Journal of Nano- and Electronic Physics
Vol. **18** No 1, 01024(4pp) (2026)

Журнал нано- та електронної фізики
Том **18** № 1, 01024(4cc) (2026)

OPEN ACCESS

REGULAR ARTICLE

Analysis of 1 × 4 Array Patch Antenna for 5G Communication

Sathish Kumar Danasegaran[1,*], S. Poonguzhali[2], S. Lalithakumari[2], G. Rajalakshmi[2], R. Pandian[2], A. Sivasangari[3], S. Dhanasekar[1]

[1] *Department of ECE, Sri Eshwar College of Engineering, Coimbatore, India*
[2] *Department of ECE, School of Electrical and Electronics, Sathyabama Institute of Science and Technology, Chennai, India*
[3] *Department of CSE, School of Electrical and Electronics, Sathyabama Institute of Science and Technology, Chennai, India*

(Received 01 December 2025; revised manuscript received 18 February 2026; published online 25 February 2026)

Modern mobile communication relies on 5G technology, which has the latent to advance production efficiency even further, expand the development field of intelligent communication, and meet the transportation needs of enormous amounts of data traffic. This technology can also be applied to various industries. At the moment, 5G mobile communication technology is extensively employed in communication engineering, offering excellent technical assistance throughout engineering construction and operation. This research proposes a 1X4 array patch antenna for 5G wireless communication. In concert with the patch component, the array antenna is crucial in wireless transmission, offering improved antenna characteristics such as return loss, gain, directivity, and bandwidth. The simulation tests were conducted to examine the application effect of 5G in communication engineering from three perspectives: return loss (RL), gain, and directivity. The optimized suggested structure simulates at the frequency of 35 GHz and provides the result of – 41.70 dB RL and more than 9 dB of gain and directivity. The suggested antenna operates within the Ka band spectrum, facilitating high-precision applications such as radar and satellite systems.

Keywords: Array antenna, Kα band spectrum, Microstrip patch antenna, Wireless communication.

DOI: 10.21272/jnep.18(1).01024 PACS number: 84.40.Ba

1. INTRODUCTION

An antenna is an essential component in transmitting and catching electromagnetic radiation from a receiver through air. In a transceiver, a radio source directs an electric flow to the antenna termini, and the antenna radiates the energy as electromagnetic waves. According to IEEE standards, antennas are referred to as "AERIALS". Micro-strip patch antennas (MPA) [1] are widely employed in industry, military, and satellite applications due to their small volume, low weight, simplicity of installation, and inexpensive manufacturing requirements. Among these configurations, a rectangular MPA is recommended for ease of understanding and study of antenna characteristics. The main disadvantages of using this antenna are inefficiency and an extremely narrow bandwidth.

The MPA consists of three essential components: the ground, the substrate, and the patch, together with a feed. The MPA is highly suitable for integration into portable wireless devices, such as cellular phones, and for satellite communications. The advantages of MPA includes reduced weight and volume, lower fabrication costs allowing for mass production, capability for both linear and circular polarisation, ability to operate at double and triple frequencies, and enhanced mechanical strength when affixed to stiff surfaces.

MPA possess several disadvantages, including limited transmission capacity, reduced efficiency, unwanted radiation from feeds and junctions, and lower gain. In communication satellite there are numerous bands like X-band, C-band, and k-bands. Among these bands k-above-band is employed for satellite application that has higher information measure in satellite communication. K-above band is additionally used for military applications in a broad region. The frequency of k-above band ranges 27.5-40 GHz. In satellite applications, a system needs a high- gain antenna for giving a communication link associating the satellite and ground station. Then, at that time the ground-station conveys a signal from the satellite for long distance through wireless transmission [2] and provide powerful radiation intensity.

The most popular strategies used in feeding techniques are microstrip line feed, co-axial probes, proximity and aperture coupling. The micro-strip line feed [3] is used for designing an antenna, which can be directly associated to the patch as a leading strip. The single element MPA is designed, has less gain and low directivity. To overcome these drawbacks array techniques are implemented as 1 × 4 to obtain high gain and better performances.

* Correspondence e-mail: dsathish134@gmail.com

Cite this article as: S.K. Danasegaran et al., *J. Nano- Electron. Phys.* 18 No 1, 01024 (2026) https://doi.org/10.21272/jnep.18(1).01024

2. LITERATURE REVIEW

The design and applications of rectangular MPAs are already available in the literature. Mahatmanto and C. Apriono [4] discussed C Band MPA for satellite applications in the frequency range of 3.794-4.528. The antenna array mentioned was designed with the material called FR4-epoxy as it contains dielectric constant as 4.3 and they used proximity coupling as the feeding technique and attained low spurious radiation. The overall gain obtained as – 13 dB with the working bandwidth 734 MHz and the design has been simulated using CST software. Reynalda [4] designed a 16-patch array antenna for Wi-MAX application with a desired frequency 3.3 GHz. The substrate material Arlon DiClad 527 was used in his design due to its thickness and attained gain of 16.02 dB with RL of 29.85 dB and VSWR of 1.97.

R. Jyosthna et al. [6] designed an antenna with slots and the operating frequency is 31.5 GHz for space application like radio astronomy and space research. The antenna is simulated using ANSYS HFSS. Imtiaj et al. [7] designed an antenna in X-band for satellite television with desired frequency 10.7 GHz with co-operate feeding technique and obtained a gain of 4 dB with RL – 18.62 dB. A high gain 2 × 1 circularly polarized rectangular micro-strip array antenna in the frequency of 5.8 GHz using slot and RT rogers 5880 and achieved a gain 10.77 dB with RL as – 24.63 dB for wide communication. V. Prakasam et al. [8] describes two feeding technique as micro-strip line feeding and pin feeding line and the antenna design is printed on NPC-H220A as substrate material. The frequency range was 8.0 to 8.4 GHz with the RL of – 12.5 dB and – 19.8 dB.

Kumar et al. [9] described future 5G application with desired frequency 7GHz, used the substrate FR4, coaxial cable as a feed the gain attained was – 21.5 dB. P. Squadrito et al. [10] compared two feeding techniques such as micro-strip line feeding and co-axial probe feeding in a rectangular MPA array. The material used was FR-4 with dielectric constant 1.6mm and simulated using CST software. D. Chandwani et al. [11] described the effect of different substrate materials such as FR4 and Rogers R3006 The feeding technique is implemented as micro-strip feed line. Better output was obtained when using Rogers 3006 in X-band.

Gharbi et al. [12] compared eight patches with single patch antenna and shown increase directivity and gain for the application of WLAN at 2.4GHz. The material is used FR-4 with RL – 19.64 dB and VSWR as 1.2 for WLAN. F. Kurniawan et al. [13] presented an array antenna for satellite communication in the operating frequency of 12 GHz with substrate material FR-epoxy obtained a gain of 8.98 dB and efficiency of 83 % with the bandwidth 693.6 MHz. For S band applications at the desired frequency of 2.45 GHz, D. Okwum [14] created a Rectangular MPA array. This array can be utilised in mobile satellite communication systems as well as in Bluetooth, Zigbee, and Wi-Fi communication technologies.

A MPA array with an inset feed approach was proposed by G. C. Huang and M. F. Iskander [15] with a resonant frequency of 30 GHz. The material utilized was RT/duroid5880, which had a relative permittivity of 2.2. With an RL of – 26.52 dB, the 2 × 3 array antenna outperformed the single patch antenna; also, the gain (G) 8.88 dB, respectively. This array has several company feeding mechanisms running at a frequency of 5.8 GHz. The outcomes encompass shifting the substrate's dimensions and the ground's length. At the 5.8 GHz resonant frequency, the patch antenna has a peak gain of 5.24 dB.

Table 1 – Geometry of suggested antenna

Parameters	Values
Width of patch (w_{pt})	3.38
Length of patch (l)	2.43
Resonant frequency (f_r)	35GHz
Dielectric constant (ε_r)	2.2
Width of the ground (w_g)	7.28
Length of the ground (l_g)	6.33
Height of thickness (h)	0.65
Thickness (t)	0.208

These are the values and parameters required for designing a rectangular shape patch antenna of four array element.

3. DESIGN STRUCTURE

An antenna with array is designed with four rectangular patches connected with four micro-strip feed line varies A PEC material is used for feed line and end feeder to advance the antenna performance as shown in fig.1. End feeder is given to give power to the feed line and patches to produce accurate results required in gain, directivity, VSWR and RL. The power gets dissipated inside the feed line and gets reflected in the substrate to produce radiation.

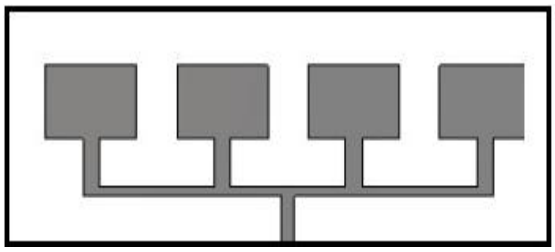

Fig. 1 – Structure of 1 × 4 patch antenna array

4. SIMULATION AND RESULTS

An array is simulated and virtualized using software known as CST Microwave Studio Suite which empowers fast and gives exact analysis of high frequency devices.

4.1 *S*-Parameter

S-parameter, commonly referred to as scattering parameters or reflection coefficient characterises the relationship between input and output at various ports within an electrical system. It also demonstrates the extent of power that is reflected from the antenna. The *S*-parameter of proposed 1 × 4 antenna array 1 is shown in Fig. 2.

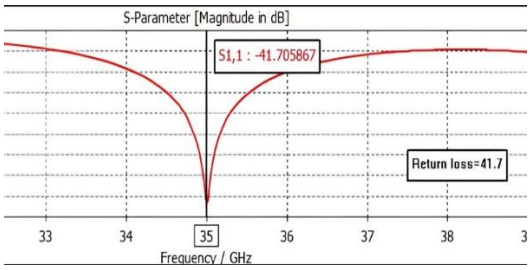

Fig. 2 – *S*-parameter

4.2 VSWR

The voltage standing wave ratio (VSWR) is an important metric that quantifies the amount of reflected power on a transmission line. The effective range of a VSWR is from 1 to 2, with values extending from 1 to infinity. The VSWR of suggested antenna array is shown in Fig. 3.

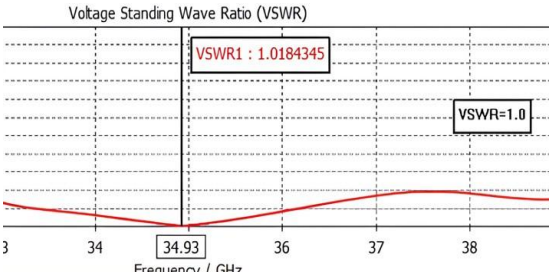

Fig. 3 – VSWR plot

4.3 Radiation Pattern

The radiation pattern is characterised by two key properties: gain and directivity. The gain values various directions. The directivity is employed to assess the antenna radiation patterns in a specific direction and illustrated in Figure 4.

5. ANALYSIS OF THE PROPOSED ANTENNA IN RELATION TO EXISTING STRUCTURES

The Table 2 list the different proposed antenna structure characteristics. The existing structure has reported with poor directivity, VSWR, RL gain and efficiency. The proposed structure of an antenna array has high return RL compared to the existing references. Compared to existing structures in the literature, the proposed structure has greater directivity and high gain. Likewise, the efficiency of proposed antenna is 98.7 % than the existing structure which provides better output for satellite applications.

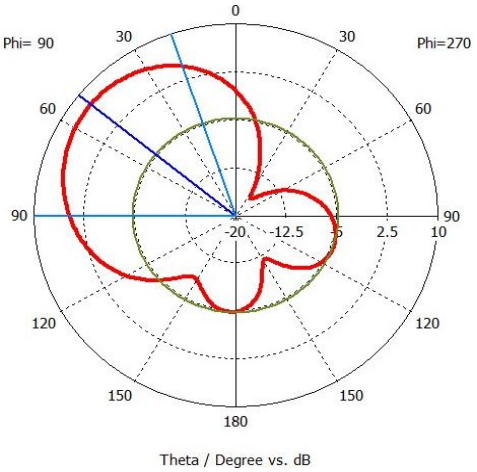

Fig. 4 – Radiation pattern

Table 2 – Proposed antenna with existing structures

Existing references	Antenna characteristics				
	Freq. (GHz)	RL (dB)	VSWR	Gain (dB)	Directivity (dB)
Proposed antenna	35	– 41.7	1.018	9.737	9.833
Ref. [4]	3.734-4.385	—	—	6.55	—
Ref. [7]	10.74	– 18.62	1.2	4	—
Ref. [8]	2.45	– 11.21	1.7	9.225	9.633
Ref. [9]	7.3	– 21.5	1.183	—	—
Ref. [12]	2.4	– 19.64	1.20	—	—

6. CONCLUSION

A rectangular MPA array of 1 × 4 structure is designed and simulated using CST software with desired frequency 35 GHz. The structure yields the outcome of -41.7 dB RL, 1.018 VSWR, 9.73 dB gain and directivity of 9.83 dB. In wireless communication systems, an array of antennas can improve gain and directivity, beamforming, signal-to-noise ratio, data rate, and is utilised in massive MIMO and phased arrays for applications such as 5G, radar, and satellite communication.

REFERENCES

1. Sathish Kumar Danasegaran, Lalithakumari Swaminathan, Anand Kumar Vaithilingam, Arunakiri Sivasangari, *J. Nanophoton.* **18** No 4, 046010 (2024).
2. D.S. Kumar, S. Lalithakumari, G. Rajalakshmi, R. Pandian, A. Sivasangari, S. Poonguzhali, *ICSTSN*, 1-5 (Villupuram: 2024).
3. G. Rajalakshmi, Sathish Kumar Danasegaran, R. Pandian, N. Jaypal, S. Lalithakumari, *Opt. Quant. Electron.* **56**, 1282 (2024).
4. B.P.A. Mahatmanto, C. Apriono, *International Conference on Telecommunications (ICT)*, 1-5, (2020).
5. T. Reynalda, A. Munir, E. Bharata, *TSSA* (Indonesia: 2020).
6. R. Jyosthna, R.A. Sunny, A.A. Jugale, M.R. Ahmed, *International Conference on Communication and Signal Processing*, 406 (Chennai: 2020).
7. S. Imtiaj, S. Bhattacharya, *IEEE Calcutta Conference*, 189 (Calcutta: 2020).
8. V. Prakasam, K.R. Anudeep Laxmikanth, P. Srinivasu, *ICCNCT* (2020).
9. D.S. Kumar, S. Pavithra, K.S. Ranjith, R. Kiruthika, E. Kavin, *International Conference on Electronics, Communication and Aerospace Technology*, 1464 (Coimbatore: 2023).
10. P. Squadrito, P. Livreri, L. Di Donato, C. Squadrito, G. Sorbello, *Electronics* **8** No 6, 689 (2019).
11. D. Chandwani, M.C. Sai, R. Kumari, *2019 3rd International*

Conference on Electronics, Communication and Aerospace Technology, 986 (2019).
12. Gharbi, R. Barrak, M. Menif, H. Ragad, *International Conference Sci. Tech. Autom Control Computer Engineering STA*, 674 (2018).
13. Farohaji Kurniawanet, Josaphat Tetuko Sri Sumantyo, Cahya, Edi Santosa, Peberlin Parulian Situmpol, Pachrur Razi, Gunayan Setyo Prabowo, *Photonics & Electromagnetics Research Symposium – Spring*, 3902 (Italy: 2019).
14. D. okwum, J. Abolarinwa, O. Osanaiye, *2020 International Conference in Mathematics, Computer Engineering and Computer Science*, 1 (2020).
15. G.C. Huang, M.F. Iskander, *IEEE International Symposium on Antennas and Propagation and North American Radio Science Meeting*, 1529 (2020).

Аналіз 1 × 4-мережевої антенної решітки для зв'язку 5G

Sathish Kumar Danasegaran[1], S. Poonguzhali[2], S. Lalithakumari[2], G. Rajalakshmi[2], R. Pandian[2], A. Sivasangari[3], S. Dhanasekar[1]

[1] *Department of ECE, Sri Eshwar College of Engineering, Coimbatore, India*
[2] *Department of ECE, School of Electrical and Electronics, Sathyabama Institute of Science and Technology, Chennai, India*
[3] *Department of CSE, School of Electrical and Electronics, Sathyabama Institute of Science and Technology, Chennai, India*

Сучасний мобільний зв'язок спирається на технологію 5G, яка має потенціал для подальшого підвищення ефективності виробництва, розширення сфери розвитку інтелектуального зв'язку та задоволення потреб у транспортуванні величезних обсягів трафіку даних. Ця технологія також може бути застосована в різних галузях промисловості. Наразі технологія мобільного зв'язку 5G широко використовується в комунікаційній інженерії, пропонуючи чудову технічну допомогу протягом усього інженерного будівництва та експлуатації. У цьому дослідженні пропонується патч-антенна решітчаста 1X4 для бездротового зв'язку 5G. У поєднанні з патч-компонентом, антенна решітчаста є вирішальною в бездротовій передачі, пропонуючи покращені характеристики антени, такі як втрати на відбиття, коефіцієнт посилення, спрямованість та пропускна здатність. Моделювальні випробування були проведені для вивчення впливу застосування 5G в комунікаційній інженерії з трьох точок зору: втрати на відбиття (RL), коефіцієнт посилення та спрямованість. Оптимізована запропонована структура моделює на частоті 35 ГГц та забезпечує результат – 41,70 дБ RL та понад 9 дБ коефіцієнта посилення та спрямованості. Запропонована антена працює в спектрі Ka-діапазону, що сприяє високоточним застосуванням, таким як радіолокаційні та супутникові системи.

Ключові слова: Антенна решітка, Спектр Kα діапазону, Мікросмужкова патч-антена, Бездротовий зв'язок.