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СВЕРХШИРОКОПОЛОСНАЯ ВНУТРЕННЯЯ ВСЕНАПРАВЛЕННАЯ АНТЕННА 2 × 2 MIMO ДЛЯ ПРИЛОЖЕНИЙ 2G, 3G, 4G И 5G

Многочастотные и широкополосные системы связи превратились в популярную тему исследований в результате растущего спроса на высокоскоростную передачу данных и сосуществования нескольких типов сетей связи. Диаграмма направленности всенаправленных антенн обеспечивает эффективную передачу и прием от мобильного объекта, что делает их удобными для ряда устройств беспроводной связи, а также способными работать с дополнительными отдельными полосами частот. Внедрение широкополосной антенны может быть важно для систем мобильной связи, поддерживающих 2G, 3G, 4G и будущие приложения 5G. Были опубликованы многочисленные исследования широкополосных антенн 5G, поскольку сеть 5G обеспечивает большую пропускную способность данных, большую надежность и меньшее энергопотребление для своей обширной пользовательской базы. Технология MIMO превратилась в ключевую технологию для приложений 5G благодаря преимуществам, включающим увеличение пропускной способности канала, повышение производительности передачи и приема сигналов, установку больших антенн в небольшом пространстве и многое другое. Недавно было предложено несколько разновидностей антенн 5G MIMO для смартфонов. В этом исследовании предлагается широкополосная антенна 2 × 2 MIMO для внутренних систем связи GSM/3G/LTE/5G. Данная антенна создает всенаправленные диаграммы направленности за счет использования двух ан-

тенных элементов, равномерно разнесенных вокруг центра. Одновременно достигается большая полоса пропускания и хорошие характеристики всенаправленного излучения. По результатам моделирования усиление до 7,5 дБ может быть использовано для получения полосы импеданса (0,7-7) ГГц с обратными потерями до -22 дБ. Антенна смоделирована в ANSYS HFSS (high frequency structure simulator) 2020.

Антенна MIMO; всенаправленная; сверхширокополосная.

I.A. Alshimaysawe

ULTRA WIDEBAND INDOOR OMNI-DIRECTIONAL 2 × 2 MIMO ANTENNA FOR 2G, 3G, 4G, AND 5G APPLICATIONS

Multi-frequency and wideband communication systems have developed into a popular research topic as a result of the rising demand for high-speed data transfer and the coexistence of several types of communication networks. The radiation pattern of Omni-directional antennas allows for effective transmission and reception from a mobile unit, making them handy for a number of wireless communication devices as well as capable of handling additional distinct frequency bands. Implementing a wide bandwidth antenna, however, might be important for mobile communication systems supporting 2G, 3G, 4G, and upcoming 5G applications. Numerous studies on 5G wideband antennas were published because the 5G network allows for larger data throughput, greater robustness, and lower power consumption for its vast user base. The MIMO technology has developed into a key technology for 5G applications because of the benefits include increasing channel capacity, boosting the performances of transmitting and receiving signals, fitting large antennas into a small space, and more. Recently, several varieties of 5G MIMO antennas for smartphones were proposed. This research proposes a wideband 2 × 2 MIMO antenna for indoor GSM/3G/LTE/5G communication systems. The antenna in use produces Omni-directional radiation patterns by employing two antenna elements that are evenly spaced out around the center. Concurrently, a large bandwidth and good omnidirectional radiation performance are attained. According to simulation results, a gain of up to 7.5 dB can be used to obtain an impedance bandwidth of (0.7-7) GHz with return losses as high as -22. The antenna is simulated by ANSYS HFSS (high frequency structure simulator) 2020.

MIMO antenna; omni-directional; ultra wideband.

I. Introduction. As telecommunication vendors look to provide 5G mobile communication systems in the world, base station and mobile antennas must to evolve to fulfil the new sub-6 GHz 5G frequency bands as well to the existing 2G, 3G and 4G bands (0.7-0.96 GHz and 1.7-2.7 GHz) [1]. THE fifth-generation (5G) communication technology can offer various benefits over the present 4G system, including a greater transmission rate and reduced latency [2–4]. It has been shown that a multiple-input, multiple-output (MIMO) antenna system should be used for 5G operations below 6GHz in order to achieve a greater transmission rate [5–13]. Several 5G MIMO antennas for smartphones have recently been proposed [14–17]. The European Commission (EC) unveiled its spectrum strategy for 5G testing in 2016, including the bands between 3.4 and 3.8 GHz. China's Ministry of Industry and Information Technology (MIIT) formally declared in 2017 that the 3.3-3.4 (indoor only), 3.4-3.6, and 4.8-5 GHz bands are set aside for 5G services [18]. A single antenna element covering the desired frequency bands is preferable than several antennas for multiple bands for indoor base stations where there is a limited amount of room for installing antennas [1]. Numerous efforts have been made to meet the 2G, 3G, 4G, and 5G applications using a single antenna that covers the frequency bands from 0.7 to 0.96 GHz and from 1.7 to 2.7 GHz [1]. In [19], dipole and patch antennas were utilized to compare performance with the proposed 2 × 2 MIMO antenna, a wide-band multiple-input multiple-output (MIMO) antenna with dual-band (2.4 and 5 GHz) operation was proposed for premium indoor access points (IAPs). In [20], the description of a technique for integrating dual-band frequencies into a single layer board with wide bandwidth. In this study, a dual-band printed dipole antenna is created by combining rectangular and two "L"-shaped radiating elements, which are embedded on a single layer structure that is relatively small. The printed dipole antenna, which covers the frequencies of 2400–2500 MHz and 4900–5875 MHz, can fully support two IEEE WLAN standards. In [21], achieved a novel omni-directional antenna with wideband and low cross-polarization for GSM1800/3G/LTE/5G indoor communication systems. The proposed antenna achieves the omni-directional radiation patterns by using printed log-periodical antenna elements that are evenly distributed around the center. Additionally, a wide bandwidth and strong omnidirectional radiation performance are accomplished concurrently between 1.7 and 3.8 GHz with a gain of roughly 1.5 dBi across the entire operating frequency thanks to the cooperation of the log-periodical antenna and annular parasitic patches. In [22], the proposed antenna consists of three radiators above a ground plane, a monopole made up of three patches fed by a coaxial line, a coupling patch above the monopole with three shorting legs to increase the lowest operating frequencies, and a top-loading disk on top of the coupling patch to further reduce the lowest operating frequencies, From 650 MHz to 6 GHz, an improved impedance bandwidth of 9.23:1 was attained with S11 -13.9 dB (for SWR 1.5). In [23], a technique for creating a small, horizontally polarized, dual-band omnidirectional antenna was presented; it combines an electrically compact upper-band Alford loop antenna with a lower-band omnidirectional loop antenna on a single substrate. To reduce the gain variation in the azimuthal plane, a method for effectively extending the Alford loop's bandwidth was developed, the electrically small loop is fed by four symmetrical radial strips extended from a circular patch, for demonstration, the electrically small loop and Alford loop were created for the 2.4- and 5-GHz Wi-Fi bands. It covers the Wi-Fi bands of 2.4-2.5 GHz and 5.1-5.9 GHz. In [1], two orthogonal dipole antennas make up the antenna used to achieve dual polarization. Three different radiator types—elliptical dipoles, bowtie dipoles, and cat-ear-shaped arms for various bands—make up each dipole. The suggested antenna provides three broad bands with individually controllable fractional bandwidths of 31.3% (0.7-0.96 GHz), 55.3% (1.7-3 GHz), and 14% (3.3-3.8 GHz). In [24], this submission demonstrated a brand-new 3-D circular conformal MIMO antenna system made up of three MED antennas. In order to achieve the dual band radiation, the single MED element was carefully designed to include one main (lower-band) dipole and two auxiliary (upper-band) dipoles. The MED element displays an impedance bandwidth of 54.2% (1.68 GHz-2.93 GHz) with a stable gain of 6.05±1.15dBi in the lower band and 9.2% (3.32 GHz-3.64 GHz) with 5.71±0.7dBi in the upper band, respectively.

In this paper, an antenna designed in [25] is developed, operating at frequencies (698-960) MHz and (1710-2700) MHz with a gain of 3 and 4, respectively, and having a VSWR value of ≤ 2.0 for the lower frequency band and ≤ 1.8 for the upper frequency band. Typical 2×2 MIMO antennas that are omnidirectional radiation pattern were developed by changing the material type for rods No.1 and 2 in Figure No.1 from aluminum metal to plastic, the results showed that a third band (2.8-3.8) GHz, and can be used for fifth generation applications, and the antenna has become more efficient. The antenna consisted of a range (0.7-7 GHz) and gain up to 7.5 dB. The frequency covers the entire WLAN frequency band (IEEE 802.11b/g and 802.11a/j) and the antenna has sufficient gain and beam coverage to apply to a premium access point, requiring the antenna to operate in the entire WLAN frequency band. a broadband antenna may make sense for mobile communication systems serving 2G, 3G, 4G and new 5G applications. It differs from the aforementioned antennas by its wide bandwidth and low return loss in addition to high gain, which makes it suitable for use in many areas and for all generations of communication systems (2-5G).

II. The proposed antenna design. The structure of the circular shape 2×2 MIMO antenna is intended for 0.8 GHz to 5.2 GHz and 0.7 GHz to 7 GHz, as illustrated in figures 1 & 2 respectively. The antenna's ground is aluminum has diameter = 213mm and thickness 1.5mm, also it consist of two active wings and two passive wings made of copper and four rods made of plastic and six rod made of aluminum. The size of the antenna as simulated in ANSYS HFSS 2020 as shown in fig. 1 and 2.

In figure 1 we have replaced the two metal rods in [25] with two plastic rods and this is the modification we have made to the shape of the antenna we proposed to develop, in fig. 2 we have added a dielectric (box) made of materials with a relative permittivity ranging from 1 to 9, and analyzed the effect on the parameters of the antennas. The best results were obtained with the values ε =2 and ε =4.

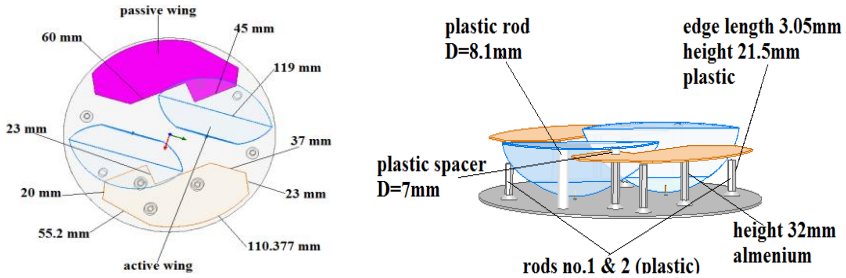

Fig. 1. MIMO 2×2 antenna Circular shape

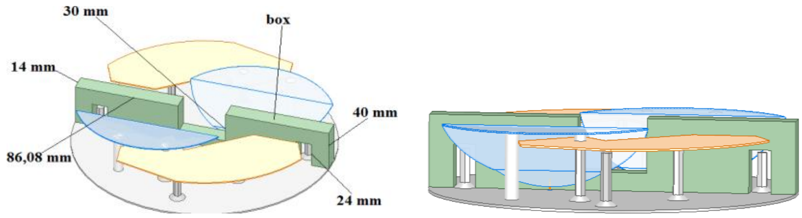

Fig. 2. MIMO 2×2 antenna Circular shape with box in the center

III. Results and discussions. The ANSYS HFSS Version 2020 software was used to design the proposed antenna. In this design of the proposed antenna in fig. 1, the results of each were obtained S11, VSWR, Radiation Intensity, Gain, Realized Gain for an ultra-wide band (0.8-5.2) GHz, whereas minimum value for S11 is -22 in 1.92 GHz, the best value for VSWR 1.16 in 1.92 and maximum value for the Gain is 6.4 dB in 4 GHz, as shown in figures (3-7). Blue dashed curves show the characteristics of the original antenna [25], and solid red curves show the characteristics of the antenna after modification of the type of rods 1 and 2 for plastic, as in fig. 1, where the proposed antenna differed in obtaining the third range (2.8–3.8) GHz, which allows it to be used for 5G applications and with greater efficiency than its predecessor.

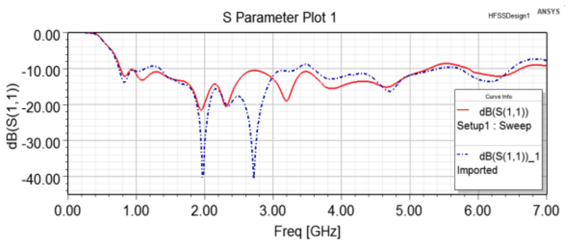

Fig. 3. Return Loss (S11)

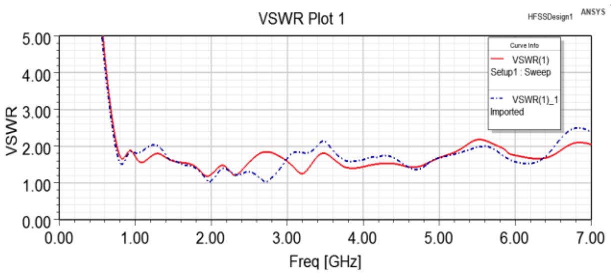

Fig. 4. The VSWR Simulated Results

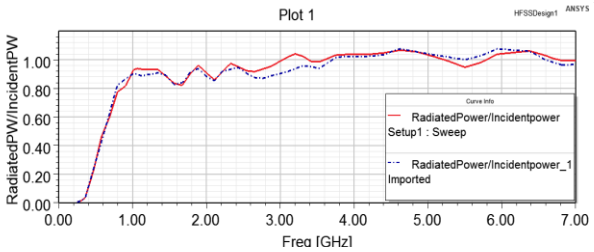

Fig. 5. The Radiated Power / Incident Power vs. Frequency

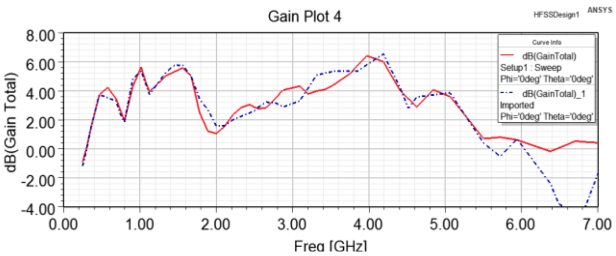

Fig. 6. The Gain vs. Frequency

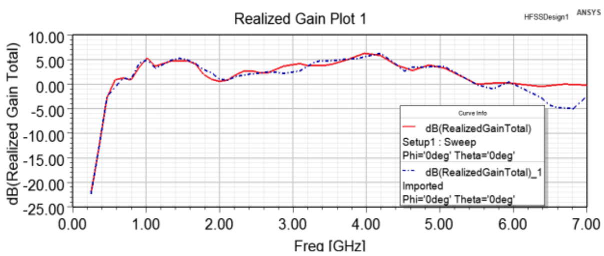

Fig. 7. The Realized Gain vs. Frequency

When laying dielectric part (box) with material have relative permittivity equal to 2 as in fig. 2 will get the results as shown in fig. (8-12), where obtained S11, VSWR, Radiation Intensity, Gain, Realized Gain for an ultra-wide band (0.77-5 & 5.9-7) GHz, whereas minimum value for s11 is -21 in 2.24 GHz, the best value for VSWR 1.2 in 2.24 and maximum value for the Gain is 5.9 dB in 0.95 GHz. red dashed curves show the characteristics of the antenna in fig. 1, and solid green curves show the characteristics of the antenna after adding dielectric part, as in fig. 2.

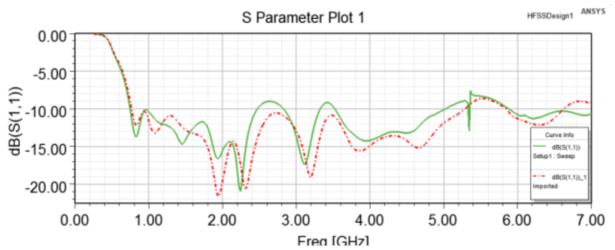

Fig. 8. Return Loss (S11)

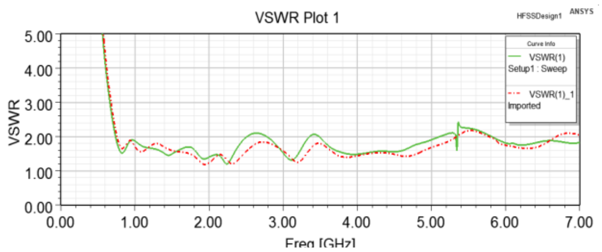

Fig. 9. The VSWR Simulated Results

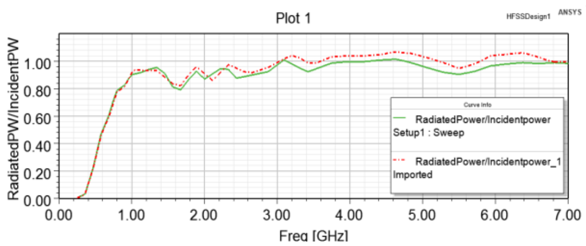

Fig. 10. The Radiated Power / Incident Power vs. Frequency

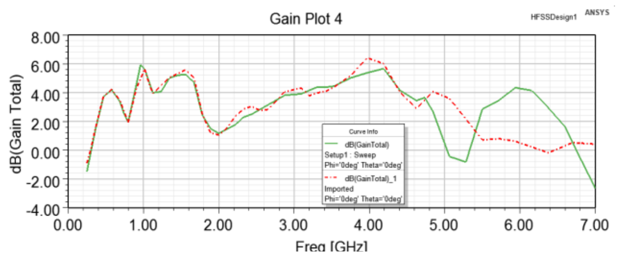

Fig. 11. The Gain vs. Frequency

Fig. 12. The Realized Gain vs. Frequency

When laying dielectric part with material have relative permittivity equal to 4 as in fig. 2 will get the results as shown as shown in fig. (13-17), where obtained S11, VSWR, Radiation Intensity, Gain, Realized Gain for an ultra-wide band (0.7-0.91 & 1.1-1.5 & 1.8-2.3 & 2.75-6.3) GHz, whereas minimum value for s11 is -15.5 in (0.8 & 1.3) GHz, the best value for VSWR 1.4 in 0.8 & 1.3 and maximum value for the Gain is 7.5 dB in 4.4 GHz. red dashed curves show the characteristics of the antenna in fig. 1, and solid green curves show the characteristics of the antenna after adding dielectric part, as in fig. 2.

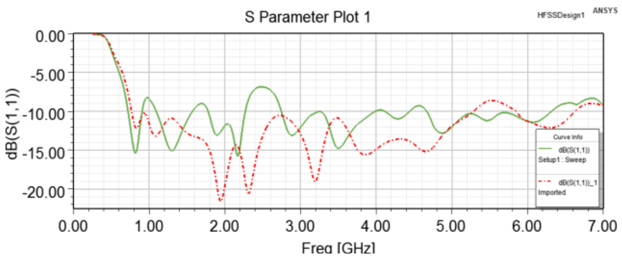

Fig. 13. Return Loss (S11)

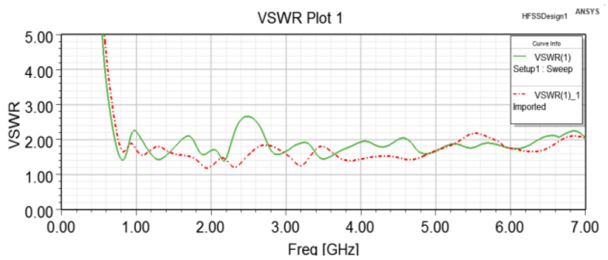

Fig. 14. The VSWR Simulated Results

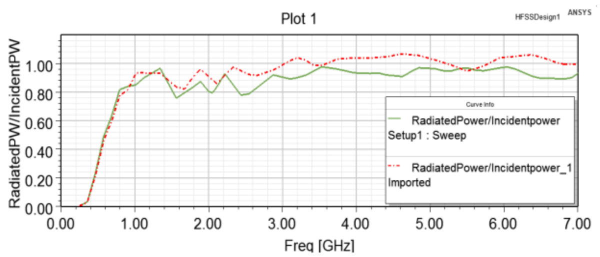

Fig. 15. The Radiated Power / Incident Power vs. Frequency

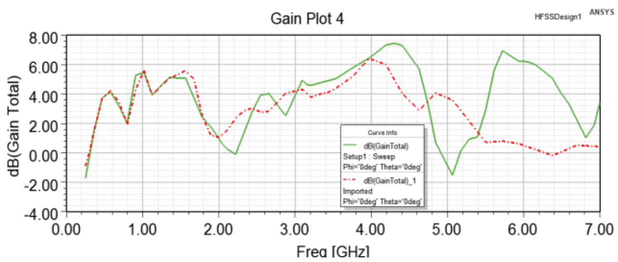

Fig. 16. The Gain vs. Frequency

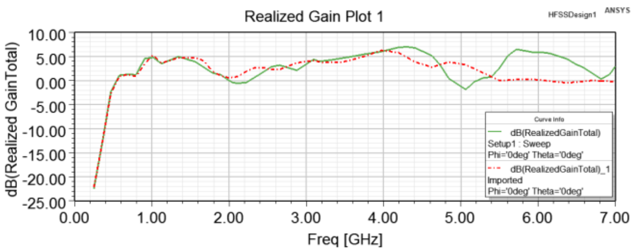

Fig. 17. The Realized Gain vs. Frequency

In comparison between results for the antenna without dielectric part (box) and the antennas with box in the two cases of material of the box, observe that the best values of S11 & VSWR for frequencies (0.7-0.91) GHz, (1.1-1.5) GHz & (4.7-6) GHz in case of material with relative permittivity(ε) equal to 4, while for frequency (6-7) GHz is best in case of material with relative permittivity(ε) equal to 2 & all other frequencies in band (0.8-5.2) GHz get the best in case of the antenna without box. The higher value of Gain in frequencies (5.7, 4.4, 1.1) GHz in ε =4, 0.95GHz in ε =2 and (1.6, 5.1, 2.2) GHz in the antenna without box.

According to the results obtained, we can choose the appropriate shape for the antenna and use the required permittivity of the added box in the manufacture of the antenna according to the important part of the frequency that we want to use for the fifth generation applications, where the antenna in Figure No. (1) is suitable for specific applications, while it is in figure No. (2) with permittivity (ε =2) and (ε =4), it is suitable for other applications, according to the results above.

Conclusions. The demand for antennas that can function across a broad spectrum of frequencies has increased as a result of the quick development of wireless technology and personal communications, making them more desirable for a number of applications and compatible with both current and future communication generations. In this paper, designed a wide-band MIMO antenna with an omnidirectional radiation pattern. The 2×2 MIMO antenna with Circular shape produced ultra-wide band frequencies (0.7-7GHz) with gain up to 7.5 dB and return losses getting close to -22, can be used in multiple applications and for all generations of mobile communication (2G, 3G, 4G and 5G applications), all classes WLAN and next new applications.

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