A Novel UWB Antenna for a Broadcasting Television System

Euclides L. Chuma

Yuzo Iano

Leonardo L. Bravo Roger

Silvio R. Messias de Carvalho

Cite this article:
Chuma, Euclides L., Iano, Yuzo, Roger, Leonardo L. Bravo, de Carvalho, Silvio R. Messias; 2017. A Novel UWB Antenna for a Broadcasting Television System. SET INTERNATIONAL JOURNAL OF BROADCAST ENGINEERING. ISSN Print: 2446-9246 ISSN Online: 2446-9432. doi: 10.18580/setijbe.2017.8. Web Link: http://dx.doi.org/10.18580/setijbe.2017.8

SET INTERNATIONAL JOURNAL OF BROADCAST ENGINEERING – SET IJBE v. 3, 2017, Article 8, 4p.

A Novel UWB Antenna for a Broadcasting Television System

Euclides L. Chuma, Yuzo Iano, Leonardo L. Bravo Roger, Silvio R. Messias de Carvalho

***Abstract*— An ultra-wideband (UWB) discone antenna with an omnidirectional radiation pattern is proposed in order to be used in a broadcasting television system. It is an ultra-wideband antenna with an omnidirectional radiation pattern, using a single antenna to receive TV signals from several transmitting stations across various geographic locations. The UWB antenna proposed in this study covers a frequency range of 0.32-1.65 GHz with a gain of 1.7 dB. It operates in both conditions: indoor and outdoor.**

***Index Terms*—antenna, UWB, TV, broadcasting, television, ultra-wideband.**

I. Introduction

TELEVISION broadcasting stations are spread across many locations. Therefore, the reception of TV signals by using only one directional antenna is not an easy task. To receive all the nearby signals, it is necessary to use several directional antennas. This fact makes such a system complex and expensive to implement. Besides, the reception system is sensible to signal loss owing to the use of external components such as mixers that experience insertion loss.

The use of an antenna with an omnidirectional radiation pattern could potentially provide a solution in a situation where it is necessary to receive signals from all directions. In this case, the antenna must also be able to receive these signals over a wide frequency range. For example, in Brazil, digital television (DTV) operates mainly in the UHF band between 470–800 MHz with a bandwidth of 6 MHz, as shown in Table I [1].

This paper proposes the use of a discone antenna. This paper presents the design, simulation, implementation and evaluation of that antenna. We chose a discone antenna because it has an omnidirectional radiation pattern and exceptional wideband [2] [3].

In this work, we study the discone antenna with an omnidirectional radiation pattern that covers the frequency range of 0.32-1.65 GHz, thus it is an UWB antenna. Over time, UWB has become a widely adopted term. Federal Communications Commission (FCC) rules [4] state the UWB band when fractional bandwidth is equal to or greater than 0.20. The fractional bandwidth is given as follows:

$$fractional\ bandwidth = 2(f_H - f_L)/(f_H + f_L) \quad (1)$$

Where, f_H is the upper boundary frequency and f_L is the lower boundary frequency. The bandwidth is equal to or greater than 500 MHz, regardless of the fractional bandwidth.

TABLE I
UHF DTV CHANNEL ASSIGNMENTS IN BRAZIL

Channel	Frequency (MHz)	Channel	Frequency (MHz)
14	470 – 476	43	644 – 650
15	476 – 482	44	650 – 656
16	482 – 488	45	656 – 662
17	488 – 494	46	662 – 668
18	494 – 500	47	668 – 674
19	500 – 506	48	674 – 680
20	506 – 512	49	680 – 686
21	512 – 518	50	686 – 692
22	518 – 524	51	692 – 698
23	524 – 530	52	698 – 704
24	530 – 536	53	704 – 710
25	536 – 542	54	710 – 716
26	542 – 548	55	716 – 722
27	548 – 554	56	722 – 728
28	554 – 560	57	728 – 734
29	560 – 566	58	734 – 740
30	566 – 572	59	740 – 746
31	572 – 578	60	746 – 752
32	578 – 584	61	752 – 758
33	584 – 590	62	758 – 764
34	590 – 596	63	764 – 770
35	596 – 602	64	770 – 776
36	602 – 608	65	776 – 782
38	614 – 620	66	782 – 788
39	620 – 626	67	788 – 794
40	626 – 632	68	794 – 800
41	632 – 638		
42	638 – 644		

E. L. Chuma is a Master Science Candidate at the State University of Campinas, and a researcher at the Laboratory of Visual Communications (e-mail: euclides.chuma@ieee.org).

Y. Iano, PhD, is a professor and coordinator of the Laboratory of Visual Communications at the State University of Campinas (e-mail: yuzo@decom.fee.unicamp.br)

L. L. Bravo-Roger, PhD, is a professor of the School of Technology at the State University of Campinas (e-mail: leobravo@ft.unicamp.br)

S. Messias, PhD, is a researcher of the Laboratory of Visual Communications at the State University of Campinas (e-mail: srcmessias@gmail.com).

http://www.set.org.br/ijbe/ doi: 10.18580/setijbe.2017.8 Web Link: http://dx.doi.org/10.18580/setijbe.2017.8

II. Antenna design

It is possible to analyze the discone antenna as a modification of the biconical antenna in which a disk replaces a cone [2]. The antenna feed is a coax located in the center of the cone that connects the outer shield to the lower cone. Besides, we connect the disk to the coax center conductor [3]. Fig. 1 shows a discone antenna with coaxial feed.

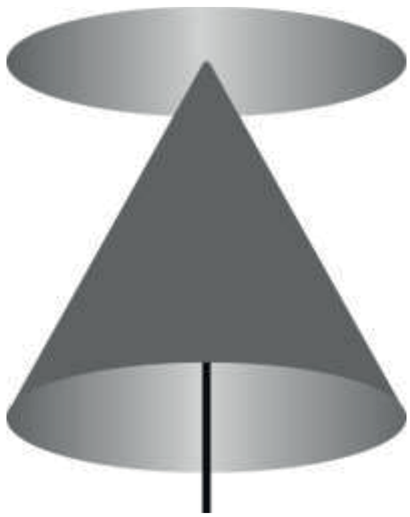

Fig. 1. A typical discone antenna.

The wide impedance bandwidth and dipole-like pattern occur because the discone antenna uses a biconical structure in which a diameter that varies smoothly at a fixed angle replaces the fixed wire diameter of the dipole [2].

A discone antenna for wideband impedance with acceptable frequency patterns can be designed using the dimensions shown in Fig. 2 such that $H = 0.7\lambda$, $B = 0.6\lambda$, $D = 0.4\lambda$, $\theta_h = 25^o$ e $\delta << D$, where λ is the wavelength of the operating frequency [2] [5].

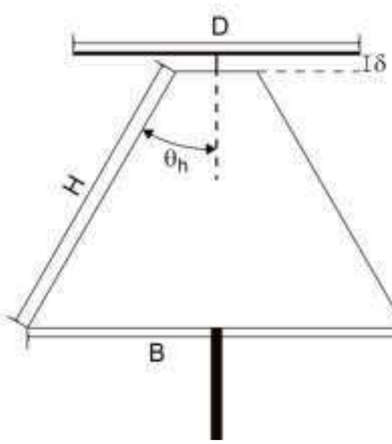

Fig. 2. Typical dimensions in the discone antenna.

We can improve the accuracy of the discone antenna by adjusting the antenna dimensions. We performed the antenna simulations using a full wave simulator Ansoft HFSS.

The discone antenna studied in this paper utilized the dimensions given in Fig. 3. We present the construction of the discone antenna in Fig. 4. A copper foil of 0.1 mm thickness was used to make the cone; the disk was made from single-sided FR-4 pcb with $\varepsilon_r = 4.4$ and a thickness of 1.6 mm. Therefore, to obtain the doubled dimensions of δ = 3.2 mm, we used the following two disks of FR-4 pcb: the copper top disk had a diameter of 160 mm and the smaller non-copper bottom disk had a diameter of 40 mm.

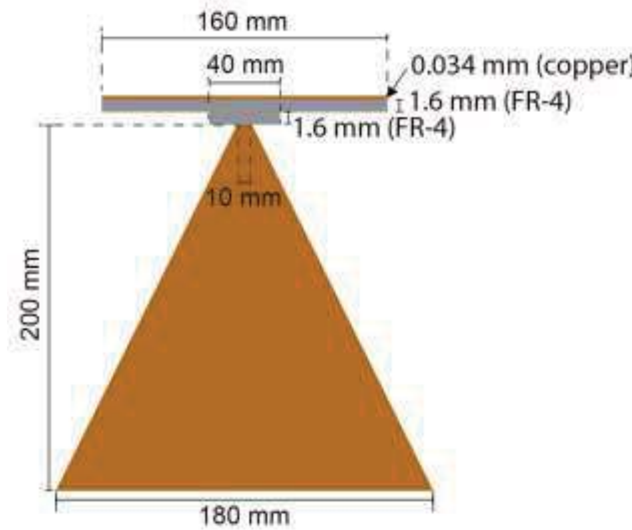

Fig. 3. Dimensions used in the discone antenna of this work.

Fig. 4. Discone antenna construction.

Fig. 5 shows the S_{11} parameters simulated and measured with a HP 8714B vector network analyzer.

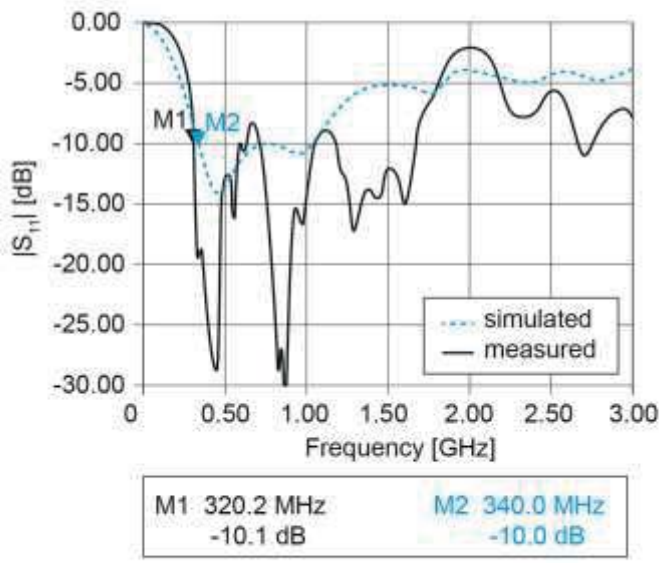

Fig. 5. Simulated and measured S_{11} of the proposed antenna.

Fig. 6 shows the simulated radiation pattern. Fig. 7 shows the simulated 3D radiation pattern.

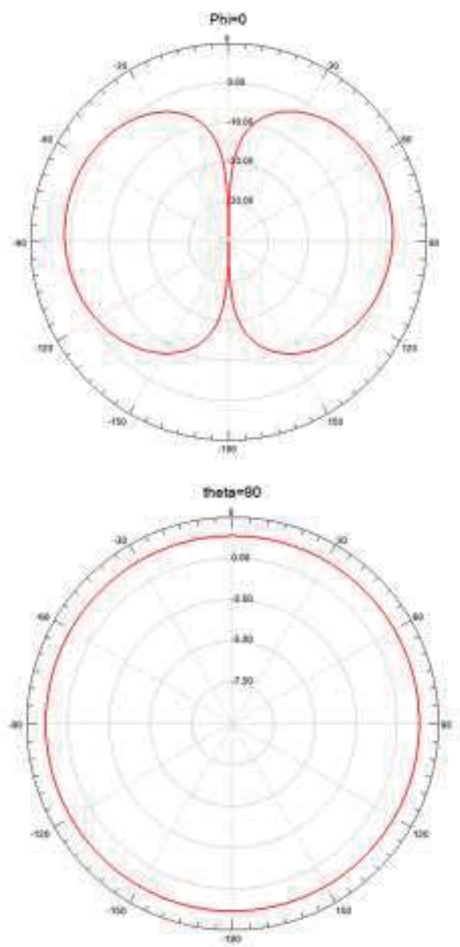

Fig. 6. The simulated radiation pattern.

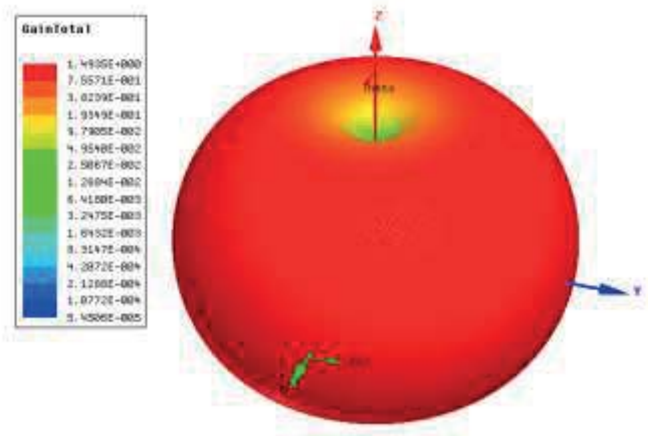

Fig. 7. The simulated 3D radiation pattern.

The Jsurf field vector at a center frequency of 635 MHz is shown in Fig. 8.

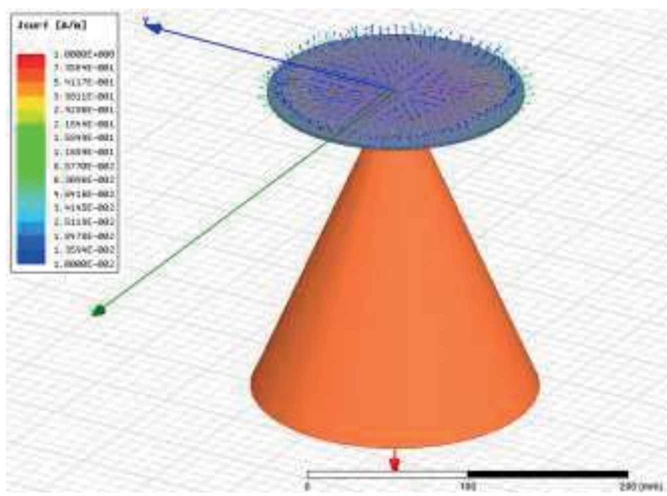

Fig. 8. Simulated Jsurf field vector of the proposed antenna.

Fig. 9 shows the discone antenna working with television. A balun matching transformer is used.

Fig. 9. A discone antenna working with a television.

http://www.set.org.br/ijbe/ doi: 10.18580/setijbe.2017.8 Web Link: http://dx.doi.org/10.18580/setijbe.2017.8

IV. Conclusions

We developed and tested an UWB omnidirectional discone antenna that was capable of operating over a frequency range of 0.32-1.65 GHz with a gain of 1.7 dB. The proposed antenna works in both conditions, namely indoors and outdoors. This research presents a proven qualitative agreement between the experimental results and the numerical simulations. The small differences are owing to effects caused by parasitic capacitances and inductances and by adapters and connectors, not considered in the simulations.

References

[1] ANATEL – Agência Nacional de Telecomunicações. Resolução nº583 de 27 de março de 2012. Available: http://www.anatel.gov.br/legislacao/resolucoes/2012/146-resolucao-583
[2] W. L. Stutzman, G. A. Thiele, “Antenna Theory and Design”, 2nd ed., John Wiley & Sons Inc., 1998, pp. 243-246.
[3] T. A. Milligan, “Modern Antenna Design”, 2nd ed., John Wiley & Sons Inc., 2005, pp. 249-250.
[4] G. Breed. "A Summary of FCC Rules for Ultra Wideband Communications", High Frequency Electronics, 2005 Summit Technical Media, pp. 42
[5] J. J. Nail, “Designing Discone Antennas”, Electronics, v. 26, pp. 167-169, aug. 1953.

Euclides L. Chuma earned a degree in Mathematics from UNICAMP and graduate degree in Network and Telecommunications Systems in the INATEL. He is currently studying MSc in Electrical Engineering at UNICAMP, SP-Brazil. He works as a software engineer in the private sector, and his research interests are Antennas, Wireless Power Transfer, Software Defined Radio and Cognitive Radio.

Yuzo Iano, PhD, is the head and founder of the Laboratory of Visual Communications since 1972. He obtained his B.Sc (1972), M.Sc (1974) and PhD (1986) in Electrical Engineering at University of Campinas, SP-Brazil. Research Interests: Digital Signal Processing (images/audio/video), Digital TV, 4G (LTE) and 5G Cellular Networks, Pattern Recognition, Smart Cities, Smart Grid, Internet of Things.

L. L. Bravo-Roger received the B. S. and M.Sc. degree in Telecommunication Systems from University of Oriente (UO), Santiago de Cuba, in 1985 and 1998, respectively, and the Ph.D. degree in Electric Engineering from Faculty of Electrical and Computer Engineering, University of Campinas (UNICAMP), Campinas, São Paulo, Brazil, in 2003. Since 2004, he is with School of Technology of UNICAMP, Limeira, São Paulo, Brazil. His research activities are in the areas of RF and microwave technologies and radar sensing systems and Wireless Sensor Networks.

Silvio R. Messias de Carvalho, PhD, obtained his B.Sc degree in Electrical Engineering at UNICAMP (1994). Holds a MSc degree (2007) and a PhD degree (2013) in Electrical Engineering from UNICAMP as well. Research Interests: Audio and video for digital TV, broadcast engineering, digital TV engineering, RF systems, mobile TV, antennas and Energy Efficiency.

Received in 2017-06-20 | Approved in 2017-11-04