Miniaturization of Microstrip Antennas for Applications in 4G Technology

OTÁVIO PAULINO LAVOR, HUMBERTO DIONISIO DE ANDRADE
Federal Rural University of Semiarid - UFERSA
BRAZIL

HUMBERTO CESAR CHAVES FERNANDES
Federal University of Rio Grande do Norte - UFRN
BRAZIL

MARINALDO PINHEIRO DE SOUSA NETO
Federal Institute of Education, Science and Technology of Rio Grande do Norte- IFRN
BRAZIL

Abstract: - This paper presents a new proposal of microstrip planar antennas designed for frequencies of 2.5 GHz and 700 MHz, with an improvement in bandwidth and miniaturization. Using the truncated ground plane, it is achieved a reduction of about 70% in size in both antennas. The antenna designed for 2.5 GHz has the bandwidth changed of 55 MHz for 580 MHz, whereas the antenna designed for 700 MHz, the change was of 20 MHz for 268 MHz.

Key-Words: - Microstrip antenna, Bandwidth, Miniaturization.

1 Introduction

Currently, there is a need for the development of devices operating in the microwave range, especially in the 2.5 GHz frequency. This is the frequency of the 4G technology that covers the range from 2.5 to 2.69 GHz.

With the advent of the forecast use of the 700 MHz band for the same 4G technology, new devices will be developed.

Considering the frequency range, the size of the antenna is expected to be physically large when the traditional design is used. Therefore, innovative techniques should be designed to reduce its size [1].

To meet some requirements, some studies are done and some miniaturizations are obtained. An antenna at sheet is proposed at the frequency of 700 MHz [2]. In this work, the patch is regarded as a sheet and a reduction in size of the antenna is achieved. A dual band antenna is proposed to cover both frequency bands: 698-960 MHz and 1.71-2.69 GHz [3]. A miniaturization of 48% is obtained in the range of 2.5 to 2.69 GHz using the technique of insertion of slots in the patch [4]. By applying the Minkowski fractal geometry for the antennas, miniaturization is achieved [5].

Therefore, this work has studied and proposed microstrip antennas in these two frequency bands, 700 MHz and 2.5 GHz. The goal is to propose antennas that may have reduced sizes compared to a conventional microstrip antenna, and can have necessary bandwidth to this technology. The technique for miniaturizing the antenna is a truncated ground plane. This truncated plane has already been used for UWB antenna (Ultra Wide Band) [6], [7].

2 Design

For the standard antenna at both frequencies, the substrate used is Rogers RO3006 with relative permittivity of 6.15; tangent of loss of 0.0025 and a thickness of 1.52 mm. The geometry of the patch is rectangular and is fed by microstrip line. The material used for patch ground plane and feed line is copper with a thickness of 0.0175 mm. The Fig.1 shows the geometry of the standard antenna.

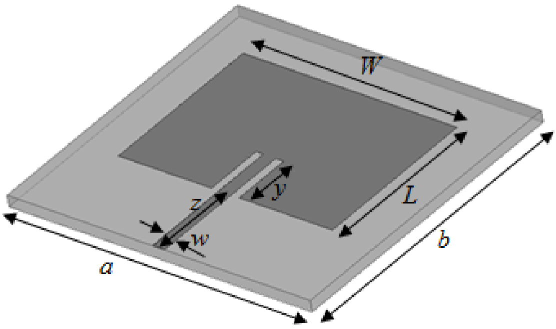

Fig. 1 Geometry of the standard antenna.

Aiming at an increased bandwidth and a reduction in size of the antenna, it is proposed a truncated ground plane. The fig.2 shows the geometry of a truncated ground plane, i.e., instead of the ground plane with dimensions of the substrate, as shown for the standard antenna, it has geometry given in Fig.2.

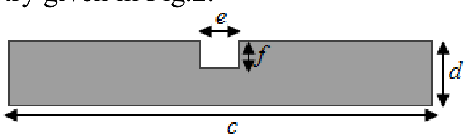

Fig. 2 Geometry of the truncated ground plane.

With the truncated ground plane, the antenna has its small size to operate in the same frequency. Table 1 shows a comparison between dimensions of the standard and proposed antenna designed for the frequency of 2.5 GHz, and Table 2 shows the same comparison for the antenna designed for the frequency of 700 MHz.

Table 1 Dimensions of the standard and proposed antenna for 2.5 GHz.

Dimension(mm)	Standard Antenna	Proposed Antenna
a	44	26
b	42	26
W	31,73	14
L	23,2	10
z	12,1	9,5
w	1,75	1,8
y	8,1	3,5

Table 2 Dimensions of the standard and proposed antenna for 2.5 GHz.

Dimension(mm)	Standard Antenna	Proposed Antenna
a	44	26
b	42	26
W	31,73	14
L	23,2	10
z	12,1	9,5
w	1,75	1,8
y	8,1	3,5

As the proposed antennas have the truncated ground plane, the Table 3 shows the dimensions of the ground plane based on Fig. 2.

Table 3 Dimensions of the truncated ground plane.

Dimension (mm)	Standard Antenna	Proposed Antenna
c	26	64
d	1	7
e	2	2
f	0,5	2

3 Results

In the previous section, were presented the design of miniaturized antennas for the frequency of 2.5 GHz and 700 MHz. In what follows, it present the simulations and experimental results of the designed antenna for 2.5 GHz and after are presented the simulations and experimental results of the designed antenna for 700 MHz.

Table 1 showed the dimensions of the standard and proposed antenna for the frequency of 2.5 GHz. While the standard antenna has an area of 1848 mm2, the proposed antenna has an area of only 676 mm2, which gives a reduction of 63%. This is also the percentage reduction in volume, because the thickness of the substrate in both the antennas is the same.

The Fig.3 shows a comparison of return loss between the standard and proposed configuration. While the standard antenna has a bandwidth of 55 MHz , the proposed antenna has bandwidth of 580 MHz.

Otávio Paulino Lavor, Humberto Dionisio De Andrade,
Humberto Cesar Chaves Fernandes,
Marinaldo Pinheiro De Sousa Neto

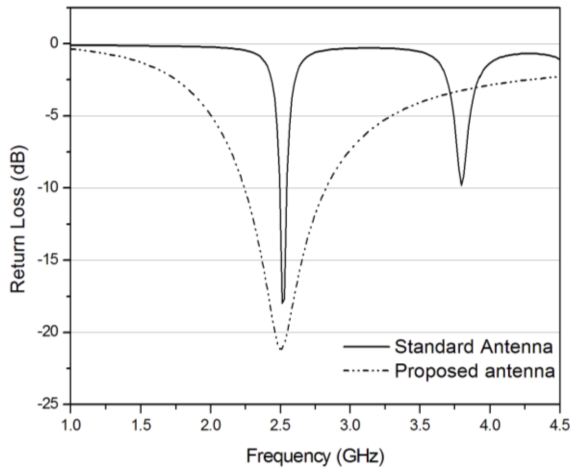

Fig. 3 Return loss versus frequency for designed antenna for 2.5 GHz.

As there was miniaturization and a wide bandwidth, the prototype of the proposed configuration was built. The picture is seen in Fig. 4.

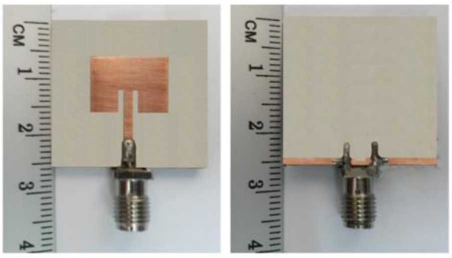

Fig. 4 Picture of the designed prototype for 2.5 GHz.

Measures of return loss and of input impedance were made in this prototype. The Fig. 5 shows a comparison of return loss, which can be observed in good agreement.

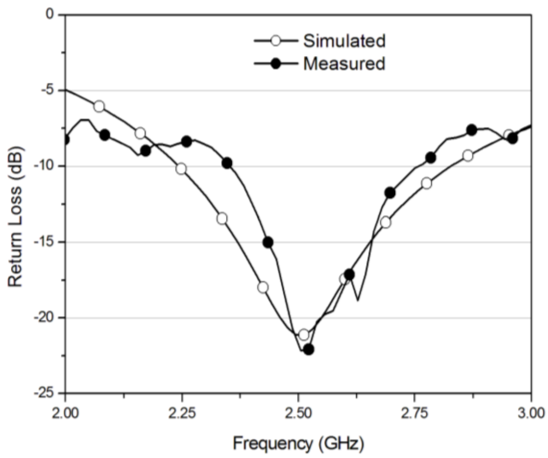

Fig. 5 Return loss of the designed prototype for 2.5 GHz.

The input impedance in the Smith chart of this prototype is showed in Fig. 6. The value of impedance at the frequency of 2.53 GHz is 50.18 - 1.98j Ω, being a value very close to 50 Ω.

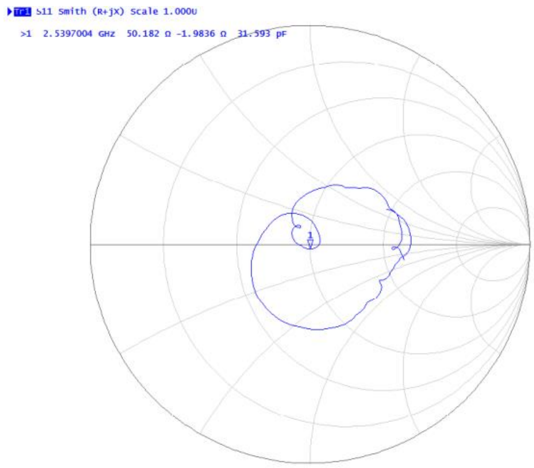

Fig. 6 Input Impedance of the designed prototype for 2.5 GHz.

With respect to the antenna designed for the frequency of 700 MHz, the Table 2 showed the dimensions of the standard and proposed configuration. While the standard antenna has an area of 17136 mm2, the proposed antenna has the area of 4480 mm2, showing a reduction of 73.9%. This is also the percentage reduction in volume, because the thickness of the substrate in both the antennas is the same.

Fig.7 shows a comparison of the simulated return loss for the standard and proposed antenna. While the standard antenna has bandwidth of 20 MHz , the proposed antenna has a bandwidth of 268 MHz.

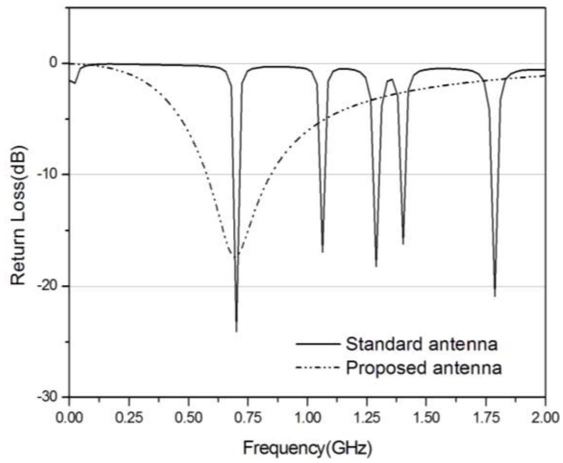

Fig. 7 Return loss versus frequency for designed antenna for 700 MHz.

As there was miniaturization and a better bandwidth, the prototype of the proposed configuration was built. The picture is seen in Fig. 8.

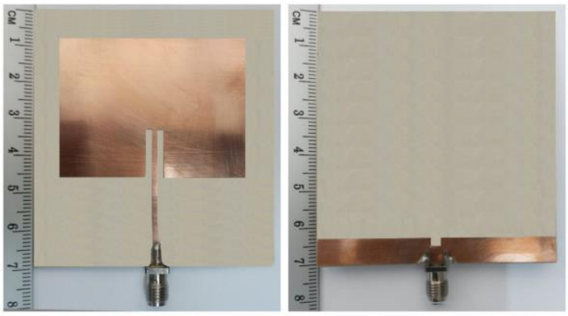

Fig. 8 Picture of the designed prototype for 700 MHz.

Measures of return loss and input impedance were made in this prototype. The Fig. 9 shows a comparison of return loss, which can be observed a good agreement, especially in the second point of resonance. In the first point of resonance, there was a displacement of the measured value compared to the simulated, however the bandwidth remained unchanged.

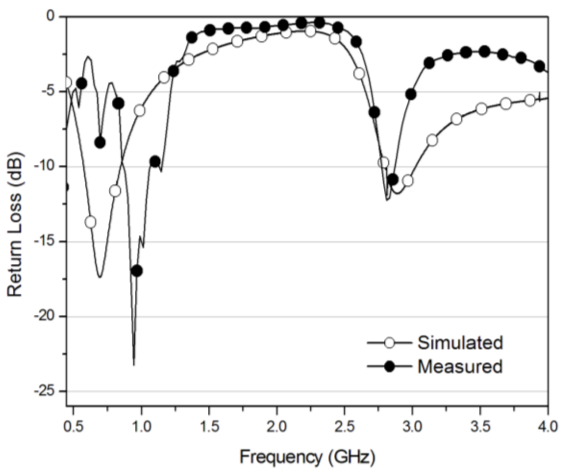

Fig. 9 Return loss of the designed prototype for 700 MHz.

The input impedance in the Smith chart of this prototype is showed in Fig. 10. The value of impedance at frequency of 940 MHz is 45.5 - 2.98j Ω.

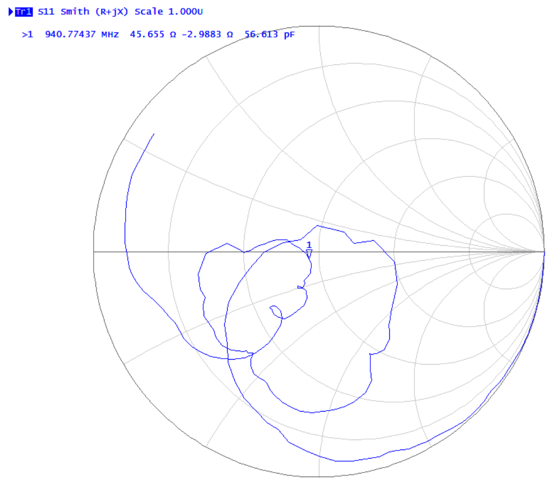

Fig. 10 Input Impedance of the designed prototype for 700 MHz.

It is observed that from the analysis of the Fig.5 and 9, there is a good agreement of the return loss when simulated and measured values are compared. Such variations and changes between the simulated and measured data are due to impurities in the material, adjust the physical connection and set-up data of the measuring equipment.

4 Conclusion

In this study, it assessed the miniaturization of microstrip antenna with rectangular patch where the frequencies of interest are 2.5 GHz and 700 MHz. In order to also better passband, for reduce the size of the antenna was considered a truncated ground plane . The first antenna obtained a reduction of 63% and a variation in the bandwidth of 55 MHz for 580 MHz, while the second antenna obtained a reduction of 73.9% with a variation in bandwidth of 20 MHz for 268 MHz. Thus, these antennas become candidates for 4G technology.

References:

[1] S. A. Rezaeieh, A. M. Abbosh, Miniaturization techniques for antennas designed for microwave-based heart failure detection systems, *Antennas and Propagation Society International Symposium (APSURSI), 2014 IEEE* , 2014, pp.520-521.

[2] P. F. da Silva Júnior , J. C. e Silva, P. H. F. Silva, Projeto de uma Antena de Folha para 700 MHz, *MOMAG 2014: 16º SBMO - Simpósio Brasileiro de Micro-ondas e Optoeletrônica e 11º CBMag - Congresso Brasileiro de Eletromagnetismo*, Curitiba, 2014.

[3] J. Dong, Y. Jiao, Z. Weng, Q. Qiu, Y. Chen, A Coupled-fed Antenna for 4G Mobile Hand-set,

Progress In Electromagnetics Research, Vol. 141, 2013, pp. 727-737.

[4] J. C. e Silva, A. Gomes Neto, T. S. Evangelista, Desenvolvimento de Antena para Sistema de Comunicação Móvel 4G, *MOMAG 2014: 16º SBMO - Simpósio Brasileiro de Micro-ondas e Optoeletrônica e 11º CBMag - Congresso Brasileiro de Eletromagnetismo*, Curitiba, 2014.

[5] S. Subramaniam, S. Dhar, K. Patra, B. Gupta, L. Osman, K. Zeouga and A. Gharsallah, Miniaturization of Wearable Electro-textile Antennas using Minkowski Fractal Geometry, *Antennas and Propagation Society International Symposium (APSURSI),* 2014, pp. 309-310.

[6] M. P. Sousa Neto, H. C. C. Fernandes and C. G. Moura. Design of a Ultrawideband Monopole Antenna Using Split Ring Resonator for Notching Frequencies. *Mivrowave and Optical Technology Letters*, vol. 56, 2014, pp. 1471- 1473.

[7] R. A. dos Santos, I. F. da Costa, A. Cerqueira Júnior; Novo Modelo de Antena Impressa com Banda Ultralarga. *MOMAG 2014: 16º SBMO - Simpósio Brasileiro de Micro-ondas e Optoeletrônica e 11º CBMag - Congresso Brasileiro de Eletromagnetismo*, Curitiba, 2014.