New USS Microstrip Antenna Proposal Based Both On Ku And Ka Frequency (New USSMA Ku Ka Band)

Chafaa Hamrouni, Naceur Abdelkarim

Abstract: In this article, we propose a Microstrip Antenna for Ultra Small Satellite (USS) telecommunication subsystem application in UWB (Ku frequency band and Ka band). The designed MA is based on circular patch antenna. We process by minimizing and adjusting the MA dimension to lift the latch of bandwidth while maintaining quality performance of other properties. We have developed a studied geometric shape and used tricks to design them. Obtained antenna feds by microstrip line and the ground plane. Antenna feed elements are placed on the same plate to reduce the spatial dimension. Successful results are presented to validate function of proposed design and its precision operating at high frequencies.

Index Terms: Microstrip Antenna (MA), UWB, Ku band, Ka band, Ultra Small Satellite (USS).

1 INTRODUCTION

NEW Ultra Small Satellite (USS) family appears since ten years ago and hundreds of copies are in orbit, in addition others under development [1]. The FemtoSat is a USS weighing less than 100 grams, consuming an electric order power of some (mW) [2][[3][4]. An accurate standard was established, called N–Prize [5] defining the constraints of FemtoSat to classify the USS and to operate it in space in several missions [6]. USS practical applications are innumerable. Several accomplishments consist on Universities research work [7], and researches test new technologies [8] before exploring them in space. We study the development of a 3D structure with microstrip antenna in a FemtoSat to determine proposed technology solution influences on both sides communication and structure [9]. Several researchers have dealt with antenna conception, materials, etc. For instance, S.Rabbani'14 studied antenna volume form influence during space craft orbiting to show its impact on Bandwidth. [10], C. Hamrouni'12, studied also the antenna geometrical form and its parameters mathematical relationship [11]. We successfully designed a U form antenna which can ameliorate the FemtoSat version by the use KickSat [12] as operating unit for the new structure containing more sensors. We employed the FR4 as a substrate of the 4.3 dielectric constant, with thickness equal to 2mm.

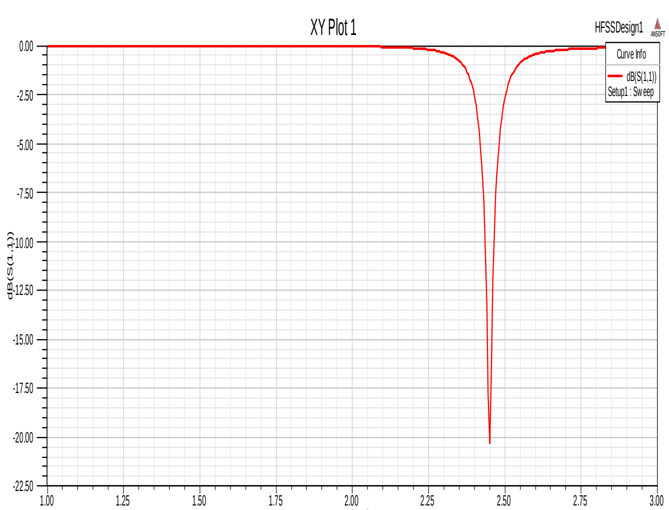

Fig. 1. *Variation of return loss with frequency*

The developments of the new systems of radioTelecommunica tions presents an evolution very important of point of life transmission of given in several scope of application military, commercial and consequently this evolution requires a new architecture of the antenna as able to adapt has this evolutions, which brings to design antennas satisfying with many constraints like low costs of manufacturing, broad band-width, compactness and operation multi-band. Generally the major drawback most important which influences the limitation of an antenna patch in technology micro ribbon is itsnarrow band-width which is intrinsically relatedto its resonant character [13] [14]. Noting that there are many studies carried out allowing the optimization of the band-width of an antenna patch and among the factors which influences the increase in the band-width one notes primarily: the geometrical shape of the resonator, types of the food, like (food bycoaxial probe, food by line microruban and foodby coupling of proximity or opening…), the type of the substrate as well as the organization of the aerial element and these parasitic elements. The developments of the new tele- communication radio systems presents an important evolution in several military and commercial application, that lead a new antenna architecture to adapt function to brings optimized antenna design satisfying with several constraints such low costs, broad band-width, compactness and operation multi-band. Generally the major drawback most important which influences the limitation of an antenna patch in technology micro ribbon is its narrow band-width which is intrinsically related to its resonant character [15]. Our studies carried out allows antenna bandwidth optimization in addition determine factors influences which increase the band-width such as the geometrical shape. In our research paper, we propose a microstrip antenna for USS telecommunication subsystem on UWB, Ku frequency band and Ka band, it is generally used for ultra small satellite [16], so a new one proposed means of circular microstrip antenna changes from small to lift the latch of bandwidth while maintaining quality performance of other properties. We begin our research work on changing the geometry shape and use some tricks to design it. This antenna fed by microstrip line, the ground plane and the antenna feed elements are placed on the same plate to reduce the spatial dimension. HFSS software was used to design our lives antenna the size and precision of the results which operate at high frequencies. We successfully design the geometry and the configuration of the antenna proposed, this form obtained after series of antenna parameters determination, engraved on a substrate of FR4 epoxy thickness characterized by: h = 1.6 mm, dielectric constant loss tangenttan δ= 0.02 and a constant dielectric = 4.2 powered by line micro ribun which is optimized to ensure the adaptation to the opening of food of 50 Ω, the power line has as a width WF =2.9mm to obtain an impedance of 50Ω. The proposed antenna has initially a circular form presented on a dielectric substrate of epoxy type FR4 of width W sub and L sub length, Lg represents the length of floor plan. We proposed the dimension before making change its form. To ensure a reduction of dimension of the antenna proposed and to ensure the adaptation of impedance on all the band- width. Table 1 illustrates different the parameter from the antenna.

TABLE.1

OPTIMIZED PARAMETERS OF THE DESIGN OF THEANTENNA PROPOSE D

Setting	Dimension
Lsub	5.8 mm
Wsub	10.2 mm
N	2.9 mm
Lg	1.6 mm
Wf	0.5 mm
H	0.5 mm
S1	0.5 mm
S2	15.4 mm
S3	5 mm
r1	9.4mm

The patch antenna initial of circular form is presented on a dielectric substrate of epoxy typeFR4 of width Wsub and Lsub length, Lg represents the length of floor plan. Nothing that the dimension initialof the circular patch before making change. The advantages of the Wilkinson divider are mainly its wide bandwidth, despite the use of impedance inverters, and its good input adaptation (S11) even if the output loads are unbalanced. In order to maintain this adaptation in a multilayer structure, it is obligatory either to transfer the surface balancing resistor or to make it in a buried layer.

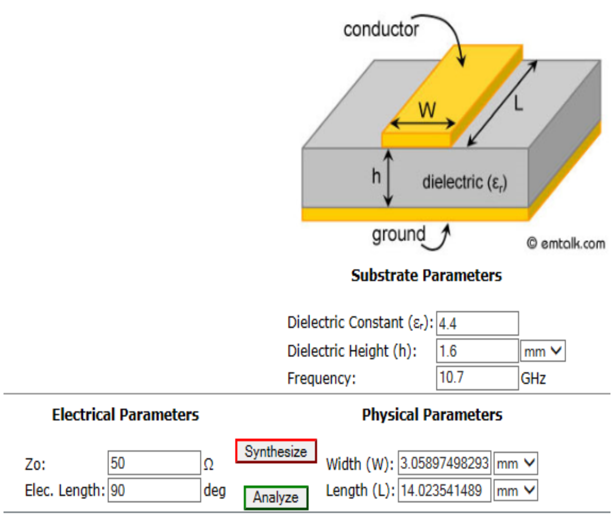

Fig.2. *Calculated Micro Ruban Line Dimension.*

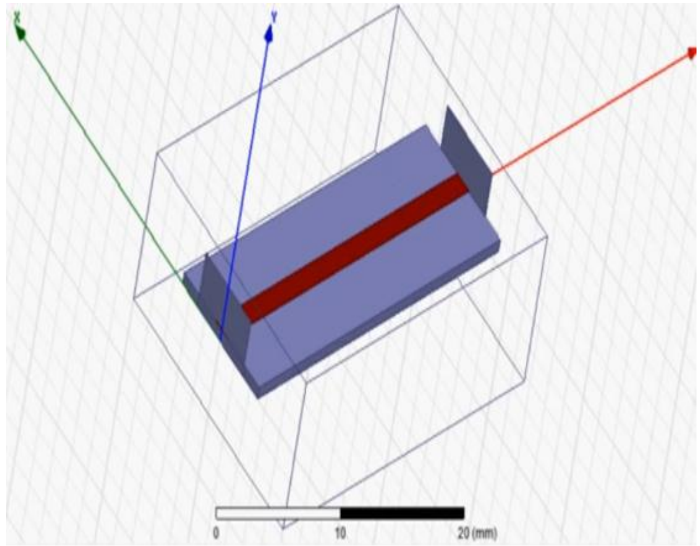

Fig.3. *Micro Ruban Ligne Transmission under HFSS tool.*

2. Excitation per Quarter Wave Line

In order to adapt the antenna to the input port in a simple way, it is sufficient to use a quarter-wave line. In order to dimension this quarter-wave microstrip line, it is necessary to know its characteristic impedance (ZC) Dependent on the guided wavelength (λg), the length of the line (L), the impedance of the load (ZH) and the input impedance (Ze). In the realized applications. The dimension of the line was calculated using the EM calculator, taking into account the types of substrate selected (Figure 2). The line width, W The values of the parameters fixed and calculated for the microstrip line are given in the following table. This line has been simulated with the HFSS software [17]. 4 shows the reflection and transmission coefficient of the microstrip line 50 ohms. A reflection coefficient of less than -27dB is obtained in the band [0.2, 10GHz] with a transmission coefficient greater than -1dB in the same frequency band. This line has been simulated with the HFSS software [18]. 4 shows the reflection and transmission coefficient of the microstrip line 50 ohms. A reflection coefficient of less than -27dB is obtained in the band [0.2 GHz, 10GHz] with a transmission coefficient greater than -1dB in the same frequency band.

3. Excitation per line 50 Ω with notch:

An essential step for feeding the antenna by a transmission line is to adapt it to a characteristic impedance of 50 Ω. This impedance depends mainly on the geometrical parameters of the line and also on the dielectric constant of the substrate εr. The thickness of the metallization is a non-modifiable parameter fixed by the manufacturing technology On the other hand, the characteristic impedance of the line is independent of the length of the line. This feeding technique consists in carrying out a power supply to the antenna of the patch antenna by a microstrip line with notches in order to ensure the proper adaptation of our antenna, the position of the feed point is chosen in such a way that the impedance Of our antenna is 50Ω (Figure 3). So our objective for this application is to look for the position on the patch where the input impedance of the antenna is 50Ω to ensure the correct adaptation. We observe that to avoid coupling the patch with the 50Ω line. The notches must not be too narrow [19] Some parameters of the line (ε_r and h) have been selected after a bibliographic search through certain works carried out. The impedance matching is very acceptable (S11 <-10 dB) at the operating frequency of 9 GHz (Figure 4). The bandwidth remains similar to that resulting from the method of excitation by quarter wave line. It has been found experimentally that the radiation pattern is very similar to that of the patch excited by a quarter wave line. It is noted that the quarter-wave excitation technique, the trend line (Especially at very high frequencies [20]) and to degrade the radiation pattern as well as the efficiency of the antenna.

4. Wave Line

We obtained the antenna has an Ultra Large Band (ULB) behavior in terms of bandwidth and reflection coefficient. Mentioned patch antenna can be used for applications in the X, Ku and Ka bands. The bandwidth ranges from 10.5GHz to 30.6GHz and has a bandwidth of approximately 20GHz. Analysis and modeling were performed using the HFSS simulator based on the finite element method.

Acknowledgment

The Authors would like to acknowledge the financial support of this work by grants from General Direction of Scientific Research (DGRST), Tunisia, under the ARUB program.

References

[1] Z.Manchester and all,' KickSat: A Crowd-Funded Mission To Demonstrate The World's Smallest Spacecraft', AIAA/USU Conference on Small, Manchester, pp:10-15, 2013.

[2] B. Stuurman, and K. D. Kumar, 'RyeFemSat: Ryerson University Femtosatellite Design and Testing', SpaceOps 2010 Conference AIAA,2010.

[3] A. Becerra all, "Feasibility Study of using a Small Satellite Constellation to Forecast, Monitor and Mitigate Natural and Man-made Disasters in Chile and Similar Developing countries", 26th annual AIAA/USU conference onSmall satellite, LOGANUtah USA, 2012.

[4] Izquierdo, J. Tristancho, "Next Generation of Sensors for FEMTO-SATELLITES Based On Commercial-Of-The-Shelf", DASC-IEEE/AIAA, SALTLE WA, 2011.

[5] D.Morgan and all, "Decentralized Model Predictive Control of Swarms of Spacecraft Using Sequential Convex Programming', 23rd AAS/AIAA Space Flight Mechanics, Hawaii, 2013.

[6] Siegried W.Janson and all, ' The Next little thing: Femtosatellites', 27th Annual AIAA/USU Conference on Small Satellites, Logan, UT, USA · Utah State University, 2013.

[7] D. Krejci and all, ' Design and Characterization of a Scalable ion Electrospray Propulsion System', International Symposium on Space Technology and Science, Hyogo-Kobe, Japan, 2015.

[8] Carlo Sau , 'Reconfigurable coprocessors synthesis in the MPEG-RVC domain' , 2015 International Conference on ReConFigurable Computing and FPGAs (ReConFig), Mexico City , pp:1-8,2015.

[9] Zhong-Ho Chen, 'Exploiting Parallelism of MPEG-4 Decoder with Dataflow Programming on Multicore Processor', International Symposium on Parallel and Distributed Processing with Applications, Taipei, pp: 367 – 373, 2010.

[10] S. Gezici et al., ''Localization via Ultra-Wideband Radios– A look at positioning aspects of future sensor networks,'' IEEE Signal Processing Magazine, vol. 2, no. 4, July 2005.

[11] Naveen Tiwari , 'Performance measurement of a fully pipelined JPEG codec on emulation platform, Advance Computing Conference (IACC), 2010 IEEE 2nd International, Patiala, pp : 167 – 171 ,2010.

[12] Lee K.F., Luk K.M., Tong K.F., Shum S.M., Huynh T., and Lee R.Q. Experimental and simulation studies of the coaxially fed u-slot rectangularpatch antenna. Microwaves, Antennas and Propagation, IEE Proceedings,144(5) :354–358, 56

[13] G. Eason, B. Noble, and I.N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955. (references)

[14] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

[15] I.S. Jacobs and C.P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G.T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271-350.

[16] K. Elissa, "Title of paper if known," unpublished.

[17] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[18] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740-741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[19] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

Chafaa Hamrouni

(M'08–SM'13) received the Master's degree in new technologies of computer sciences. He's graduated and obtained his PhD degree in sciences computer engeneering. Currently, He is interested in small satellite design and development. Actually, Dr. C. Hamrouni is A.Professor in the University of Gabes; High School of Technicl Studies of Gabes- Tunisia

Mohamed N. ABDELKRIM

Professor was born in Metouia in Tunisia on 20 July 1958. he is the head of the Research Unit « Modeling, Analysis and Control Systems-MACS with more than 90 researchers in Master, Doctorate and habilitation degrees ». He has more than 50 publications in international revues and more than 200 communications in national and international conferences. He directed more than 20 Thesis of Doctorate and several research Masters.