Dual Band Frequency Slotted Microstrip Antenna Design

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***Abstract*- One of the constant concerns in the wireless mobile devices, is to cover different radio communication services, with separated bands and each one with his own bandwidth, in this way, it is necessary that these devices have an integrated antenna in order to satisfy this objective, for that, the microstrip antenna design is a challenge for all radio communication technology devices. This work proposes a microstrip antenna based on a slotted structure to be installed into smart wireless mobile devices in order to cover WiFi and IMT applications, describing the design, simulation, and measurement method.**

Keywords*- *IMT, slotted microstrip antenna, S_{11} parameter, radiation pattern, WiFi.

I. INTRODUCTION

As we know, Wi-Fi uses wireless LAN infrastructure to serve mobile voice and data requirements, which operates on WiFi 2.4 GHz and/or 5.5 GHz Bands. Relative to the 7 GHz band, "The World Radiocommunication Conference 2019 (WRC-19)", that was held in Sharm El-Sheikh, Egypt, the last November 2019 [1], and which outcome of the meeting addresses the following [2] : Working Group COM6/2: Studies on frequency-related matters for the Terrestrial Component of International Mobile Telecommunications identification in the frequency bands 3300–3400 MHz, 3600–3800 MHz, 6425–7025 MHz, , and 10.0–10.5 GHz, which third band mentioned, 7 GHz, it is the case in question.

The wireless mobile devices, as cell phones, tablets, laptops, etc., should be able to operate with these technologies at this scale, and the antenna design claims a high degree of miniaturization due to the reduced given space and volume within the radio device, an efficient wireless link, high gain, resonance frequency, wide bandwidth, in order to be assembled into the reduced space of the mobile devices.

On the other hand, different antenna structures have been applied in order to obtain resonance at different no adjacent bands, for instance, slot antennas [3, 4], fractal antenna [5,6], printed monople antenna [7, 8], etc., and in accordance with size, volume, and its own reference parameters, applicable for wireless mobile device applications. In the same way For example a printed small wide bandwidth antenna is proposed by [9], which a wide bandwidth of 3.78-18.54GHz is reported, a microstrip antenna Vivaldi type [10] is reported, in order to eliminate the cellular narrow band problem, and a wide slot microstrip antenna is proposed for UWB applications [11].

In this sense, a microstrip patch slotted antenna, which shape is similar to a swastika shape, is the baseline of this work, focused to cover two bands, WiFi, 5.5. GHz, and IMT, 7025–7125 MHz, and in order to determine the performance of design parameter, as impedance, resonance frequency, radiation pattern, wideband, etc., by means of virtual simulation of its construction, the CST software (Computer Simulation Technology) [12] has been used.

The paper is organized as follows: section II describes a brief antenna foundations, section III simulation results, section IV describes the measurement method, concluding the presently work with conclusions and references.

II. ANTENA FOUNDATIONS

The slot radiates electromagnetic waves in a way similar to a dipole antenna, and the shape and size of the slot, as well as the driving frequency, determine the radiation pattern. The polarization of a slot antenna is linear, and the fields of the slot antenna are almost the same as the dipole $\lambda/2$.

The slotted patch antenna is generally made of conducting material such as cooper and the substrate material should have particular dielectric constant. with one or more holes or slots cut out, the shape and size of the slot, as well as the driving frequency, determine the radiation pattern. The designed antenna is based on the slotted loop patch structure or folded dipole structure, as shown in Figure 1, which can be considered as a structure based on two different resonant cavities, where, the lower resonance frequency value is determined by the smallest cavity, internal cavity, surrounded by the large cavity, external cavity, determining higher resonance frequency value [13].

III. SIMULATION

A. S_{11} parameter

Computer Simulation Technology software, CST, has been used to simulate the designed antenna (see Fig. 2).

The simulation stage consists of a tradeoff between substrate thickness and permittivity and in order to construct the prototype, FR-4 substrate has been selected, which electric permittivity is εr = 4.4 and loss tangent δ= 0.0009 [14]. The technique to feed the structure is by line transmission which length is λ/4, printed in the same substrate, and this one is connected to a external coaxial line, which consists of the outermost conductor is connected to the ground surface and the inner conductor is connected to the line, in the same way the feeding line length enables to match impedance antenna with SMA connector [14].

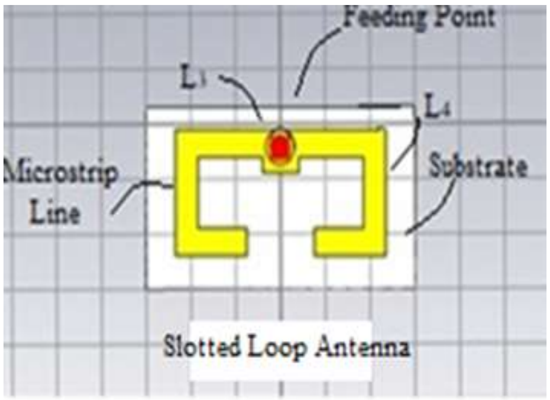

Fig. 1. Slotted loop patch antenna.

The antenna dimensions are approximately equal to 16 mm x 12 mm, which dimensions comply with volume and space in order to be fit into the radio mobile device, which shape is becoming similar to a swastika shape.

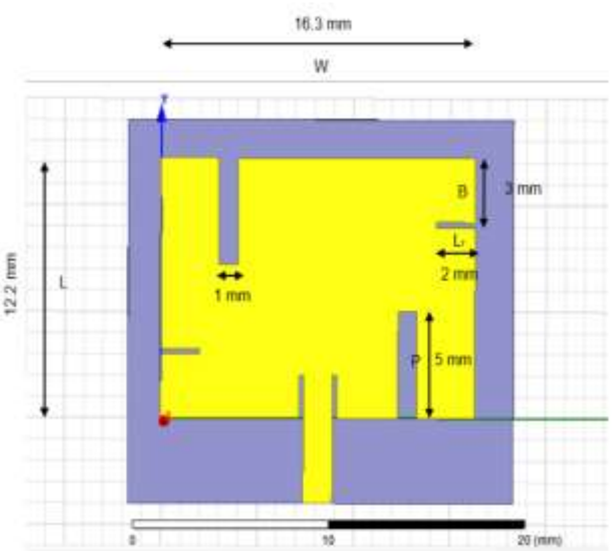

Fig.2. Simulated antenna.

As shown in Figure 2 the antenna consists of four slots, two pairs of slots, equal length, a slotted array antennas, each pair with the same shape, perpendicular between them, the horizontal pair forming a λ/8 dipole and the other vertical pair forming a λ/4 dipole. This position configuration avoids interference conflicts (interference). The horizontal array tuned to the upper band, 7 GHz, , and the vertical tuned to the lower band, 5.5 GHz

On the other hand, as we know, the S_{11} describes the performance antenna, also known as reflection coefficient, ten percent of the radiated energy is reflected from the antenna. In this sense, the S_{11}simulation result graphic is depicted in figure 3 [14, 15].

Outcomes obtained from simulation model display four bands, a multiband antenna, and for our purposes, it's in our interests, two bands, 5GHz, and 7GHz, 5.1- 5.3 GHz, and 7-7.3 GHz, respectively. The M2 point marks 5.5 GHz and the M4 marks 7.0 GHz, approximately a bandwidth equal to 200 MHz and 300 MHz. It can be observed, there also two bands, which deppest peaks are ubicated approximately in 11 GHz and 13 GHz. we must take into account in accordance with improve the services we wish to provide at future.

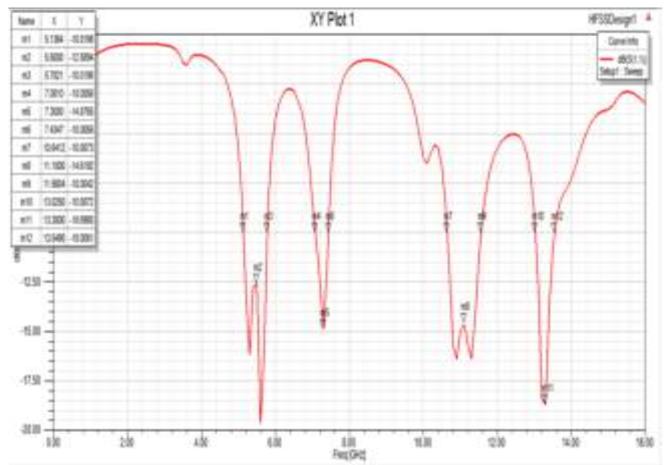

Fig. 3. S_{11} parameter simulation.

B. Radiation Pattern

Graphical representation of the spatial distribution of radiation consists of E-Plane ($E\ vs.\ \theta$, vertical pattern), H-Plane ($E\ vs.\ \varphi$, horizontal plane), and 3-D graphic, which is the combination of the radiation planes. In this sense, fig. 4 shows E-plane graphic, where the semi null is ubicated at 180° and the maximum is pointed to 30°. The achieved radiation patterns shape is useful to multipoint services due to the antenna can cover a considerable area.

Figure 5 shows the 3-D radiation pattern, it can be observed that , this one, it is quasi-directional, the red color shows the best performance, which maximum value, above mentioned, occurs pointing to 30°, with a directional gain equal to 4.9 dB. Let us remember that the λ/2 dipole gain is equal to 2.15 dB.

On the other hand, the figure 6 shows the current distribution along the whole substrate surface, it can be observed that the highest current concentration appears in the middle of the patch.

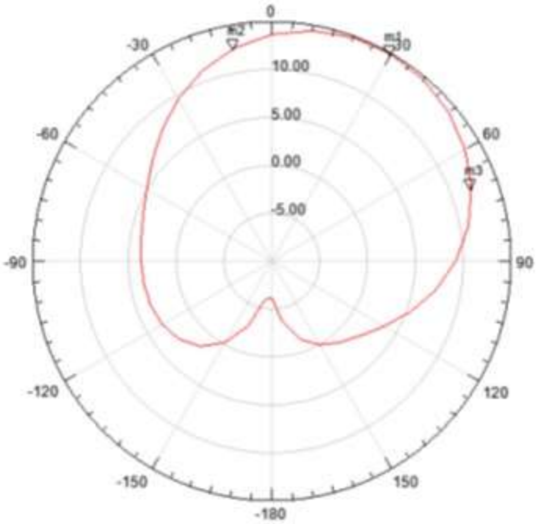

Fig. 4. E-Plane radiation pattern.

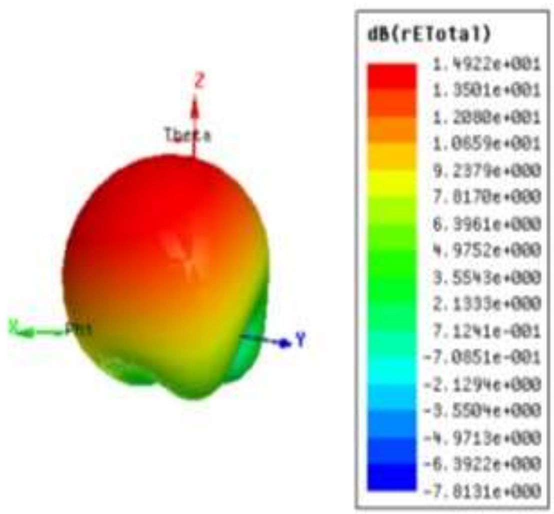

Fig. 5. 3-D radiation pattern.

IV. Experimental measurement method

Unfortunately, due to extremely disruptive interference on the part of the driven by the effects of the health crisis and alert over Covid 19 outbreak, experimental actions were not be possible to achieve, because of the laboratory installations, at the time this work is written, remain closed.

However, the next lines describe the method which the antenna is tested into laboratory in order to obtain experimentally the radiation pattern shape. This one consists of to place the prototype antenna inside the anechoic chamber, acting as receiver antenna connected to a RF receiver and a second antenna, whose parameters are known, acting as a transmitter antenna, connected to the RF generator transmitting with power and frequency value are known, depicted in Fig.7. After the data has been obtained the Friis Equation [16, 17] is applied (1), in order to achieve the antenna gain.

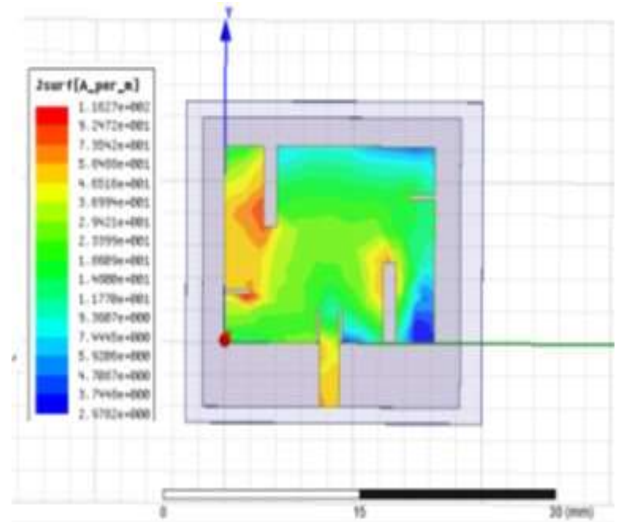

Fig. 6. Current distribution.

$$P_{RX} = P_{TX} G_{TX} G_{RX} \left(\frac{\lambda}{4\pi r}\right)^2$$

(1)

where:

P_{TX}, Transmmited power.

P_{RX}, Received power.

G_{TX}, Transmmiter antenna gain.

G_{RX}, Receiver antenna gain.

r, Separation distance between antennas. Radiation pattern measure technique.

Conclusion

In this paper, we presented a dual band microstrip antenna in order to be applied to mobile services as WiFi, 5.5 GHZ and IMT Technology, 7 GHZ band. The designed antenna has been simulated, which results are the S_{11} parameter along the mentioned bands.

The proposed antenna, in accordance with the simulation results, meets with the required band, and efficient radiation pattern shape, because of a good coverage on a large area is possible.

In the same way, the antenna meets small size, low cost requirements and easily construction with flexibilty flexibility and functionality in order to be applied to the mentioned wireless mobile services.

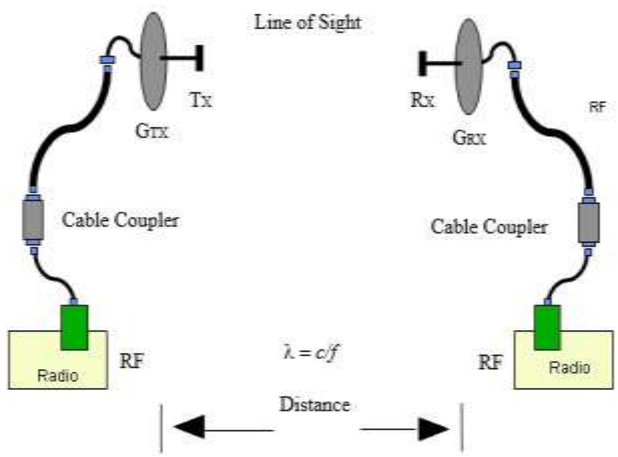

Fig. 7. Radiation pattern measurement method.

REFERENCES

[1] Speech by Malcolm Johnson, ITU Deputy Secretary-General, Sixth Wuzhen World Internet Conference - "5G, Opening a new era of digital economy", 21 October 2019 - Wuzhen, China

[2] Key outcomes of the World radiocommunication Conference 2019, ITU News Magazine, No. 6, 2019.

[3] N. Prema. A. Kumar, “Design of multiband microstrip patch antenna for C and X band”, Optik, Volume 127, Issue 20, October 2016, Pages 8812-8818.

[4] H. Hammas, M. Hasan, A. Jalial, “Compact Multiband Microstrip Printed Slot Antenna Design for Wireless Communication Application”, Advanced Electromagnetics, vol. 9, no. 2, october 2020.

[5] Manisha Gupta, and Vinita Mathur, “Wheel shaped modified fractal antenna realization for wireless communications,” AEU-International Journal of Electronics and Communications, vol. 79, pp. 257-266, 2017.

[6] I. Ganesan, P. Iyampalam, “ A Review of Ultra-Wideband Fractal Antennas”, Proceedings of the 2nd International Conference on Inventive Communication and Computational Technologies (ICICCT 2018) IEEE Xplore Compliant - Part Number: CFP18BAC-ART; ISBN:978-1-5386-1974-2.

[7] Lu, J.H.; Chou, W.C.: Planar dual U-shaped monopole antenna with multiband operation for IEEE 802.16e. IEEE Antennas Wireless Propag. Lett., 9 (2009), 1006–1009.

[8] K.G. Jangid, P.K.Jain, B. R. Sharma, V.K.Saxena, V.S.Kulhar, D. Bhatnagar: Ring Slotted Circularly Polarized U-Shaped Printed Monopole Antenna For Various Wireless Applications. Advanced Electromagnetics, Vol. 6, No. 1, March 2017.

[9] P. Wang and Z. Shen, “End-fire surface wave antenna with metasurface coating,” IEEE Access, vol. 6, pp. 23778–23785, 2018.

[10] Y. Dong, J. Choi, and T. Itoh, “Vivaldi antenna with pattern diversity for 0.7 to 2.7 GHz cellular band applications,” IEEE Antennas and Wireless Propagation Letters, vol. 17, no. 2, pp. 247–250, 2018.

[11] A. Wu and B. Guan, “Printed slot antennas for various wideband applications using shape blending,” International Journal of RF and Microwave Computer-Aided Engineering, vol. 26, no. 1, pp. 3–12, 2016.

[12] https://www.cst.com/Academia/Student-Edition.

[13] S. Ricardo Meneses G., Rita T. Rodríguez M., “ Microstrip Antenna Array Design for (698-806) MHz UHF Band Application”, Telematics and Computing 7th International Congress, WITCOM 2018 Mazatlán, Mexico, November 5–9, 2018, Proceedings, ISSN 1865-0929 ISSN 1865-0937 (electronic), Communications in Computer and Information Science, ISBN 978-3-030-03762-8 ISBN 978-3-030-03763-5 (eBook), https://doi.org/10.1007/978-3-030-03763-5.

[14] S. Ricardo Meneses G., Rita T. Rodríguez M., “Tri-Band Log - Periodic Microstrip Antenna Design (2.4, 5.5 and 3.6 GHz Bands) for Wireless Mobile Devices Application”, Telematics and Computing 9th International Congress, WITCOM 2020 Puerto Vallarta, Mexico, November 2–6, 2020. ISSN 1865-0929 ISSN 1865-0937 (electronic) Communications in Computer and Information Science ISBN 978- 030-62553-5 ISBN 978-3-030-62554-2 (eBook) https://doi.org/10.1007/978-3-030-62554-2 Proceedings.

[15] Kin-Lu Wong, “Compact and Broadband Microstrip Antennas”, 2002 John Wiley & Sons, Inc.

[16] C. A. Balanis, “Antenna Theory, Analysis and Design”, 1982, John Wiley & Sons, Inc

[17] E. C. Jordan and K. G. Balmain, “Electromagnetic Waves and Radiating Systems”, 1968, Prentice Hall.