Design of a new model of miniature antenna quasi-isotropic coverage

Abdellatif Berkat[1], Noureddine Boukli-Hacene[2] and F. Tarik Bendimerad[3]

[1] Telecommunication Laboratory, Faculty of Technology, Abou-Bekr Belkaïd University
Tlemcen, 13000, Algeria

[2] Telecommunication Laboratory, Faculty of Technology, Abou-Bekr Belkaïd University
Tlemcen, 13000, Algeria

[3] Telecommunication Laboratory, Faculty of Technology, Abou-Bekr Belkaïd University
Tlemcen, 13000, Algeria

Abstract

In this paper we propose a new model for antenna design with a new geometry, in order to generate a quasi-isotropic radiation pattern in the far-field region. The main feature of the proposed antenna is the capability to generate a quasi-isotropic radiation pattern. The design details of the conceived antenna are presented and discussed. Simulations of the reflection coefficient and radiation pattern are presented. These were carried out using *CST Microwave Studio* .This antenna is easy to make and has got numerous applications in wireless systems, network sensors, field measurements and electromagnetic compatibility.

Keywords: *miniature antenna, quasi-isotropic, circular polarization, isotropic coverage.*

1. Introduction

Wireless sensor networks for home, industrial or environmental monitoring, personal body area networks, motion capture systems based on body sensors as well as satellite positioning devices are typical upcoming applications demanding for reliable wireless transmissions with constant link budget between devices, even if randomly oriented or quickly rotated with respect to each other. In such systems, various phenomena can deteriorate the transmission at the physical layer level such as an obstruction between devices, a multi-path fading or the presence of interferers [2]. These phenomena are particularly sensitive to the motion of devices or objects in the environment.

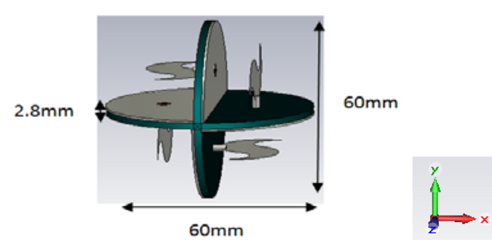
Concerning the impact of an arbitrary device orientation, the two main phenomena appear to be the anisotropy of the radiating pattern as well as the polarization mismatch between antennas. Directions of departure and arrival of a beam can change rapidly while in use and fall into the antenna radiating holes. Tilt between polarization states of antennas causes attenuation in the transmitted power. These effects can be greatly mitigated by a proper design of the radiation pattern properties of the antenna. Nowadays, new wireless applications come to market. They involve small telecommunication devices where orientation between emitter and receiver can change randomly while in use [2].

However, the transmitted signal is expected to be as stable as possible, whatever the orientation of the communicating objects is. For short distance, low cost, low data rate and low consumption applications, that is to say, when an adaptive solution cannot be envisaged, the most straightforward strategy is to search for an antenna radiating uniformly in all directions, knowing that an isotropic antenna doesn't exist [11].

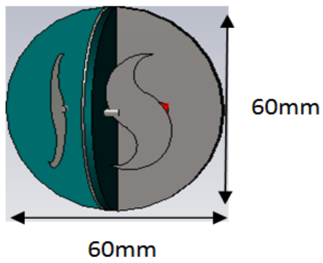
The antenna structure, the feeding network as well as the far-field pattern results are successively presented below.

2. Antenna configuration

The antenna structure is depicted in Fig1. Four patches are located along the sides of two intersected cylinders. patches are fed through a ground plane by a microstrip network, etched on the bottom side of the PCB.



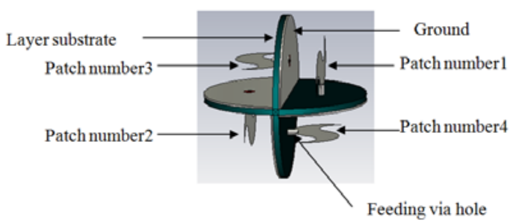
(a)



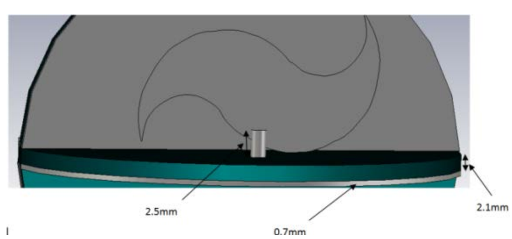
(b)

Fig1-(a) Horizontal view, (b) Vertical view of the new antenna model.

Fig 2 illustrates the antenna structure. The green top layer is made of a low permittivity and low-loss substrate, in order to optimize the antenna efficiency and bandwidth, where $\varepsilon_r = 2.33$, $\mu = 1$ and thickness = 2.1 mm. A 0.7 mm thick copper layer is used as a ground plane for the antenna structure.



(a)



(b)

Fig 2 - (a) Structure of the antenna with four patches, (b) Layer and arrangement of the patch antenna

Fig 3 shows that the elementary patch is 32.64 mm long, 19.46 mm wide and are made of copper. It is fed via holes that are 1 mm across and 2.5 mm long. These holes are connected to the feeding network.

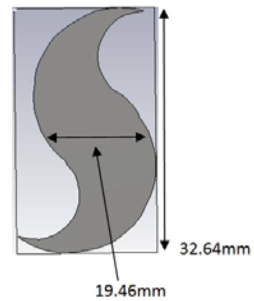


Fig3: Patch used

The four patches are fed with equal amplitudes. S2 and S3 are fed with the same phase of 90°. There is a phase difference of 90° between S1, (S2,S3) and S4. This feeding scheme leads to the targeted particular quasi-isotropic radiation pattern. It presents the advantage of greatly reducing the mutual coupling between patches.

Patch number	1	2	3	4
Amplitude relative to patch	1	1	1	1
Phase delay relative to patch	0°	90°	90°	180°

Table : Amplitude and phase constraints of the antenna.

3. Feeding network

The feedind network aims at feeding each Patch with the required amplitudes and phase. A microstrip network with two 90° hybrid couplers and one 180° hybrid coupler are located in the bottom side of the PCB. The network architecture is shown in Fig 4.

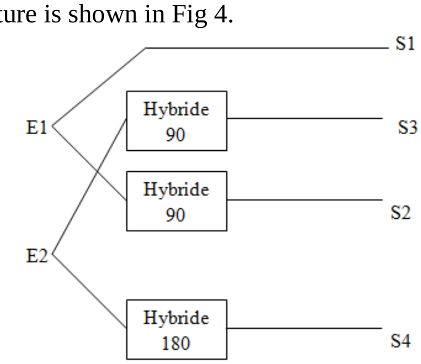


Fig4: Schematic of the feeding network [9]

The circuit layout, as illustrated in Fig 5, was designed using ISIS Proteus. The components are ultra small SMT. The input network is connected through two U-fl coaxial connectors (E1 and E2).

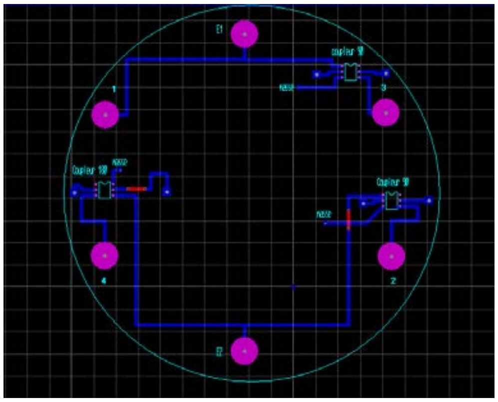


Fig 5: Layout of the microstrip network [14].

The antenna will be positioned in a vertical mode on the PCB.

4. Radiation properties of the antenna

In Fig 6, at the frequency of 3.8 GHz, a resonant mode and a good adaptation are observed. A peak appears at -35 dB .

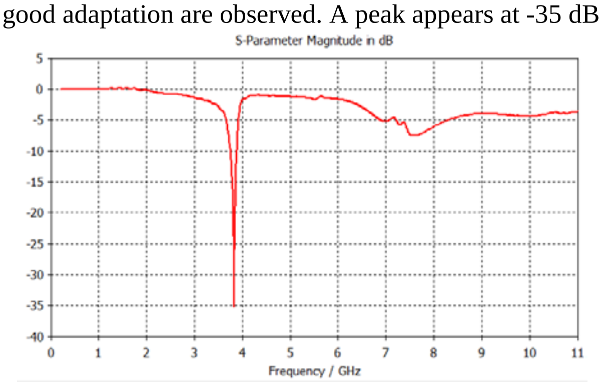


Fig 6: Computed return loss of the antenna

The main purpose of the antenna is to obtain a quasi-isotropic radiation pattern which allows the communication performances to be uniform between devices whatever their orientations are. The antenna radiation pattern is nearly isotropic. Fig 7, Fig 8, Fig 9 and Fig 10 exhibit the antenna radiation patterns at 3.8 GHz.

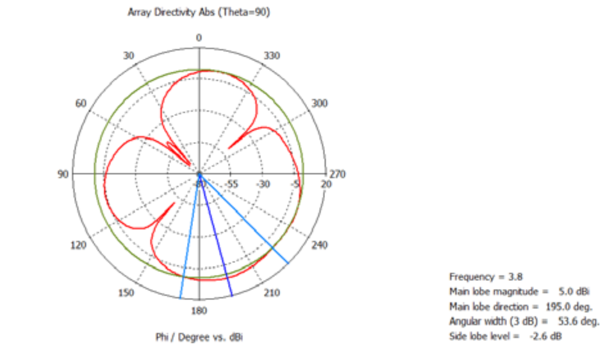


Fig7 : Polar diagrams (Theta=90°) at frequency = 3.8 Ghz

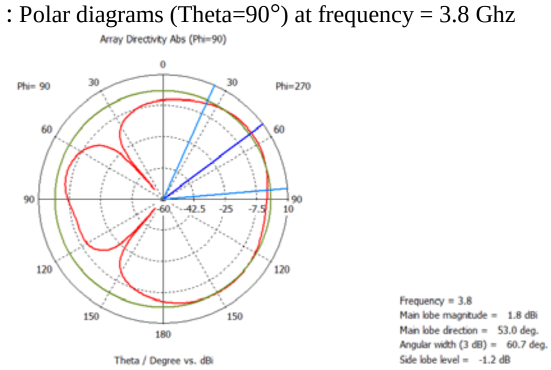


Fig8 : Polar diagrams (Phi=90°) at frequency = 3.8 Ghz

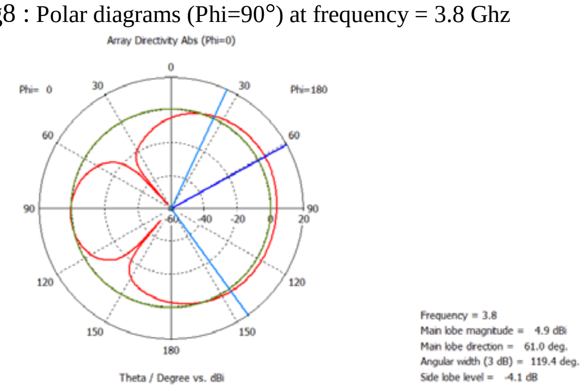


Fig9 : Polar diagrams (Phi=0°) at frequency = 3.8 Ghz

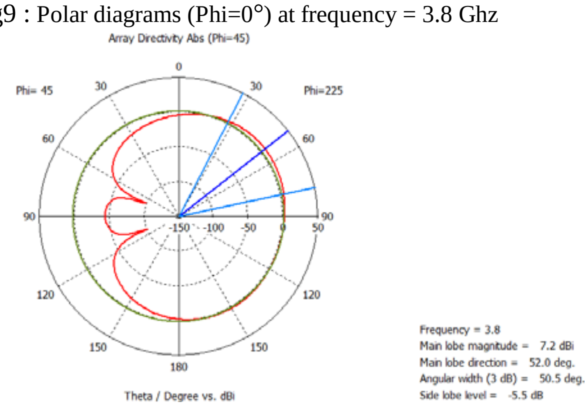


Fig10 : Polar diagrams (Phi=45°) at frequency = 3.8 Ghz

5. Conclusion

It was shown that this new miniature antenna that involves four novel patches presents a quasi-isotropic radiation pattern. The simulated results were conducted using the CST Microwave Studio. This new quasi-isotropic radiator has great applications in wireless systems and network sensors. Finally, it is also worth mentioning that similar quasi-isotropic antennas can be designed for other frequency bands, by a small change in the antenna geometry.

References

[1] E. da S. Pires(LEMA, Av. Aprígio Veloso, 882, UFCG/CCT/DEE, Campina Grande, PB, 58109-970, Brazil), G. Fontgalland(LEMA, Av. Aprígio Veloso, 882, UFCG/CCT/DEE, Campina Grande, PB, 58109-970, Brazil), R. M. do Valle(LEMA, Av. Aprígio Veloso, 882, UFCG/CCT/DEE, Campina Grande, PB, 58109-970, Brazil), G. F. Aragão(LEMA, Av. Aprígio Veloso, 882, UFCG/CCT/DEE, Campina Grande, PB, 58109-970, Brazil), W. R. N. Santos(LEIAM, Av. Aprígio Veloso, 882, UFCG/CCT/DEE, Campina Grande, PB, 58109-970, Brazil), T. P. Vuong(2LCIS/ESISAR-INPG, 50, rue Barthélémy de Laffemas, Valence, 26902, France) ,'' Proposal of a New Compact Isotropic Antenna'',IEEE 2006 .

[2] Huchard, M., Delaveaud, C.,Tedjini, S,''Miniature Antenna for Circularly Polarized Quasi Isotropic Coverage'', Antennas and Propagation, 2007. IEEE 2007 .

[3] Lev Pazin, Aleksey Dyskin, and Yehuda Leviatan,'' Quasi-Isotropic X-Band Inverted-F Antenna for Active RFID Tags'', IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 8, 2009 .

[4] M. HUCHARD, C. DELAVEAUD, S. TEDJINI, '' Critère d'évaluation de la couverture d'une antenne à partir de son champ lointain'' , 14èmes Journées Nationales Microondes 11-12-13 Mai 2005 Nantes .

[5] Sami HEBIB,''Nouvelle topologie d'antennes multi-bandes pour applications spatiales'', Délivré par l'Université Toulouse III - Paul Sabatier .

[6] Zhi Ning Chen, Kazuhiro Hirasawa(*Member, IEEE),* Kwok-Wa Leung,(*Member, IEEE),* and Kwai-Man Luk, (*Senior Member, IEEE),* ''A New Inverted F Antenna with a Ring Dielectric Resonator'', IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 48, NO. 4, JULY 1999 .

[7] M. Fawzi Bendahmane, Mehadji Abri , F. Tarik Bendimerad and Noureddine Boukli-Hacene, '' A Simple Modified Transmission Line Model for Inset Fed Antenna Design'' , IJCSI International Journal of Computer Science Issues, Vol. 7, Issue 5, September 2010 .

[8] Haim Matzner(Holon Academic Institute of Technology, Holon, Israel) , Kirk T. McDonald(Joseph Henry Laboratories, Princeton University, Princeton, NJ 08544) ,'' Isotropic Radiators'', April 8, 2003 .

[9] Mathieu HUCHARD ,'' Caractérisation et Conception d'Antennes Isotropes Miniatures pour Objets Communicants'', préparée au Laboratoire d'Electronique et de Technologie de l'Information du CEA Grenoble dans le cadre de l'Ecole Doctorale .

[10] Yue Gao, ''Characterisation of Multiple Antennas and Channel for Small Mobile Terminals'', Department of Electronic Engineering
Queen Mary, University of London,United Kingdom,June 2007 .

[11] Mathieu Huchard(CEA-LETI, Grenoble, France) , Christophe Delaveaud(CEA-LETI, Grenoble, France) and Smail Tedjini(LCIS/ESISAR-INPG, Valence, France) , ''Characterization of the Coverage Uniformity of an Antenna based on its Far-Field'',IEEE 2005 .

[12] Kirk T. McDonald ,'' Radiation of Turnstile Antennas Above a Conducting Ground Plane'', Joseph Henry Laboratories, Princeton University, Princeton, NJ 08544 (September 18, 2008) .

[13] Huan-Chu Huang , Xiaojing Xu, and Yuanxun Ethan Wang ''Dual-Band Isotropic Radiation Patterns from a Printed Electrically Small Loop-Loaded Dipole Antenna'', Department of Electrical Engineering, University of California at Los Angeles, 405 Hilgard Ave., Los Angeles, CA90095-1594, U.S.

[14] Jean-Christophe MICHEL, ''www.gecif.net'' , ISIS Proteus ,July 2011 .

Abdellatif BERKAT was born in Algeria in 1987. He obtained his Master's Degree in Telecommunications, from Abou Bekr Belkaid University, Tlemcen, Algeria, in 2010. Abdellatif BERKAT is interested in the following topics: antenna design, algorithmic and programming theories, optimization algorithms, development of artificial intelligence methods. Abdellatif BERKAT is a doctorate student in the same university working on antenna design.

Noureddine Boukli-Hacene was born in 1959 in Tlemcen, Algeria. He received his Diplome d'Etudes Approfondies in microwave engineering (DEA Communications, Optiques et Microondes) and his Doctorate Degree in electrical engineering from Limoges University, France and from the National Center of Spatial Studies (Centre National d'Etudes Spatiales) in Toulouse, France, in 1982 and 1985 respectively. Recently, he was appointed as a lecturer at the University of Tlemcen. His research interests include, among others, microstrip antennas and microwave circuits.

F. Tarik Bendimerad was born in 1959 in Sidi Bel Abbès, Algeria. He received his Engineering Degree in 1983 from the Science and Technology University in Oran, Algeria and his Doctorate Degree from Nice Sophia Antiplois University, France, in 1989. He is a professor and the Director of the Telecommunications Laboratory. His main area of research is the microwave techniques and radiation and he is responsible of the antenna section.