Journal of Alasmarya University: Basic and Applied Sciences
Vol. 6, No. 5, December 2021, Special Issue for Forth Conference on Engineering Science and Technology (CEST-2021)
مجلة الجامعة الأسمرية: العلوم الأساسية والتطبيقية
المجلد 6 ،العدد 5، ديسمبر 2021، عدد خاص بالمؤتمر الرابع للعلوم الهندسية والتقنية (CEST-2021)

A Flexible and Compact 28 GHz Inset Fed Rectangular Patch Antenna Based on Circuit in Plastic Technology for 5G System

Salem A. Almazok

Electrical & Computer Engineering Department, Faculty of Engineering, Alasmarya Islamic University, Libya

ABSTRACT

This paper presents the use of circuit in plastic (CiP) as a new technology to develop a polycarbonate substrate microstrip patch antenna (PSMPA) for a fifth-generation (5G) system. The proposed compact PSMPA operates at a resonant frequency of 28 GHz and uses silver as a conductor instead of copper. The polycarbonate substrate has a thickness of 3 mm and a dielectric constant of 2.9. The inset feed technique is used as a feeding scheme to match the patch and the 50 Ω microstrip line. The proposed PSMPA structure has been simulated using Computer Simulation Technology (CST) Microwave Studio and its performance has been evaluated and compared with similar existing designs in the literature. The proposed PSMPA shows a return loss (S_{11}) of -23.011 dB, bandwidth (BW) of 1.173 GHz, voltage standing wave ratio (VSWR) of 1.3560, gain (G) of 5.684dBi, and radiation efficiency (ηrad (%)) of 70.14%.

***Keywords**:*
Antenna.
Antenna parameters.
Circuit in plastic.
Fifth-generation.
Patch antenna.
28GHz frequency band.

Author Email: salemalmazok1986@gmail.com

1 INTRODUCTION

The antenna is an essential component of the wireless communication system that serves as a transducer for transmitting and receiving radio electromagnetic waves. In such a situation, the antenna behaves like an electrical element or a conductive tool that results in converting electromagnetic waves or radio frequencies into electrical energy. Nowadays, there is a rapidly growing need for higher data rates in wireless mobile communication networks. Due to the requirements of compact systems with large bandwidth and high data rates, wireless technologies have evolved from the first generation (1G) to the fifth generation (5G). Unfortunately, the current operating mobile networks still cannot meet all the requirements of end-users. To solve this problem, the 5G mobile network system has been developed. It is expected that the 5G system will greatly improve the communication capacity by utilizing an enormous amount of millimeter-wave (mm-wave) spectrum band [1,2]. In addition, the 5G system is expected to support and offer an extremely high data rate, which is hundreds of times the capacity of the fourth generation (4G) system [1,3,4]. The 5G system offers several advantages. The main advantages include wide bandwidth, high-security features, higher energy efficiency, and the ability to support numerous users simultaneously at a high speed. 5G is also capable of supporting rich multimedia features such as interactive gaming and video conferencing [5,6]. To meet the above requirements, the antenna in the 5G system and its parameters such as gain, directivity, and bandwidth can affect the overall performance of the 5G system.

ISSN: 2706-9524 (Print) ISSN: 2706-9532 (Online)

In the 5G system, the antenna must be broadband to allow a high bit rate so that multiple applications can be reached. It should also provide high gain to reduce obstacles to radio waves [2,7].

Due to the advancement in wireless mobile technology, antennas must be lightweight, easy to install, compact (low profile), small, easy to manufacture, compatible with non-planar and planar surfaces, and fit in the area designed for the antenna in the mobile phone [2,6]. The microstrip patch antenna (MPA) can meet the criteria for mobile and wireless communication technologies. The MPA has advantageous features such as low cost, low profile, ease of fabrication and feeding, operation in multiple bands, and compatibility with non-planar and planar surfaces [6], [8]. The MPA consists of three layers, the bottom ground layer and the top patch layer, which is usually made of copper as the conducting element. These two layers are separated by a dielectric substrate [9]. Although copper is one of the most commonly used conductive elements in MPA, it is a contaminated material in the environment. Some studies are focusing on the development of alternative materials that can replace copper [10].

Circuits in plastic (CiP) is a new technique presented to fabricate fully waterproof circuits inside their area in the heat treatment phase [11]. This new CiP technique proposed to use transparent plastic as a substrate to be used in humid, dusty, and massive impact environments. Moreover, silver paint was used as a conductor instead of copper to minimize the negative impact on the environment [10]. In this work, a 28GHz MPA for 5G applications based on CiP principle has been presented as new technology. The novelty in this work is the use of a new CiP technology concept to develop an MPA for a 5G system. The proposed antenna based on CiP technology uses silver as the conductor for the ground and patch layers and transparent plastic polycarbonate as the substrate. The proposed polycarbonate substrate microstrip patch antenna (PSMPA) uses the inset feed technique and is simulated using Computer Simulation Technology (CST) Microwave Studio [12]. The rest of this paper is organized as follows. Section 2 presents the materials and methods, Section 3 presents the calculations of the proposed PSMPA and the design process, Section 4 presents the simulation results and discussion, and finally, Section 5 presents the conclusion and outlook for future work.

2 MATERIALS AND METHODS

To evaluate the performance of the proposed antenna and analyze the obtained results, firstly, the PSMPA design is needed, the designing process consists of multiple steps, these steps include identifying the operating resonant frequency and the bandwidth, selecting the substrate material type and its dimensions, determining the ground plane dimension, identifying the rectangular patch dimension and determining the feeding technique [13].

The PSMPA is designed to be inset feed broad-band and operated on the resonant frequency at 28GHz, The 28 GHz frequency band was specifically chosen for several reasons. First, there is a wide range of available and licensed mm-Wave bands around the 28 GHz band that is underutilized and can provide hundreds of megahertz to support 5G services [14,15].

Second, compared to other higher frequencies, the 28 GHz band is particularly well suited for creating multipath propagation environments and can be used for non-line-of-sight propagation [14]. In addition, the 28 GHz frequency band is one of the mm-Wave bands available in most countries around the world, making 28 GHz a globally harmonized frequency band [15]. The proposed PSMPA design uses new CiP technology so that silver material is used as a conductor for ground and patch layers, whereas transparent polycarbonate plastic is a substrate. Polycarbonate (PC) is classified under the thermoplastic noncrystalline polymers which is one of the plastic or polymer materials which represent the preferred materials for flexible antenna applications [16]. The used silver has a conductivity of 6.3012e+07 [S/m] and the used lossy PC for the substrate is a normal type with a dielectric constant ε_r= 2.9.

3 THE PROPOSED PSMPA CALCULATION AND DESIGN

Edges dimension calculations of the proposed PSMPA are performed to form the shape of the antenna and this calculation mainly depends on the operating frequency, the type of dielectric substrate, and its relative permittivity, which represent the design foundation of the PSMPA.

In the first step, the maximum value for the thickness of the substrate was identified based on the following formulation [13].

$$S_{th} \leq \frac{0.3c}{2\pi f_r \sqrt{\varepsilon_r}} \leq \frac{0.3\times 3 \times 10^8}{2\pi \times 28 \times 10^9\sqrt{2.9}} \leq 0.3\text{mm} \quad (1)$$

Where S_{th} is the substrate thickness, c = 3×10^8 is the speed of electromagnetic waves in free space, f_r is the resonant frequency and ε_r dielectric constant.

The next step is to calculate the width of radiating patch based on the following calculation [13]:

$$W_P = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{3 \times 10^8}{2 \times 28 \times 10^9}\sqrt{\frac{2}{2.9+1}} = 3.84\text{mm} \quad (2)$$

Where W_P is the patch width.

Regarding the length of radiating patch, the effective dielectric constant $e\varepsilon_r$ of the substrate is needed to be calculated first. it is determined based on the following formula[13] :

$$e\varepsilon_r = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2\sqrt{1+12(\frac{S_{th}}{W_P})}} = \frac{2.9+1}{2} + \frac{2.9-1}{2\sqrt{1+12(\frac{0.3}{3.84})}} = 2.63 \quad (3)$$

After calculating$e\varepsilon_r$, the patch effective length l_e also need to be calculated according to the following equation [13]:

$$l_e = \frac{c}{2f_r\sqrt{e\varepsilon_r}} = \frac{3 \times 10^8}{2 \times 28 \times 10^9\sqrt{2.63}} = 3.30 \text{ mm} \quad (4)$$

Next, the decrement value Δl in patch length is also needed to be calculated to determine the final patch length, Δl is calculated using the following formula [13]:

$$\Delta l = \frac{0.412 \times S_{th}\,(e\varepsilon_r+0.3)\,(\frac{W_P}{S_{th}}+0.264)}{(e\varepsilon_r-0.258)(\frac{W_P}{S_{th}}+0.8)} = \frac{0.412\times 0.3\times 10^{-3}\,(2.63+0.3)\,(\frac{3.84}{0.3}+0.264)}{(2.63-0.258)(\frac{3.84}{0.3}+0.8)} = 0.15 \text{ mm} \quad (5)$$

Then, the value of patch length $L_P$is calculated as following [13]:

$$L_P = l_e - 2\Delta l = 3.30 - 2(0.15) = 3\text{mm} \tag{6}$$

After determining the patch dimensions, the dimensions of the ground plane also need to be calculated. The length of the ground plane L_g is calculated using the following equation [13]:

$$L_g = L_P + 6S_{th} = 3 + 6(0.3) = 4.8\text{mm} \tag{7}$$

The width of the ground plane W_g is calculated using the following equation [13]:

$$W_g = W_P + 6S_{th} = 3.84 + 6(0.3) = 5.64\text{mm} \tag{8}$$

Taking into account that the dielectric substrate is placed and adjusted on the ground plane so that the substrate has assumed to have the same dimensions.

The used silver material as a conductor for ground and patch layers has thickness (Ag_{th}) of 0.015 mm. The thickness was chosen to be 0.015 mm to account for the fact that the thickness of the conductor is several times skin depth [17], so 0.015 mm was thick enough. Moreover, this thickness of silver (0.015 mm) is one of the options available on the market.

For calculating the inset feed depth F_i, the following formula is used to determine the inset depth [4]:

$$F_i = 10^{-4}[0.001699\varepsilon_r{}^7 + 0.1376\varepsilon_r{}^6 - 6.1783\varepsilon_r{}^5 + 93.187\varepsilon_r{}^4 - 682.69\varepsilon_r{}^3 + 25619.9\varepsilon_r{}^2 - 4043\varepsilon_r + 6697]\,\frac{L_P}{2} \tag{9}$$

$$F_i = 10^{-4}[0.001699(2.9)^7 + 0.1376(2.9)^6 - 6.1783(2.9)^5 + 93.187(2.9)^4 - 682.69(2.9)^3 + 25619.9(2.9)^2 - 4043(2.9) + 6697]\frac{3\times10^{-3}}{2} = 1.17\text{mm}$$

Also, there are auxiliary parameters A and B that need to be determined to calculate the dimensions of the feed line with characteristic impedance $Z_c = 50\ \Omega$ [13] :

$$A = \frac{Z_c}{60}\sqrt{\frac{\varepsilon_r+1}{2}} + \frac{\varepsilon_r-1}{\varepsilon_r+1}(0.23 + \frac{0.11}{\varepsilon_r}) = \frac{50}{60}\sqrt{\frac{2.9+1}{2}} + \frac{2.9-1}{2.9+1}(0.23 + \frac{0.11}{2.9}) = 1.29 \tag{10}$$

$$B = \frac{60\pi^2}{Z_c\sqrt{\varepsilon_r}} = \frac{60\pi^2}{50\sqrt{2.9}} = 6.95 \tag{11}$$

Considering auxiliary parameter A is lower than 1.52, the feed line length L_f and its width W_f can be determined from the following equations [13]:

$$L_f = 3S_{th} = 3(0.3) = 0.9\text{mm} \tag{12}$$

$$W_f = \frac{2}{\pi}\left\{B - 1 - \ln(2B-1) + \frac{\varepsilon_r-1}{2\varepsilon_r}\left[\ln(B-1) + 0.39 - \frac{0.61}{\varepsilon_r}\right]\right\}.S_{th} \tag{13}$$

$$W_f = \frac{2}{\pi}\left\{6.95 - 1 - \ln(2\times6.95-1) + \frac{2.9-1}{2\times2.9}\left[\ln(6.95-1) + 0.39 - \frac{0.61}{2.9}\right]\right\}\times 0.3\times10^{-3}$$

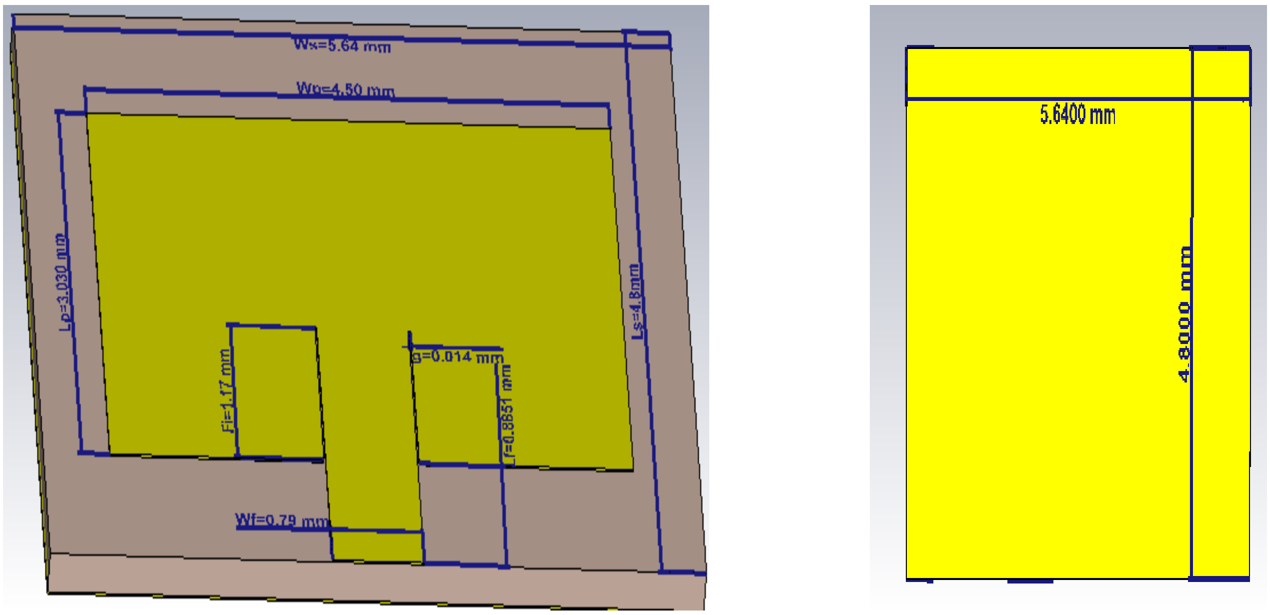
$$W_f = 0.79\text{mm}.$$

The notch width g was selected to be g =0.014 mm.

Up to this stage, the numerical model for the designing process of the proposed PSMPA is completed, the previous values were used for the initial design. However, The L_P is manually changed from 3 mm to 3.030 and W_P changed from 3.84 to 4.50 mm to adjust the resonant frequency to be at 28 GHz and enhance the performance parameters of PSMPA. The change in L_P leads to an insignificant change in L_f to become 0.8851 mm instead of 0.9 mm. The PSMPA design parameters are tabulated in Table 1. The designed simulated PSMPA in CST studio is shown from the top and back view sides in Figure 1.

Table 1. PSMPA design parameters.

Parameter	Symbol	Dimension(mm)
Substrate Thickness	S_{th}	0.3.
Patch Width	W_P	4.50.
Patch Length	L_P	3.030.
Ground Plane Width	W_g	5.64.
Ground Plane Lenght	L_g	4.8.
Dielectric Constant	ε_r	2.9.
Substrate Width	$W_s = W_g$	5.64.
Substrate Length	$L_s = L_g$	4.8.
Feed Line Width	W_f	0.79.
Feed Line Length	L_f	0. 8851.
Silver Thickness	Ag_{th}	0.015.
Inset feed depth	F_i	1.17
Notch Width g	G	0.014



(a) **(b)**

Figure 1. PSMPA top and back view sides: (a) PSMPA top view side; (b) PSMPA back view side.

4 RESULTS AND DISCUSSION

The proposed designed PSMPA was simulated using CST Microwave Studio to evaluate its performance, there are five parameters were used for this purpose, these parameters include: return loss S_{11}, bandwidth BW, voltage standing wave ratio VSWR, gain G, and radiation efficiency ηrad (%).

4.1 Return Loss S_{11}

Return loss S_{11} is measured in dB and it represents the ratio between the incident power and reflected power of the MSPA [18,19], S_{11} also named as reflection coefficient [13,18,19]. -10 dB value of $S_{11}$is selected as the reference value which indicates that 90% of incidental power is received by the antenna and only 10% of the power is reflected, this percentage is considered good for the mobile communication system [13]. Hence S_{11} should be a minimum -10 dB to provide effective performance [18,19]. Simply S_{11}tells how much power is reflected. The lower S_{11}, the better performance of the antenna is achieved. Figure 2 shows the result of S_{11} concerning the frequency. It can be observed from the figure that at 28 GHz, S_{11} value is -23.011 dB which is considered a good value of S_{11}as it means only 0.49% of the input power is reflected.

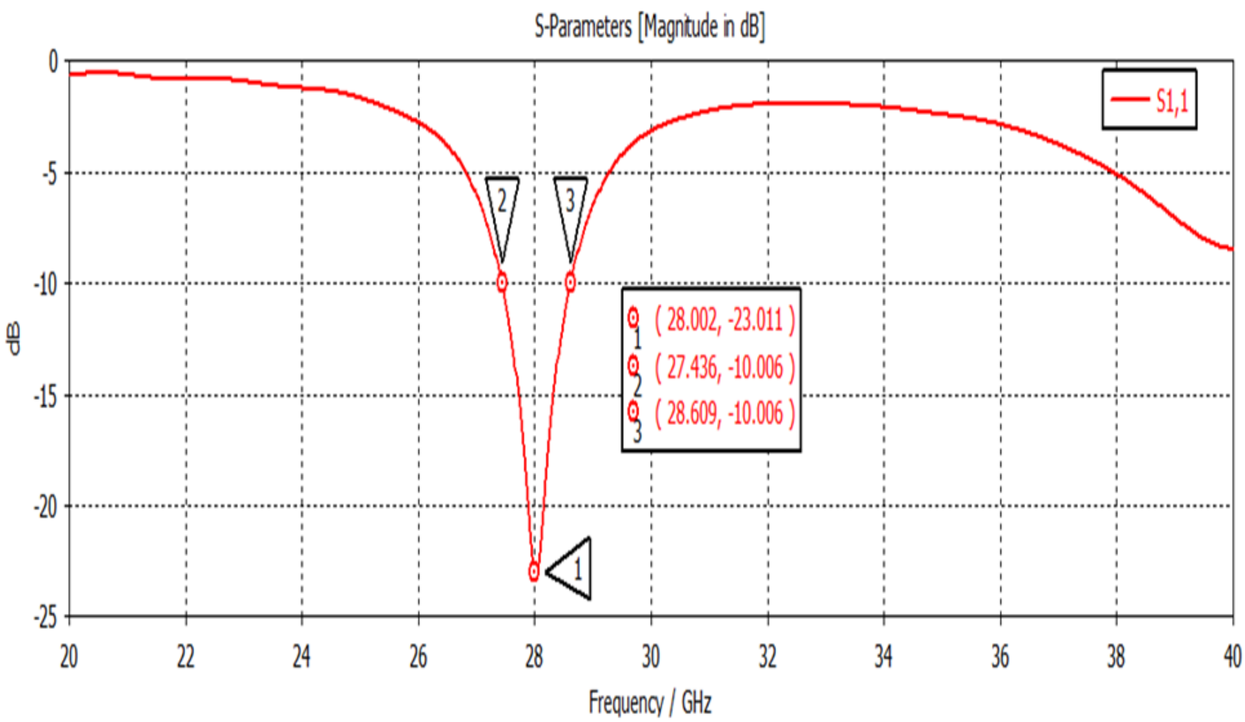


Figure 2. S_{11} with respect to frequency of PSMPA

4.2 Bandwidth BW

The BW of the proposed PSMPA can be calculated as the difference between the frequencies where S_{11} is lower than -10 dB [2], based on Figure 2, BW will be in this case the difference between 28.609 GHz and 27.436GHz (28.609-27.436=1.173GHz). Accordingly, the PSMPA has BW=1.173 GHz which is very good compare to others in the literature.

4.3 Voltage Standing Wave Ratio VSWR

VSWR is a quantity that represents the amount of reflected power from the antenna toward the transmitter [2]. In terms of MSPA, VSWR should not exceed 2 and less than 1 across the bandwidth of the antenna. In an ideal case, VSWR equals 1[4, 13]. Figure 3 shows VSWR versus the frequency of the proposed PSMPA. It can be observed from the figure that the value of VSWR at the resonant frequency is 1.1519. It is an acceptable VSWR value as it is lower than two.

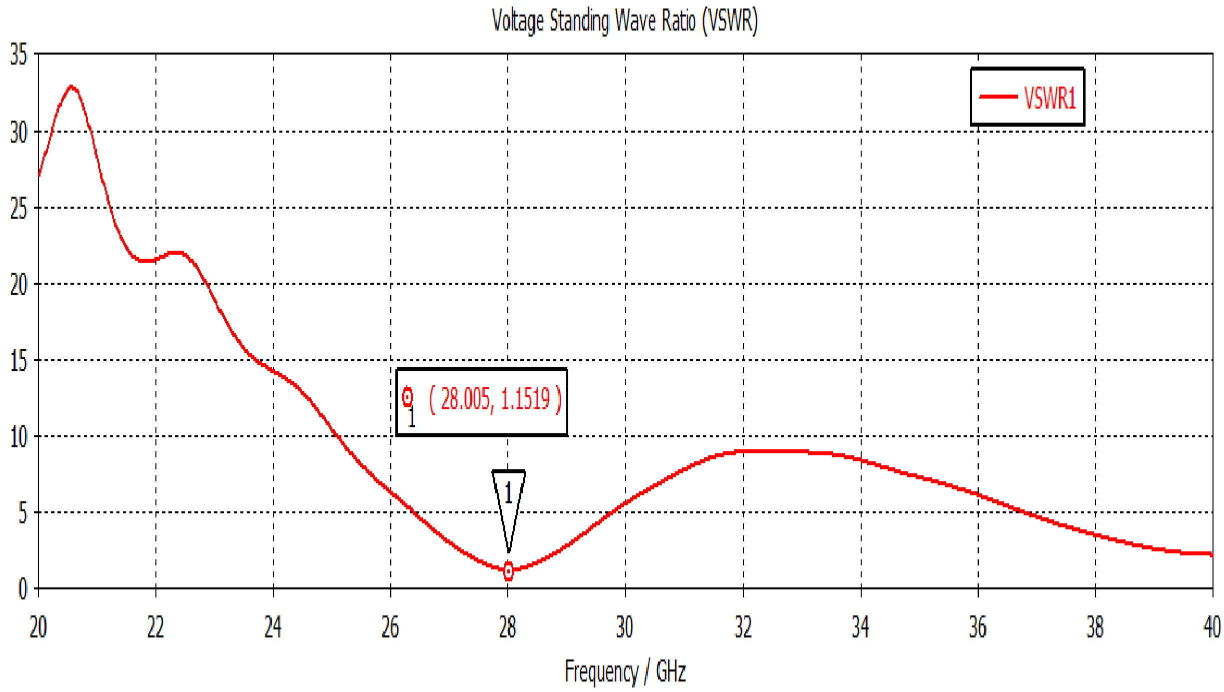


Figure 3. VSWR with respect to frequency of PSMPA.

4.4 Gain G and Radiation Pattern

To show the antenna gain and other antenna characteristics such as directivity and lobes features, a radiation pattern plot in 2-D and 3-D can be used [2]. The radiation pattern is an important parameter that indicates the amount of radiated energy by MPA [18,19]. In terms of gain, it can be defined as the ratio between the power density of the MPA at a specific point to the power density of the reference isotropic antenna at the same point when both antennas feed by the same power [6]. The introduced PSMPA shows a gain of 5.648 dBi at the resonant frequency as occurs in Figure 4 of the 3-D radiation pattern plot, which is considered a competitive value for compact MSPA.

In addition, the PSMPA has 86.8^0 for half-power beamwidth and -14.9 dB for side lobe level value as shown in figure 5 of the 2-D radiation pattern plot.

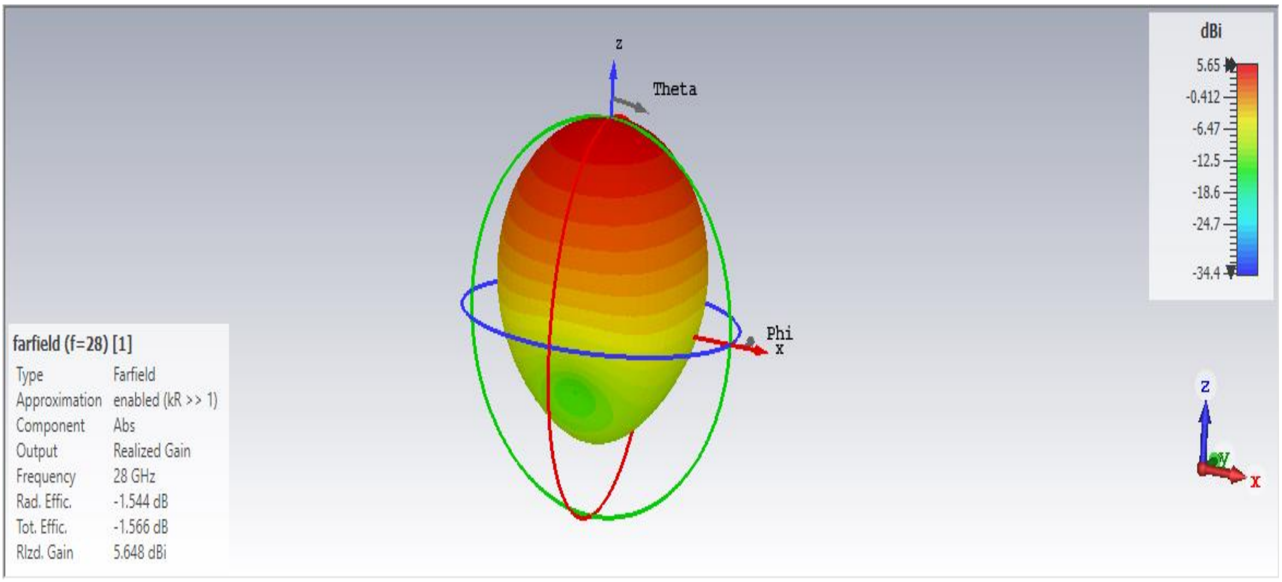


Figure 4. 3-D radiation pattern plot of PSMPA

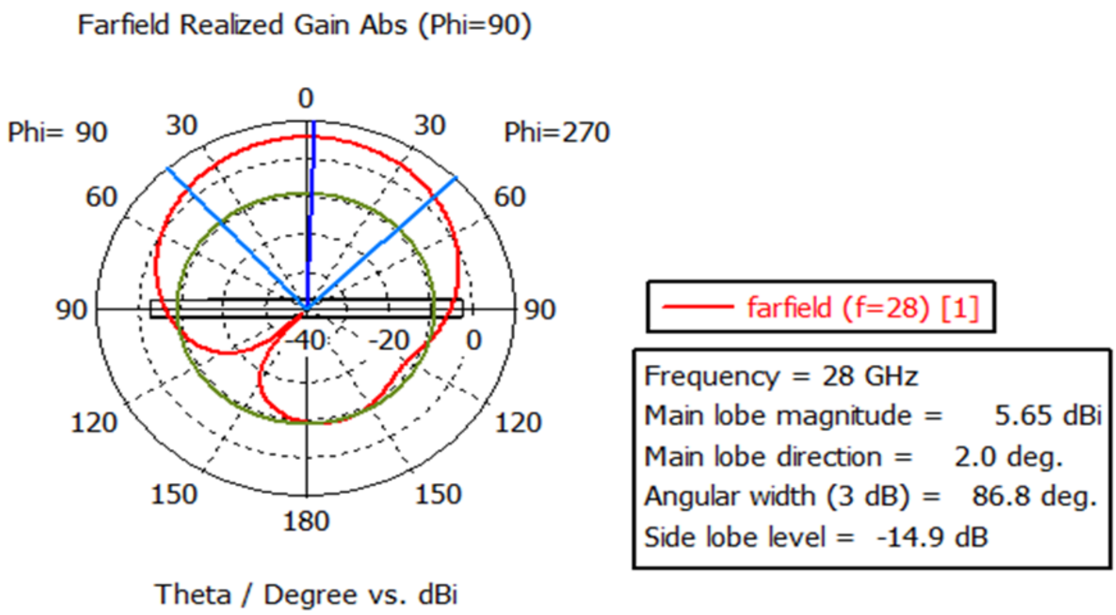


Figure 5. 2-D rdation pattern plot of PSMSPA.

4.5 Radiation Efficiency ad (%)

Radiation efficiency ηrad (%) represents one of the useful performance parameters to indicate how much the antenna is good at transmitting and receiving electromagnetic waves. ηrad (%) can be defined as the ratio between the total power radiated by MPA and total input power received by MPA [19]. ηrad (%) indicated how much of the input power received by MSPA radiated effectively in free space. The higher ηrad (%), the better performance of the antenna is obtained. The introduced PSMPA shows a radiation efficiency of -1.544 dB as indicated in Figure 4. This value is equivalent in percentage to 70.14 %, which can be considered a reasonable result.

4.6 Comparison of the Introduced PSMPA with other Similar Designs

The obtained simulation results of the proposed PSMPA and other results of similar patch antennas presented in the literature are organized in Table 2. The results in Table 2 indicate that the proposed PSMPA shows the lowest S_{11} value in comparison with antennas design introduced in [4,20,21], the lower S_{11} implies less power is reflected and better performance of the antenna is achieved. Regarding BW, The introduced PSMPA indicates the widest bandwidth in comparison to designs cited in [4,20,21]. The wider bandwidth is suitable for a 5G system which needs wide bandwidth. Furthermore, from Table 2 the proposed design shows lower VSWR than designs cited in [4,20,21]. The VSWR of the proposed antenna structure is closer to the ideal value of 1. On the other hand, the proposed design exhibits relatively low realized gain compare to the gain (IEEE) of antenna reported in [20] and also lower than realized gain of antenna reported in [4]. Moreover, the realized gain of the proposed structure is relatively lower than the gain of the antenna cited in [21]. In terms of ηrad (%), the introduced design shows a reasonable percentage of radiation efficacy, and it is 0.04 % lower than the antenna design reported in [4]. In general, the simulation results of the proposed PSMPA structure indicates a competitor performance in comparison with similar previous designs introduced in the literature

Table 2. Comparison of simulation results between introduced PSMPA and similar published researches.

Work Ref. No.	S_{11} (dB)	BW(GHz)	VSWR	G	ηrad (%)
[4]	-13.48	0.847	1.5376	6.630dB	70.18%
[20]	-14.15084	0.8	1.4878	6.061dBi	-
[21]	-12.59	0.582	1.77	6.69 dB	-
Present research	-23.011	1.173	1.3560	5.684dBi	70.14%

5 CONCLUSION AND FUTURE WORK

This work introduces the use of CiP as new technology to design a 28 GHz inset feed polycarbonate substrate microstrip patch antenna PSMPA for a 5G system. The conducted simulations using CST Microwave Studio indicate that the introduced design has S_{11} value of -23.011 dB, 1.173 GHz bandwidth value, and VSWR is 1.3560 in comparison with similar structures. The proposed structure shows better performance in terms of S_{11}, BW and VSWR. However, the limitation of the proposed design is relatively lower gain and radiation efficiency compared to similar structures presented in the literature. The scope for future work can be done to improve the gain and radiation efficiency of the proposed PSMPA structure.

6 REFERENCES

[1]. J. G. Andrews et al. What will 5G be?. IEEE J. Sel. Areas Commun., 2014, 32 (6), pp. 1065–1082.
[2]. K. A. Fante and M. T. Gemeda. Broadband microstrip patch antenna at 28 GHz for 5G wireless applications. International Journal of Electrical and Computer Engineering (IJECE),2021, 11(3), pp. 2238~2244.
[3]. W. Roh et al. Millimeter-Wave Beamforming as an Enabling Technology for 5G Cellular Communications : Theoretical Feasibility and Prototype Results. IEEE Communications Magazine, 2014,25(2),pp. 106-113.
[4]. O. Darboe et al. A 28 GHz Rectangular Microstrip Patch Antenna for 5G Applications. Int. J. Appl. Eng. Res. 2019, 12(6), pp.854–857.
[5]. S. Kumar et al. A Future Communication Technology: 5G. International Journal of Future Generation Communication and Networking,2016, 9(1), pp. 303-310.
[6]. C. Seker and M. T. Güneşer. Design and simulation of 26 GHz patch antenna for 5G mobile handset. In 11th Conference International Conference on Electrical and Electronics Engineering (ELECO), Bursa, Turkey.IEEE,2019,676-678.
[7]. S. Ershadi et al. Wideband High Gain Antenna Subarray for 5G Applications. Progress In Electromagnetics Research C, 2017, 78, pp. 33-46.
[8]. M. A. Misbah, et al. Design and Analysis of Millimeter-Wave Microstrip Patch Antenna for 5G Applications. In The International Conference on Technical Sciences (ICTS2019), Tripoli, Libya,2019,137-142.
[9]. S. R. M.Zaini and K. N. A. Rani. Wearable Inset-Fed FR4 Microstrip Patch Antenna Design. In IOP Conference Series: Materials Science and Engineering, 2018,1-9.
[10]. F. Majeed and D.V.Thiel. An Optimized Circuit in Plastic Meander Line Antenna for 2.45 GHz Applications. International Journal of Antennas and Propagation, 2016,2016, pp.1
[11]. D.V.Thiel et al. Plastic circuit reliability and design for recycling. In Proceedings of the 11th Electronic
Packaging Technology Conference, Singapore, 2009, 858–862.
[12]. CST Studio Suite. CST Microwave Studio. 2019. Available from: http:// www.cst.com.
[13]. R. Przesmycki et al. Broadband Microstrip Antenna for 5G Wireless Systems Operating at 28 GHz. Electronics, 2021, 10(1),pp.2-19.
[14]. K. Sakaguchi et al. Where when and How mmWave is used in 5G and beyond. IEICE Trans. Electron., 2017,100(10), pp. 790-808.
[15]. Halberd Bastion Radiofrequency Technologies. n257 (28 GHz). Available from:
https://halberdbastion.com/technology/cellular/5g-nr/5g-frequency-bands/n257-28-ghz [Accessed 27 Oct 2021].
[16]. S. G. Kirtania et al. Flexible Antennas: A Review. Micromachines, 2020, 11(9), pp 5.
[17]. M. E. V. Valkenburg and W. M. Middleton .Reference Data for Engineers: Radio, Electronics, Computers and Communications, 9th edition, Boston, Newnes,2001,p 6-6. [Online] Available from:
https://www.sciencedirect.com/science/article/pii/B978075067291750008X [Accessed 29 Oct 2021].
[18]. M. Faisal et al. Return Loss and Gain Improvement for 5G Wireless Communication Based on Single Band Microstrip Square Patch Antenna. In 1st International Conference on Advances in Science, Engineering and Robotics Technology 2019 (ICASERT 2019), Dhaka, Bangladesh,2019, 1-5.
[19]. J. Colaco and R. lohani. Design and Implementation of Microstrip Circular Patch Antenna for 5G Applications. In 2020 International Conference on Electrical, Communication, and Computer Engineering (ICECCE), Istanbul, Turkey, 2020, 1-4.
[20]. Dr.M.Kavitha et al. 28 GHZ Printed Antenna for 5G Communication with Improved Gain Using Array. International Journal of Scientific & Technology Research, 2020,9(3),pp 5127-5133.

[21]. R. K. Goyal and U. Shankar Modani,. A Compact Microstrip Patch Antenna at 28 GHz for 5G wireless Applications. In 2018 3rd International Conference and Workshops on Recent Advances and Innovations in Engineering (ICRAIE), Jaipur, India, 2018, 1-2.

تصميم هوائي شريطي مستطيل مرن ومضغوط بتغذية داخلية عند تردد 28 جيجاهرتز باستخدام تقنية الدائرة البلاستيكية لنظام الجيل الخامس

سالم عبدالله المزعوق

قسم الهندسة *الكهربائية والحاسوب*، كلية الهندسة، الجامعة الأسمرية الإسلامية، زليتن، ليبيا

الملخص

يقدم هذا البحث كيفية استغلال تقنية الدائرة البلاستيكية (CiP) كتقنية جديدة لتصميم الهوائي الشريطي الدقيق بطبقة عازلة من البولي كربونيت (PSMPA) لنظام الجيل الخامس (5G) . يعمل هوائي PSMPA المضغوط المقترح بتردد رنين يبلغ 28 جيجاهرتز ويستخدم الفضة كموصل بدلاً من النحاس مع مادة الطبقة العازلة المصنوعة من البولي كربونيت بسماكة 3 مم وثابت العزل الكهربائي 2.9، تُستخدم تقنية التغذية الداخلية كاحد التغذية لمطابقة الرقعة الشريطية والخط الشريطي الدقيق الذي قيمة معاوقته 50 اوم. تمت محاكاة هوائي PSMPA المقترح باستخدام تقنية محاكاة الكمبيوتر (CST) وتم تقييم أدائه ومقارنته بالتصاميم الموجودة المماثلة في المؤلفات. يُظهر PSMPA المقترح فقد إرجاع (S_{11}) بقيمة23.011- ديسيبل ، وعرض النطاق الترددي (BW) بقيمة 1.173 جيجاهرتز ، ونسبة الموجة المتوقفة للجهد (VSWR) 1.3560 ، وقيمة الكسب (G) 5.684 ديسيبل ، وكفاءة الإشعاع (ηrad %) بقيمة 70.14%.

البريد الإلكتروني للباحث: salemalmazok1986@gmail.com

الكلمات الدالة:
الهوائي.
معاملات الهوائي.
الدائرة اللاستيكية.
الجيل الخامس.
الهوائي الشريطي الدقيق.
النطاق الترددي 28 جيجا هيرتز.