A Triple-U Triple-Domain Antenna Designed For Mobile Generations Supporting Up-To 5GH

Wael Ahmed, Ayman Haggag, Ahmed Shaker

Abstract: In this paper, a triple-band U-shaped antenna is designed for better mobile communication performance to support 5G networks. The antenna is designed with dimensions of 91 x 92.5 mm and a thickness of 1.57 mm. The thickness of 1.57mm gives a design to the capacity of the GSM antenna and allows it to cover the multi-frequency band between 9. - 2.4GHz. The antenna is suitable for various previous generations up to the beginning of the fifth generation. Antenna performance has been improved by adding a third antenna chip with an integrated aperture with the previous two antennas operating at 2.4 GHz and generating higher resonant frequencies that help support the required fields. Then get multiple coverage range for mobile phones until the beginning of the fifth generation. Simulation was done using an electromagnetic simulator (CST Microwave Studio). With the static radiation patterns over the entire frequency range, at frequencies 0.9, 1.8 and 2.4 GHz, a good agreement between the simulation results and the measurements was made. The antenna has widely accepted radiation characteristics and provides good performance in avoiding interference with wireless systems

Keywords: Microstrip Antenna; CST Microwave studio; Radiation Pattern; (UWB) ultra wideband

I. INTRODUCTION

At the present time, wireless mobile phones have witnessed a great development in transmitting and receiving information and multiple applications, and many of these current applications require high speeds, and this has led to new requirements, such as the need to increase the gain, direction and antenna frequency in order for the mobile phone to operate quickly in multiple areas. The frequency that depends on the antenna to transmit and receive, which uses many different frequency networks for mobile phones (GSM-3G-4G-5G) [1] The wireless connection uses an antenna with a higher frequency than the previous frequencies, as it is characterized by high-speed, short-range wireless connections and high data transfer rates, which has the advantage of increasing the bandwidth and the ability to reduce interference between environments spread wireless networksAt the turn of the century, a new generation of communications was needed, the fifth generation of wireless communication, which provides high-speed data. It improves the service provided to a large number of users, and this is what distinguishes them from previous generations [2]. Due to the increased demand for frequencies for audio, video, games and multimedia applications, improvements have been made to antennas and increased bandwidth [3], and improvements have been made to increase the bandwidth of the generation antenna operating in the frequency range over 2 GHz. The antenna needs good performance and is lightweight.

- *Wael Ahmed, Ayman Haggag, Ahmed Shaker*
- *Electronics Technology Department, Faculty of Technology and Education, Helwan University Cairo, Egypt*
- *Communication and Electronics Department, Faculty of Engineering, Helwan University Cairo, Egypt*
- *waelwael13170@gmail.com, haggag@techedu.helwan.edu.eg, ahmed_shaker@h-eng.helwan.edu.eg*

Small, low-cost and high-gain [4] triple-band printed antennas are used to meet the requirements of wireless systems. Where the three bands were placed in a U-shape and one feed source, which helped generate different frequencies, making the antenna support up to the fifth generation and in the (2400) MHz band [5] [6]. The third figure was added to be parallel to the two previous figures to work in a higher frequency range than the previous two figures and their dimensions are 16.5 x 21 mm [7], where the three antennas were connected and fed to one phase. An antenna was designed consisting of cellular frequencies, measured directional patterns, directional gain and high gain at frequencies Between (900-2400) MHz [8][9] Use the antenna to cover the frequency ranges from GSM to 5G, Emphasis has been placed on the maximum bandwidth to provide GPS power for this new generation [10] [11]In this paper, a U-shaped frequency band single-pole aperture antenna is proposed. Its frequency range to drive this antenna operates from [0.9 to 2.4] GHz, and constant proportional radiation patterns are achieved for all directions across the entire frequency range
.

II. ANTENNA DESIGN

A. Antenna design

n Fig. 1, the proposed visualization mechanism for .II designing a U-shaped three-frequency antenna consisting of triple units by coaxial path is implemented. The dimensions of the antenna are captured in (Figure 1). The antenna is designed (dielectric constant εr = 2.17, H = 1.57 mm and resistance of 50 ohms). Required frequency bands around F1 = 900 MHz and F2 = 1700 MHz F3 = 2400MHz After that, the antenna was designed with a CST Studio After that, the antennas were designed [Microwave [12] with dimensions of 92.5 * 91 and the dimensions of the triple antennas were different in terms of length and width using the(CST Studio) [13] microwave. The optimized dimensions for the triplei-domain antenna are shown in Table 1

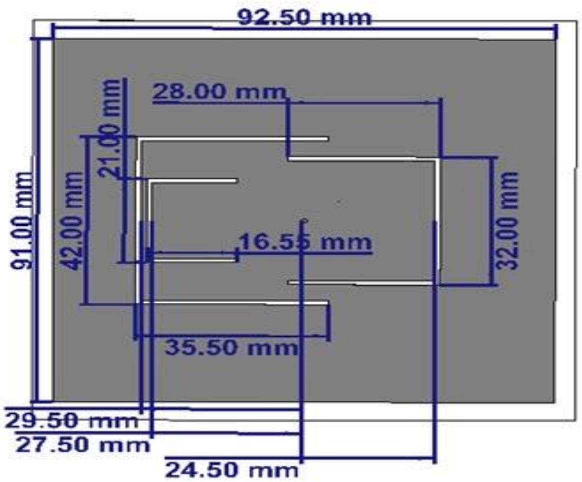


Fig. 1. *triple-unit antenna.*

A. Analisis of a rectangular patch with rectangular slot etched on metal ground plane

To illustrate the operating mechanism associated with the rectangular patch with rectangular openings drilled on a metallic ground plane, and feeding the triple antennas, surface current distributions of the three antennas and simulations were performed on the radiating patch using a relatively stable, insulating substrate. Fig 2 shows the design and dimensions of the proposed triangular antenna.

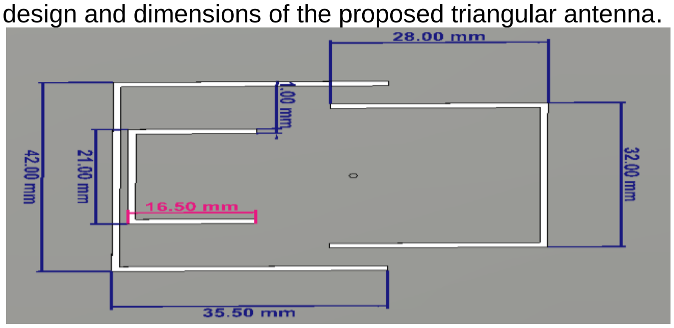


Fig. 2. Dimentions of the proposed antenna

***Table 1** shows the improved dimensions of the multi-band antenna.*

TABLE I. *IMPROVED DIMENTIONS OF MULTI-FIELD ANTENNA*

No	Parameter	Value
1	Thickness of substrate	1.75 mm
2	Length of substrate	91 mm
3	Width of substrate	92.5 mm
4	Width trapezoidal patch1 w	42 mm
5	Width trapezoidal patch2 w1	32 mm
6	Width trapezoidal patch3 w2	21 mm
7	Length trapezoidal patch1 h	35.5 mm
8	Length trapezoidal patch h1	28 mm
9	Length trapezoidal patch h2	21 mm
10	Thickness of notched cs	1 mm
11	Radius the notched, r	5 mm

III. MODULAR ANALYSIS

Resonant frequencies were compared with a triple-size 92.5 x 91.0 mm antenna without holes and triple U-shaped antennas for operation, TM10 mode determined: full correction frequency is F1 =. 9 GHz, the area inside the U slots is classified as two frequencies F2 = 1.77 GHz, the frequency of the region inside the U slots is at F3 = 2.4 GHz, and the antenna is fed by Microline with an impedance of 50 ohmsFirst, the material is chosen as a Rogers RT / Duroid 5880 material with a relative diffraction amplitude of 2.17 and 1.57 mm Second, the antenna format was U-shaped before showing the antenna tuning. Three U-shaped slots were added with a frequency of (2.4) GHzriple U antenna operating modes simulated. The current density on the antenna element unit is distributed to F1 = 0.9 GHz (left), F2 = 1.77 GHz (right), F3 = 2.4 GHz (left) The resonant frequencies of the triple U antenna differ from those required F1 = 942 MHz, F2 = 1 758 MHz, and F3 = 2414 for less than 5%. The initial coefficients are calculated using the following formula.

$$f(J) = min \sum_{f=.9ghz}^{f=1.7ghz} |s1.1(f)| + min \sum_{f=1.7ghz}^{f=2.4ghz} |s1.1(f)|$$

Table 2 shows the comparison of resonance frequencies of the patch without slots and the triple-U antenna

TABLE II. *COMAPRISON OF RESONANCE FREIQUENCIES OF THE PATCH WITHOUT SLOTS AND THE THREE-U ANTENNA*

Patch		U-slot
Mode	F [GHz]	F [GHz]
TM10	0.897	0.606
TM01	0.923	
TM11	1.288	1.160
TM20	1.775	1.702
TM02	1.847	1.791
TM21	2.018	
TM12	2.414	1.960
TM22	2.575	2.231
TM30	3.0	

B. Current Distributions

The triple-range antenna operating modes and .III current density distribution of U on the antenna element power unit were distributed to F1 = 0.94 GHz (left), F2 = 1.76 GHz (right), F3 = 2.41 GHz (left). simulation of the resonant frequencies of the triple U antenna differs from those required F1 = 942MHz, F2 = 1.761MHz, F3 = 2.414 less than 5%. In the case of a triple-unit antenna. Figure 3 shows the simulated reflection coefficient [s.11], the full-frequency correction at the low frequency F1, the currents are concentrated in the region outside the holes U at the frequency higher than F3 - F2, the currents in the region inside the slots are U the effective role. In the flick of polarization X. Looking at contact in horizontal polarization, the antenna shows cross polarization of -18.69 dB in the lower band, and cross polarization of -3 dB in the upper band.

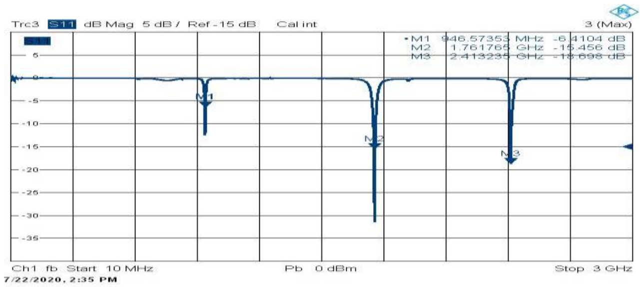


Fig. 3. *Simulated reflection coefficient*

Fig.4, Fig. 5, and Fig. 6 show similar results. There are currents that are not mentioned inside the U-slots in the lower belt and outside the U-slots at the top.

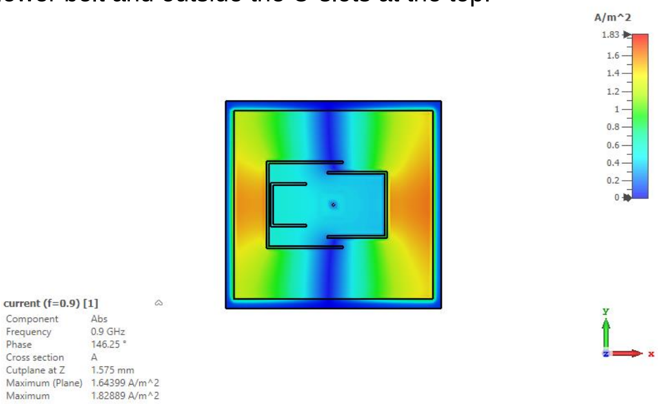


Fig. 4. *Currrent distributions at 0.9 GHz*

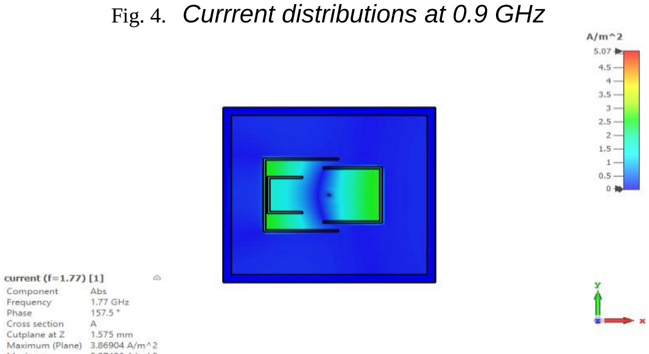


Fig. 5. *Currrent distributions at 1.77 Ghz*

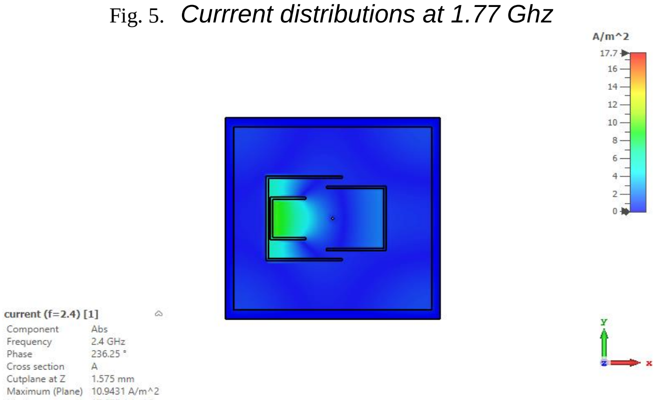


Fig. 6. *Current distributions at 2.4 GHz*

A. Reflection Coefficients

It is evident from the measurement and simulation of the three-frequency range antenna u while determining the frequency response s 11 in Figure 7, the new frequencies of the resonant frequencies obtained by simulation and measurement can be determined at the low resonant frequency f1, the value of s11 is relatively small (-15 dB In simulations, -11 dBm in measurement). At a higher frequency f3, the method is better (-27 dB in the simulation and -14 dB in the measurement), the reflection coefficient was measured at the antenna input and compared with the results of the full wave analysis.

.

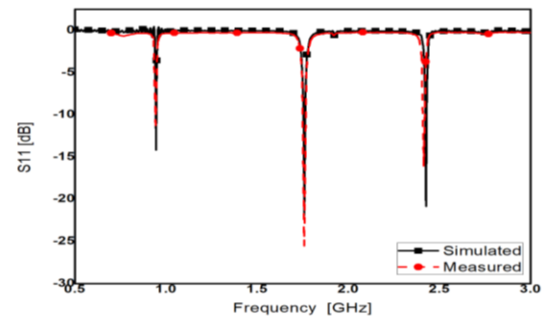


Fig. 7. *Measurement and simulation of the reflection coefficient*

Fig. 8 shows the gain variation from 0.9 dB to 2.4 dB over the operating frequency range. It can be concluded that the gain variation is 1.7 dB over the entire operating frequency range.

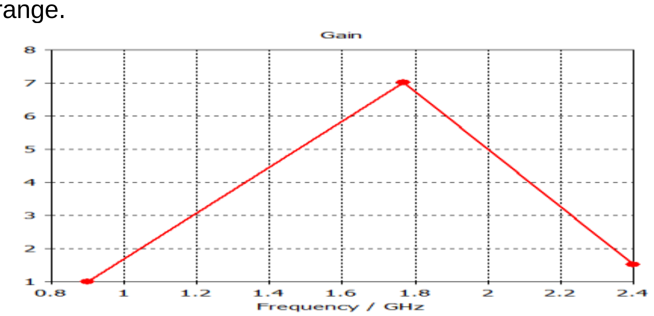


Fig. 8. *Gain at operating frequency range*

B. Directivity Patterns

inFig.9, the antenna has been assigned to compute the 3D directional plots computed by CST Microwave Studio above, and below we see the measured diagrams in the E and H planes. In patterns, the gain magnitude is depicted. In 3D shapes, trend patterns are obtained in the E plane when following the black circle, and patterns can be seen in the H plane when moving along the blue circle. After cutting the circles in the 3D patterns, the corresponding process of gain can be observed in the measured 2D patterns. inmost cases, the directivity scheme consists of a wide beam directed perpendicular to the surface of the antenna. The U-shaped aperture antenna displays the minimum depth of the directivity pattern in the vertical direction, and at the frequency f3 = 2.4 GHz, inFig 10, the measured parameters of the three antennas where frequency f, bandwidth M, band frequency BM (given by S11 = 14 dB), reflection parameters on the M-S11 series distribution frequency, and gain at operating frequency M associated with the motor polarization. Calculated coefficients of the investigated antennas, radiation efficiency and EF antenna efficiency at process frequencies m1. M 2 m 3

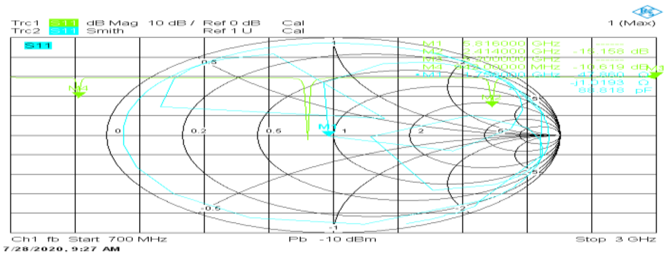


Fig. 9. *Measured radiation patterns*

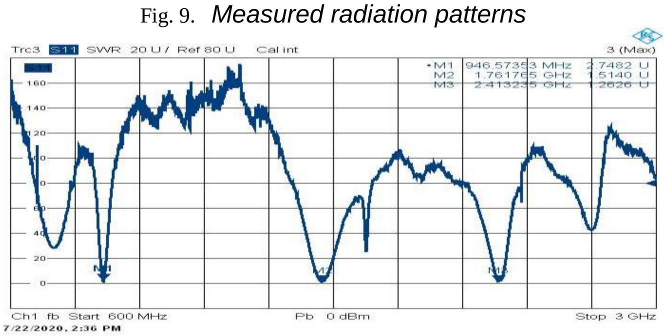
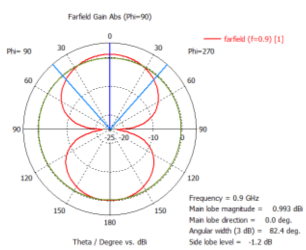
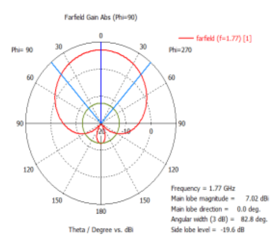


Fig. 10. *Measured parameters*

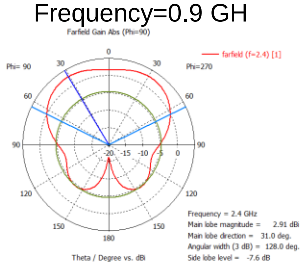
To achieve the desired value of reflectance stabilization within the required frequency range, advanced optimization techniques must be exploited. When formulating an improvement task, the desired reflection characteristics must be included in the objectivefi 11 shows the radiation patterns of the proposed antenna in a different plane where the illustration is illustrated in the x-z and y-z axes at the frequencies of 0.9 GHz and 2.4 GHz. The results show that the radiation pattern is completely constant as the frequency changes with the omnidirectional radiation pattern in the H level and the unipolar radiation patterns in the E level. Also, the internal noise may contribute to the occurrence of these discrepancies.



Frequency=0.9 GH



Frequency=1.7GH



Frequency=2.4 GHz

Fig. 11. *The Simulation radiation pattern of the optimum*

the antenna consists of three points: the largest of them resonate at a lower frequency than the antenna, and the smallest at the higher frequencies. It can be said that the tri-band antenna consists of three u-patches. Looking at the measured digital frequencies, even here, the three-unit antenna provides the best results except for the value of the reflection coefficient in the lower range: given its measured value. Figure 12 shows the VSWR simulator and the size of the proposed antenna.

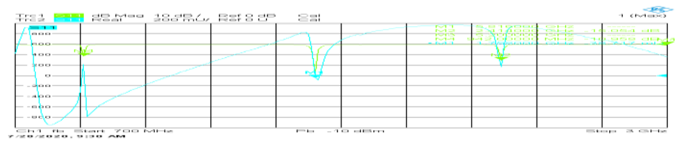


Fig. 12. *Simulated and measured VSWR*

Fig 13 shows a picture of the proposed antenna after manufacturing. The figure on the left is the designed antenna while the figure on the right is the antenna feeder.

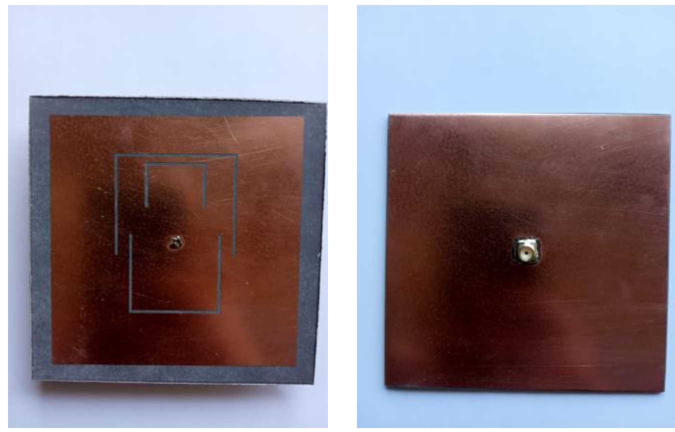


Fig. 13. *Picture of the proposed antenna*

IV. CONCLUSIONS

this paper, a correlated method between multi U thin band antennas and CST program simulation technology is presented. The proposed technique is used to design a triangular antenna. The antenna is built on Rogers RT / Duroid 5880 substrate with area of 91 x 92.5mm2, thickness of 1.575mm with relative tolerance, r = 2.17, which can cover frequency range from 0.9GHz to 2.4GHz. The antenna design gives the following advantages, low power, good noise immunity, signals can easily penetrate a variety of materials, and high immunity to multi-path fade. The antenna can be used in both mobile applications.

REFERENCES

[1] GARG, B., BAHL, I. Microstrip Antenna Design Handbook. Nor- wood: Artech House, 2001.

[2] KUMAR, G., RAY, K. P. Broadband Microstrip Antennas. Nor- wood: Artech House, 2003.

[3] WONG, K. L. Compact and Broadband Microstrip Antennas. New York: J. Wiley and Sons, 2002.

[4] Senic, D., zivkovic, Z., simic, M., & Sarolic, A. (2014). Rectangular patch antenna: Design, wideband properties and loss tangent influence. 2014 22nd International Conference on Software, Telecommunications and Computer Networks (SoftCOM).

[5] Revolvy, L. (2017). "5G" on Revolvy.com. (Revolvy.com) Retrieved from https://www.revolvy.com/main/index.php?s=5G

[6] ZHAN, L., RAHMAT-SAMII, Y. Optimization of PIFA-IFA com- bination in handset antenna designs. IEEE

Transactions on Antennas and Propagation. 2005, vol. 53, no. 5, p. 1770–1778.

[7] LATIF, S. I., SHAFAI, L., SHARMA, S. K. Bandwidth enhancement and size reduction of microstrip slot antennas. IEEE Transactions on Antennas and Propagation. 2005, vol. 53, no. 3, p. 994 to 1003.

[8] Stutzman, W., & Thiele, G. (2013). Antenna theory and design. John Wiley & Sons, Inc. Tang, X., Qing, X., Liu, W., Nasimuddin, Zhai, G., & Chen, Z. N. (2016). Effect of Mutual

[9] Coupling on Ka-band Circularly Polarized Beam Scanning Antenna Array. 2016 IEEE

[10] International Symposium on Antennas and Propagation (APSURSI), 2193 - 2194..

[11] Uncategorized | mansipruthi. (2017). (Mansipruthi.wordpress.com) Retrieved from https://mansipruthi.wordpress.com/category/uncategorized/

[12] Volakis, J. L. (2007). Antenna engineering handbook. New York: Toronto.

[13] Yang, X. M., Liu, X. G., Zhu, X. Y., & Cui, T. J. (2012). Reduction of mutual coupling between closely packed patch antenna using waveguide metamaterials. IEEE Antennas and Wireless Propagation, 11, 389–391.Zhao, H., Mayzus, R., Sun, S., Samimi, M., S., J. K., A., . . . T. (2013). 28 GHz Millimeter Wave Cellular Communication Measurements for Reflection and Penetration Loss in and around Buildings in New York City. IEEE International Conference on Communications (ICC), 9-13