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5G ДВУХДИАПАЗОННАЯ ПРЯМОУГОЛЬНАЯ МИКРОПОЛОСКОВАЯ АНТЕННА С ДВУМЯ ТРАВЛЕНИЯМИ И ВЕРХНИМ ШЕСТИГРАННЫМ ВЫРЕЗОМ НА КОНЦЕ CPW FED

Во всем мире беспроводная или удаленная связь стала фундаментальной и незаменимой. Каждый день миллиарды пользователей получают доступ к звонкам, Интернету и социальным сетям. Многие электрические устройства, в том числе антенны, используются в сложных сетях и системах, поддерживающих такой массивный обмен информацией. Электрическое устройство, известное как антенна, отправляет или принимает информацию в космосе. Антенна является ключевым компонентом многих систем, в том числе радио- и телевизионной передачи, приемников связи, радаров, сотовых телефонов, гаджетов с поддержкой Bluetooth и спутниковой связи. Быстрое распространение беспроводных технологий и персональной связи увеличило спрос на многодиапазонные антенны, которые могут работать на нескольких частотах и подходят для различных приложений. В этой статье представлена двухдиапазонная прямоугольная микрополосковая патч-антенна с *компланарным волноводом (CPW) для приложений 5G, WiMAX, ISM и WLAN. Предлагаемая антенна надежна, дешева, легка и проста в изготовлении, резонирует на частоте 2,4 ГГц при -12,182379 s11 с полосой пропускания 205,7 МГц и на частоте 3,42 ГГц при -37,344879 s11 с полосой пропускания 464,9 МГц, тогда как усиление составляет 3,85 и 3,41 соответственно. Патч-элементы размещаются на изолирующей подложке FR408 (без потерь) с относительной диэлектрической проницаемостью 3,75, высота подложки составляет 1,6 мм. Результаты моделирования представлены с помощью CST STUDIO SUITE 2019.*

Приложения 5G; патч-антенна; питание CPW; двухдиапазонный режим; CST 2019.

Yu.V. Yukhanov, I.A. Alshimaysawe

A 5G DUAL-BAND RECTANGULAR MICROSTRIP ANTENNA WITH TWO ETCHES AND UPPER HEXAGONAL END CUT CPW FED

Around the world, wireless or distant communication has become fundamental and indispensable. Every day, billions of users access calls, the internet, and social media. Many electrical equipment, including the antenna, are used in the sophisticated networks and systems that support that massive information interchange. An electrical device known as an antenna sends or receives information across space. The antenna is a key component in many systems, including radio and television transmission, communications receivers, radar, cellular phones, Bluetooth-enabled gadgets, and satellite communications. The rapid expansion of wireless technology and personal communication has increased the demand for multiband antennas, which can operate at several frequencies and are suited for a variety of applications. Dual-band coplanar waveguide (CPW) fed rectangular microstrip patch antenna for 5G, WiMAX band, ISM Band, and WLAN applications is presented in this paper. The proposed antenna is robust, cheap, light weight, and easy to fabricate, resonating at 2.4 GHz in -12.182379 s11 with 205.7 MHz BW and 3.42 GHz in -37.344879 s11 with 464.9 MHz BW whereas gain is 3.85 and 3.41 respectively. Patch elements are placed on isolation FR408 (loss-free) substrate of relative permittivity 3.75 kept at a substrate height of 1.6 mm. Results of simulation are presented using CST STUDIO SUITE 2019.

5G applications; patch antenna; CPW-fed; Dual-band; CST 2019.

I. Introduction. It is well recognized that an antenna is one of the most significant electrical devices for receiving and/or transmitting information across space [1]. Microstrip antennas are extremely popular these days, with a wide range of applications due to their lightweight, small size, high-performance characteristics, and conformance [2]. These antennas are characterized by being small in size and can be easily integrated with other structures with the possibility of being resonant for more than one frequency [3, 4]. Where the radiating patch is located above the dielectric substrate and a ground plane is located beneath the substrate layer. Due to the simplicity of performance estimation, different antenna configurations such as rectangular, square, and circular patch forms are used [5]. These antennas are commonly found in portable electronics such as laptops and cell phones, and used in satellite communication and missile system etc [4, 6, 7]. The patch antenna's main disadvantage is its limited bandwidth [8]. To overcome the narrowband bandwidth problem, many approaches have been offered in the literature. Defecting the ground plane with various shapes, lowering the substrate height, and so on are some popular techniques. C.P. Wen created the CPW method in 1969, which is used to construct antennas with minimal weight and low transmission losses [9]. The CPW-Feed approach is less expensive, and line impedance and phase velocity are less affected by substrate height than by slot width [10]. Because of its wide bandwidth, compact structure, and low return loss in monolithic microwave integrated circuits, coplanar waveguide fed antennas have gained popularity [11, 12].

Previous proposed results into CPW fed microstrip antennas by researchers are as follows. In 2016 Paresh Jain and R.K Khola [13] introduced a CPW fed microstrip patch antenna with a rectangular shape at a resonant frequency of 2.4 GHz in -22.1 S11 with 2.55 dB as gain and 1.15 VSWR. In 2018 Dhara M Patel [14] designed a CPW-fed microstrip antenna for uses of wireless (ISM band) application where return loss was – 19.65dB at 2.4GHz. In 2020 Piyush Kuchhal, et al [15] designed microstrip antenna CPW-Fed for commercial uses and various scientific at 2.5 GHz where S11 was -47dB and 1.6 bandwidth. In 2021 Piyush Kuchhal, et al [16] proposed a Co-planer fed (CPW) microstrip antenna with two bands of resonance at 1.8 GHz and 5.2 GHz. In 2021 G. Anjaneyulu and J. Siddartha Varma [17] presented a compact CPW-fed patch antenna that has simple defective ground structures (DGS) at resonating frequency at 10.1 GHz with a gain of 4.2dBi.

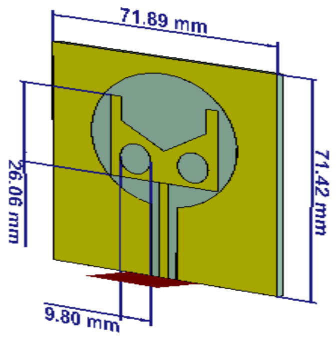

Fig. 1. The microstrip patch antenna design

In this paper, the CPW-fed technique used to design a dual-band antenna suitable to work with the industrial, scientific, and medical radio band (ISM Band), WLAN, WiMAX, and 5G applications [18, 19, 1], consist of a rectangular patch with dual symmetrical holes in circular shapes and upper hexagonal end cut printed on the substrate whereas both the patch and the ground sharing the same plane.

II. Antenna design. The structure of the Coplanar waveguide fed rectangular patch microstrip antenna is intended for 2.4 GHz and 3.42 GHz, as illustrated in figure 2. The antenna's substrate has a dielectric constant (ε_r) of 3.75 with a height of 1.6mm, the patch and ground used copper (pure). Table 1 shows the size of the antenna as simulated in CST.

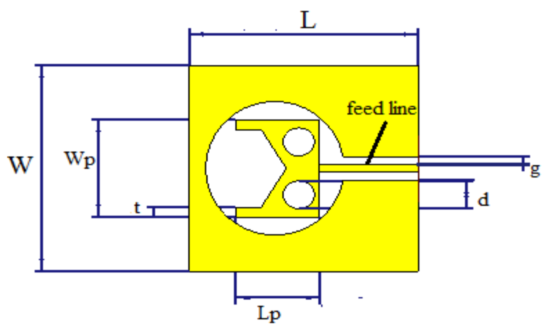

Fig. 2. Antenna geometry proposed

Table 1

Parameters of the antenna design

L (substrate length)	71.42mm
W(substrate width)	71.89mm
H (substrate height)	1.6mm
Lp (patch length)	26.06mm
Wp (patch width)	34.14mm
d (holes diameter)	9.80mm
g (gap)	2.74mm
t (edge width of patch)	3.49mm
L_f (feed length)	30.77mm
W_f (feed width)	2.73mm

The width and length of the conventional Microstrip antenna as shown in both relationships 1 and 2 using the equations found in Balanis [20].

$$L = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}\sqrt{\varepsilon_{reff}}} \quad (1)$$

$$W = \frac{\upsilon_\circ}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (2)$$

where L is an actual length of a patch, ε_{reff} is an Effective dielectric constant, W represents the actual width of a patch, υo denote a free space velocity of light, fr is a resonant frequency and εr is a dielectric constant.

III. Simulation results. The CST STUDIO SUITE Version 2019 software was used to design the proposed antenna. The following are the simulation findings acquired after analyzing the design. The proposed design's Return Loss (S11) against frequency (in GHz) curve is shown in figure 3. At 2.4 GHz with the band (2.3046-2.5103) and 3.42 GHz with the band (3.1969-3.6618), the simulated antenna has a better return loss of -12.182379 dB and -37.344879 dB, respectively. Which is suitable for supporting applications of WLAN(wireless local area network), ISM-band, WiMAX band, and 5G.Figures 4 and 5 depict the radiation pattern in 2D and 3D polar plots for both resonant frequencies, as well as the gain and directivity (in dB).

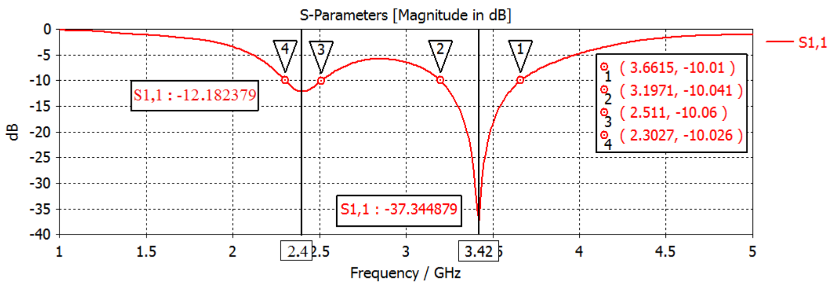

Fig. 3. Return loss (S11) for 2.4 GHz & 3.42 GHz

The VSWR characterizes the antenna's performance in adapting to the transmission line; Unity is the perfect match as agreed with the VSWR simulation results. The VSWR values as a function of the frequency range are shown in figure 6. The VSWR measured at the resonance frequency was 1.0275 for 3.42 GHz, which is considered a typical value, while for 2.4 GHz was 1.6524, it is also in the desirable dual-band conditions (VSWR≤2).

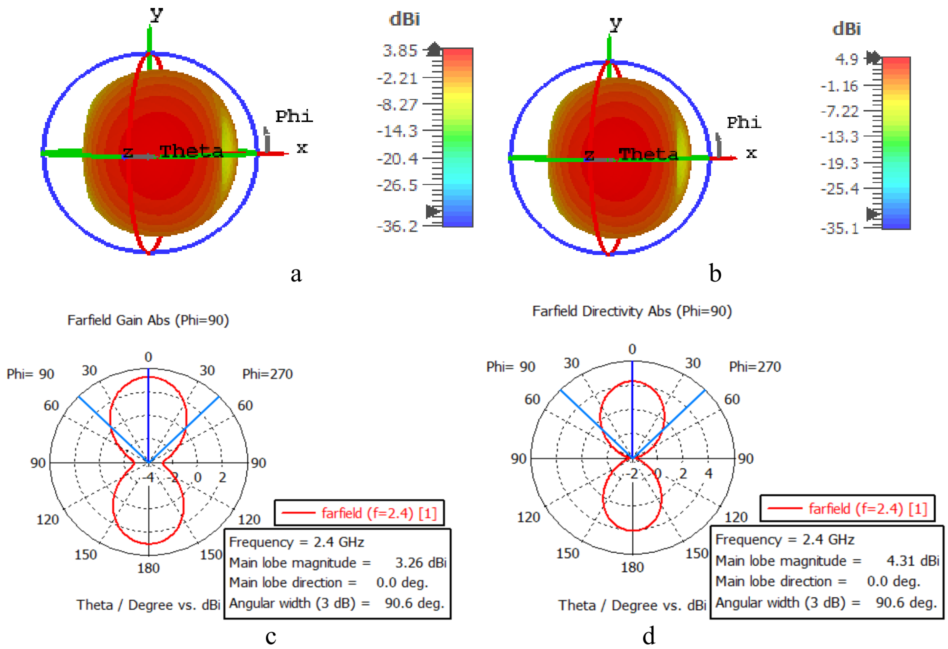

Fig. 4. For 2.4 GHz (a) & (b) show Gain and Directivity respectively in 3D, (c) & (d) show farfield Gain and Directivity respectively in polar plot.

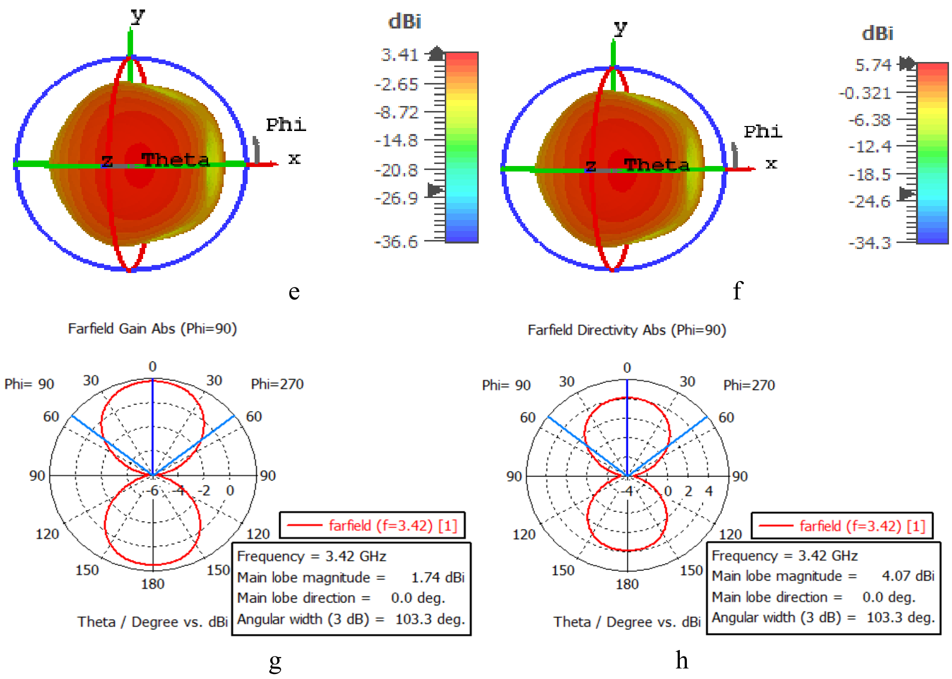

Fig. 5. For 3.42 GHz (e) & (f) show Gain and Directivity respectively in 3D, (g) & (h) show farfield Gain and Directivity respectively in polar plot

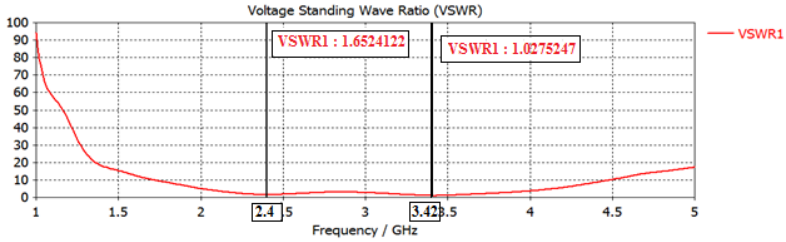

Fig. 6. The VSWR simulated results 2.4GHz & 3.42GHz

Conclusions. Microstrip antenna has become a rapidly growing field of study. Because of their light weight, tiny size, and ease of antenna assembly, their applications are virtually limitless. A robust, affordable, lightweight, and easy to manufacture dual-band CPW-fed rectangular microstrip patch antenna has been introduced using the CST MWS platform. It has a compact size of 71.42 × 71.89 × 1.6 mm^3. The proposed antenna design can work with two bandwidths, making it suitable for current and future 5G bands. The dual-band frequency range provides from 2.3046-2.5103 GHz and 3.1969-3.6618 GHz for resonant frequency 2.4 and 3.42 GHz, respectively, according to the simulation results. These are appropriate for high-data-rate ISM-band, WLAN, WiMAX, and 5G applications.

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ИССЛЕДОВАНИЯ АКУСТИЧЕСКИХ СИГНАЛОВ, ИЗЛУЧАЕМЫХ АВТОМОБИЛЬНЫМ ДВИГАТЕЛЕМ ВНУТРЕННЕГО СГОРАНИЯ

Работа посвящена проблеме диагностирования автомобильных двигателей внутреннего сгорания. Проблема контроля состояния двигателей внутреннего сгорания сейчас наиболее актуально из-за увеличения числа автомобилей и ужесточения экологических требований. В работе рассмотрены последствия работы неисправного двигателя внутреннего сгорания. Целью работы является разработка такого метода, который способен помочь наиболее точно и быстро обнаружить неисправность. С появлением современных технологий давно известный метод оценки состояния двигателей внутреннего сгорания по звуку может стать самым передовым, поскольку исключается человеческий фактор, для обработки сигнала применяется вычислительная техника анализ звукового спектра, в которой осуществляется с помощью искусственных нейронных сетей. Применение искусственных нейронных сетей для анализа звукового спектра нашло применение в распознавание речи и для диагностики заболеваний дыхательной системы. В статье рассмотрены механизмы, которые способны генерировать звуковые сигналы во время работы двигателя