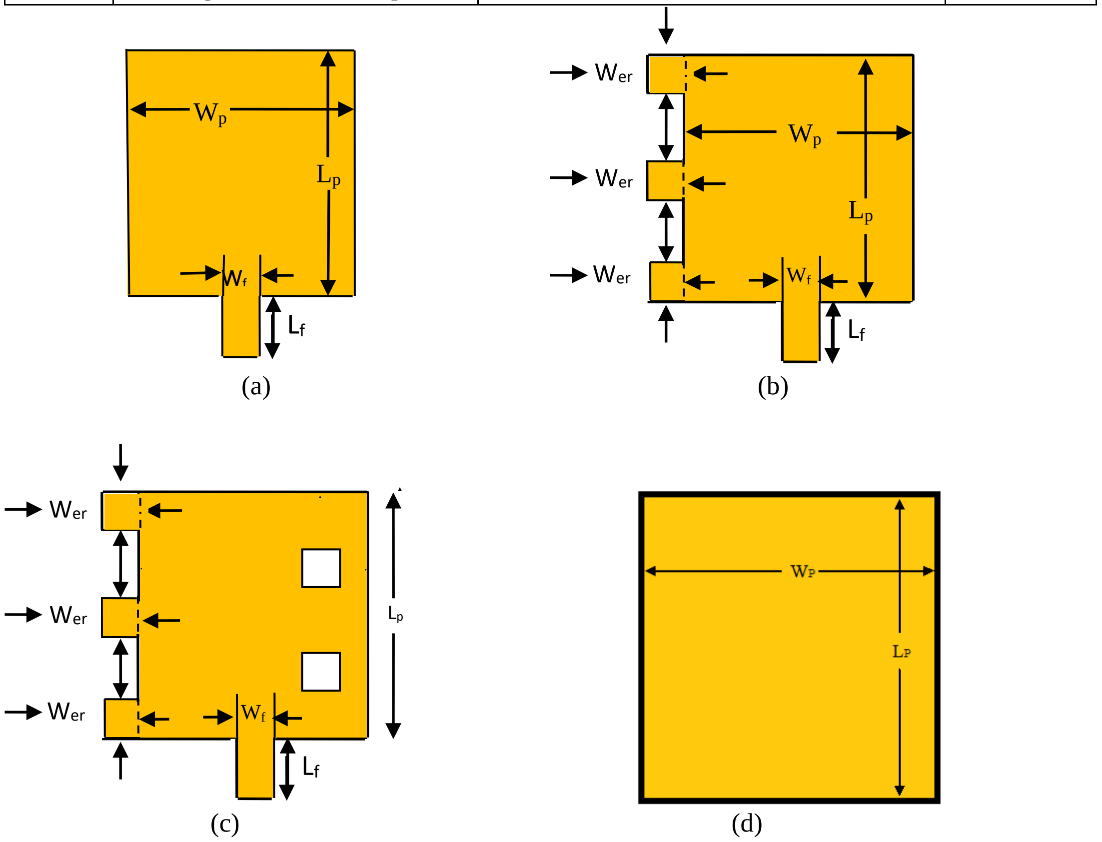

Fig 1 Proposed antenna (a) Front view case-I (b) Front view case-II (c) Front view case-III (d) Back view.

III. RESULT AND DISCUSSION

There to obtain results, the CST microwave studio simulator is used for both Case-I and Case-II of the proposed antenna for the frequency range from 1 GHz to 12 GHz. Characteristics of both case antennas are compared in terms of return loss, gain, bandwidth, gain, Front-back ratio, and efficiency.

A. Return Loss and VSWR

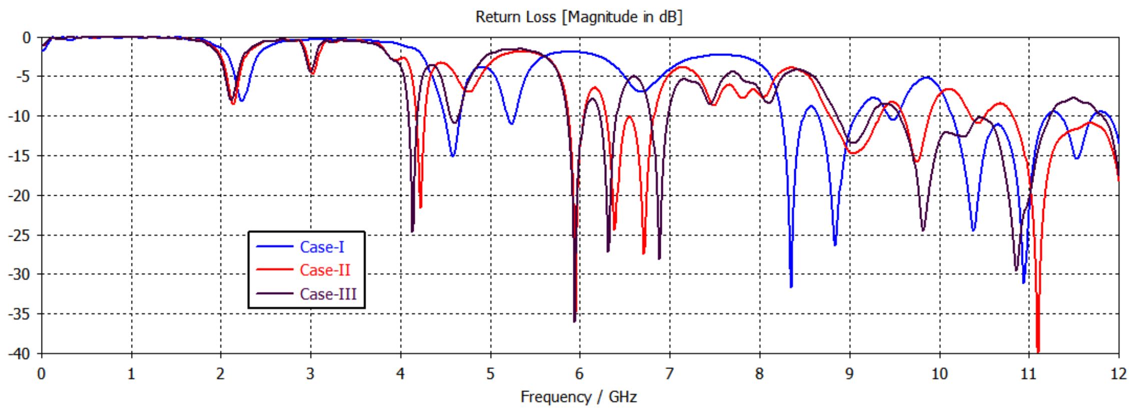

Fig 2 Return loss v/s frequency curve.

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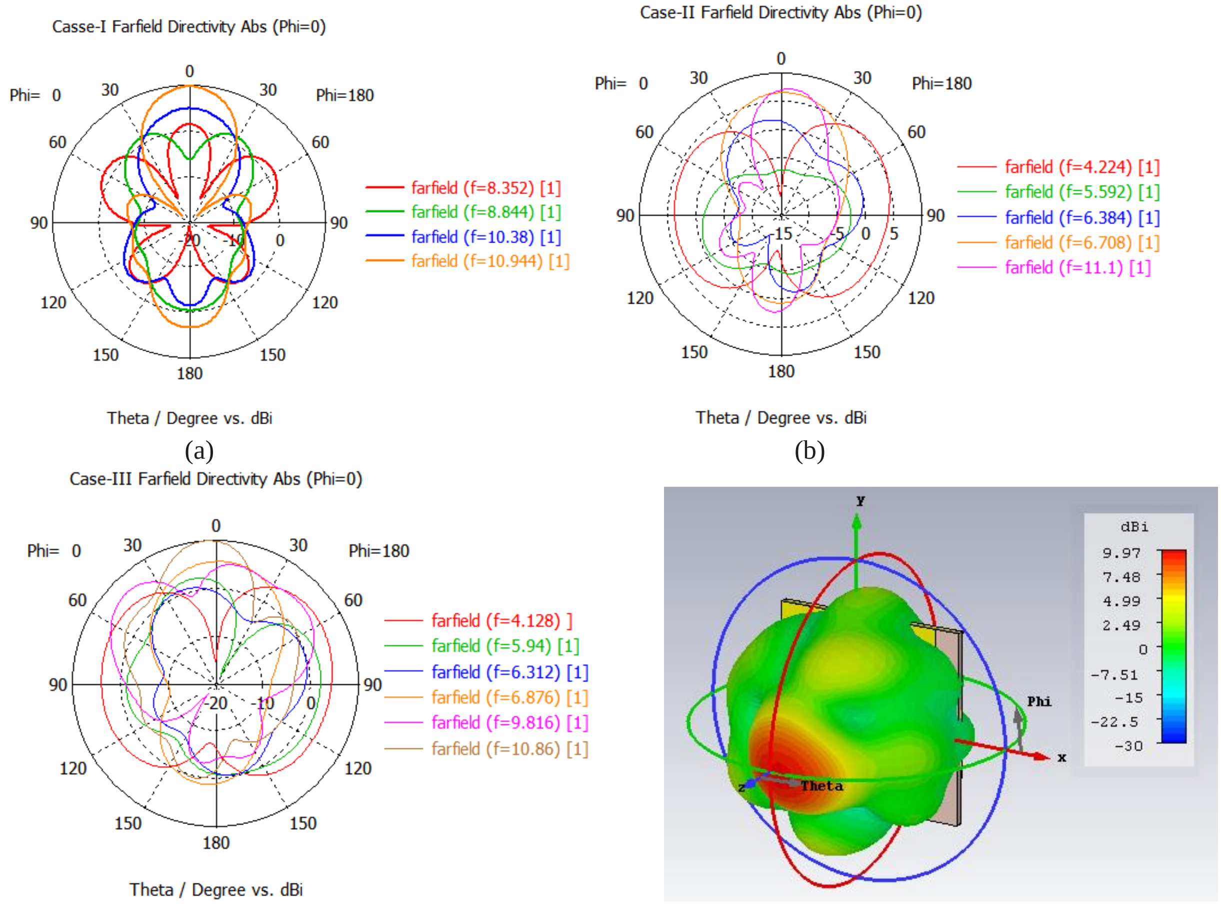
Table 2

S.No.	Proposed antenna Case-I			Proposed antenna Case-II			Proposed antenna Case-III		
	Frequency (GHz) (S11<-20dB)	Return Loss(dB)	Band width (%)	Frequency (GHz) (S11<-20dB)	Return Loss(dB)	Band width (%)	Frequency (GHz) (S11<-20dB)	Return Loss(dB)	Band width (%)
1	8.352	-31.66	3.02	4.224	-21.31	2.37	4.128	-24.62	2.45
2	8.844	-26.32	4.74	5.952	-34.74	2.81	5.94	-35.99	3.13
3	10.38	-24.54	4.92	6.384	-24.34	4.09	6.312	-27.14	2.99
4	10.944	-31.11	5.03	6.708	-27.48	4.13	6.876	-28.05	2.79
5	---	---	---	11.1	-39.84	7.64	9.816	-24.47	9.24
6	---	---	---	---	---	---	10.86	-29.59	7.05

By analyzing table-2, we observed that in the proposed antenna Case-I only four resonance bands occur with a minimum -31.66dB return loss at 8.352 GHz, and the maximum bandwidth has been 5.03% (10.652-11.203 GHz). When the extra three rectangular blocks are added to the patch, the proposed antenna provides five resonance bands with a minimum-39.84dB return loss at 11.1 GHz, and it also provides a maximum bandwidth of 7.64% (10.812-11.660GHz). After creating slots on the feeding patch, the proposed antenna case-III provides six resonance bands with a minimum-35.99dB return loss at 5.94 GHz, and it also provides a maximum bandwidth of 7.05% (10.474-11.24GHz). Here it is also clear, that after etching slots on the patch of the antenna, it has been converted into a wideband antenna but the return loss response of the antenna is less appreciable as compared to previous cases. VSWR is an important parameter of the antenna, which is an assessment of how much power reflects from the antenna to the transmission line. The VSWR of the proposed antenna is less than 1.18 in all cases.

B Radiation Characteristics



(a) (b) (c) (d)

Fig 3 Farfield-2D plot (a) For case-I antenna (b) For case-II antenna (c) For case-III antenna (d) Farfield-3D plot for case-III antenna.

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The 2D-farfield directivity plot of the proposed antennas is represented in Fig 3 (a, b, c). For all cases of the antenna structures, the lower frequency resonance band is bi-directional along with the X-axis, at the higher frequency resonance band is unidirectional in the direction of the Z-axis, and at the mid-frequency resonance, and the proposed antenna provides an omnidirectional radiation pattern. Finally, the conclusion of the radiation pattern is that the proposed structure of antennas is most appropriate for C and X band applications.

C Antenna Gain and Efficiency

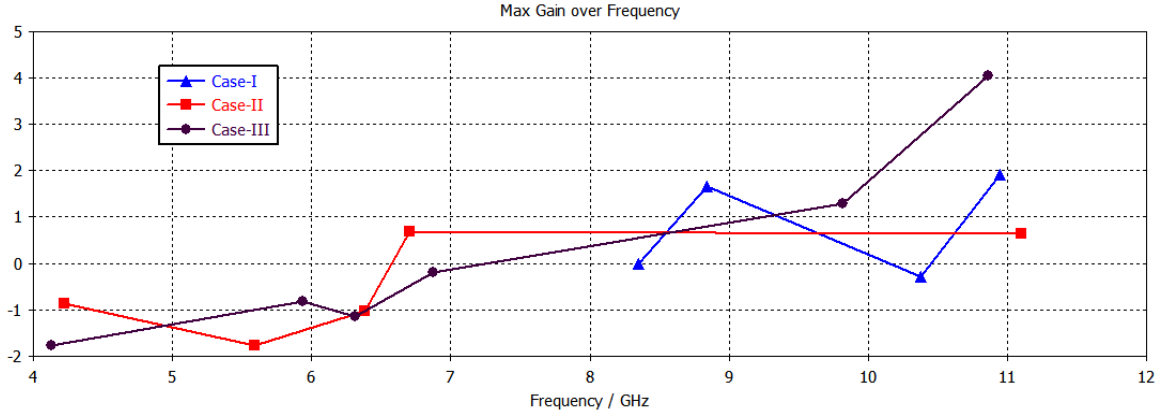

Fig 4 Frequency v/s gain plot.

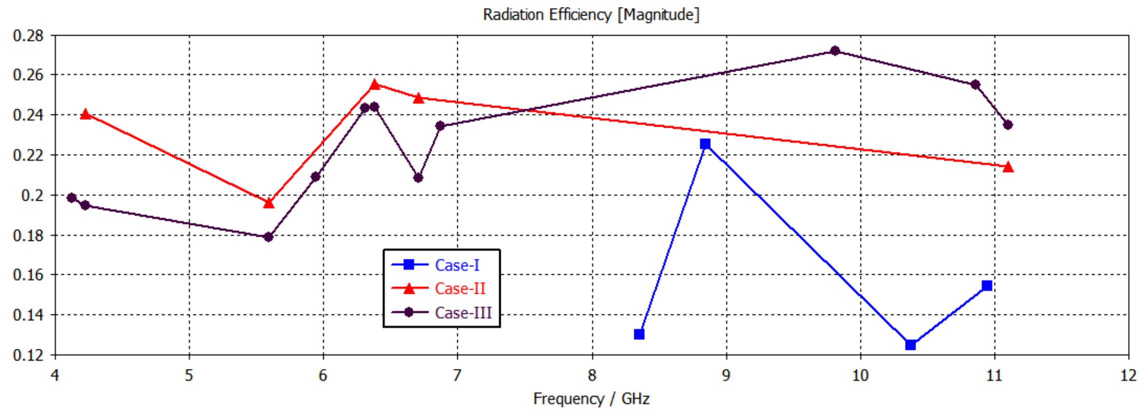

Fig 5 Frequency v/s radiation efficiency plot.

Table 3

S. no.	Proposed antenna Case-I			Proposed antenna Case-II			Proposed antenna Case-III		
	Frequency (GHz)	Antenna Gain(dB)	Radiation Efficiency	Frequency (GHz)	Antenna Gain(dB)	Radiation Efficiency	Frequency (GHz)	Antenna Gain(dB)	Radiation Efficiency
1	8.352	-0.01	13.03%	4.224	-0.87	24.03%	4.128	-1.76	19.85%
2	8.844	1.65	22.5%	5.952	-1.57	19.6%	5.94	-0.82	20.88%
3	10.38	-0.29	12.5%	6.384	-1.02	25.5%	6.312	-1.14	24.31%
4	10.944	1.91	15.5%	6.708	0.69	24.8%	6.876	0.20	23.44%
5	---	---	---	11.1	0.64	21.6%	9.816	1.28	27.19%
6	---	---	---	---	---	---	10.86	4.031	25.42%

Efficiency and gain are important parameters for any antenna. By exploration of the above two diagrams and table-3, it is apparent that the case-III of the proposed antenna is better as compared to previous cases in terms of efficiency and antenna gain.

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IV. Conclusion

In this paper, a rectangular patch E-shaped antenna with two square slots is simulated and produces six resonances, frequency bands. All cases of the proposed antenna were successfully designed and simulated in the CST microwave studio. After analysis and comparison of simulation results, the final conclusion is case-III of the proposed antenna is better. It renders with a minimum return loss of-35.99dB, 9.24% maximum bandwidth, 4.03dB maximum gain, and 27.19% maximum radiation efficiency. The proposed antenna is small in size, easy to fabricate, and compatible with C, and X band applications.

REFERENCES

1. Balanis, Constantine A. "Antenna theory analysis and design, A JOHN WILEY & SONS." *Inc., Publication* (2005).
2. Hossain, Md Biplob, and Md Faruque Hossain. "Design of a Triple Band Rectangular Slot Microstrip Patch Antenna for Wireless Applications." *2020 IEEE Region 10 Symposium (TENSYMP)*. IEEE, 2020.
3. Vaid, Varun, and Sunil Agrawal. "Bandwidth optimization using fractal geometry on rectangular microstrip patch antenna with DGS for wireless applications." 2014 International Conference on Medical Imaging, m-Health and Emerging Communication Systems (MedCom). IEEE, 2014.
4. Mamatha, A. G., and Pradeep M. Hadalgi. "Rectangular Slotted Microstrip Antenna for Multiband Application." 2019 International Conference on Smart Systems and Inventive Technology (ICSSIT). IEEE, 2019.
5. Faiza, Mouhouche, A. Azrar, and Djafri Kahina. "Study of Microstrip antenna using complimentary metamaterial etched in ground plane." *2015 4th International Conference on Electrical Engineering (ICEE)*. IEEE, 2015.
6. Bhat, Mohd Mujtahid, B. K. Subhash, and C. Biradar Rajashekhar. "A Compact Square Shaped Multiband Antenna loaded with Rectangular and U-slots for UMTS, WiMAx, WLAN and X-band Applications." *2019 4th International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT)*. IEEE, 2019.
7. Afzal, W., M. M. Ahmed, and F. A. Mughal. "L-shaped multiband microstrip patch antenna for DCS and WLAN applications." *2013 IEEE 9th International Conference on Emerging Technologies (ICET)*. IEEE, 2013.
8. Islam, M. M., M. T. Islam, and M. R. I. Faruque. "Design of a triple frequency band patch antenna on FR4 substrate material." *2013 IEEE International RF and Microwave Conference (RFM)*. IEEE, 2013.
9. Sharma, Vinay, and Deepak K. Patidar. "Design and analysis of staked multiband microstrip antenna." *International Journal of Advanced Research in Computer and Communication Engineering* 6.4 (2017): 74-80.
10. Saxena, Nikita, and Asmita Rajawat. "Design and Analysis of Multi Band antenna for S and C Band." *2018 International Conference on Advances in Computing, Communication Control and Networking (ICACCCN)*. IEEE, 2018.
11. Parikh, Rina, and Bharati Singh. "Effects of Slots On Resonant Frequencies of a Microstrip Patch Antenna." *2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA)*. IEEE, 2018.