ENHANCED DESIGN FOR AN OMNI-DIRECTIONAL UWB ANTENNA

Guan-Yu Chen and Jwo-Shiun Sun
Department of Electronic Engineering, National Taipei University of Technology
Microwave & Wireless Components Laboratory
1, Sec.3, Chung-Hsiao E. Rd. Taipei 106, Taiwan,
E-mail: s1669012@ntut.edu.tw & jss@en.ntut.edu.tw

Sen-Yi Huang and Yi-Jay Lee
Institute of Mechatronic Engineering, National Taipei University of Technology
Institute of Computer, Communication and Control, National Taipei University of Technology
E-mail: s3408010@ntut.edu.tw & s3419003@ntut.edu.tw

1. Abstract

This paper proposes an omni-directional UWB antenna pattern in azimuth cut, low voltage standing wave ratio (VSWR), and easy to construct antenna for ultra wideband (UWB) systems. The designed antenna uses the multi circular blade configuration with a radiating element and a square ground plane. The multi-circular blades UWB antenna suitable for IEEE 802.15.3a and IEEE 802.16 UWB communication applications at 3.1-10.6 GHz and 2-11 GHz bands is presented. This paper discusses the phenomenon of dispersal in UWB antennas and presents a simple design to evaluate the radiated fields from antennas structures. Measured results exhibits extend return loss bandwidth and lower omni-directional pattern deviation in azimuth cut. The antenna design allows a quick assessment of dispersion in design. The proposed multi-circular blades UWB structures is capable of achieving broadband and omni-direction at azimuth cut characteristics within 2~11GHz for UWB wireless communication applications.

2. Introduction

Ultra wideband (UWB) is widely recognized as the modern generation short range wireless communications technology [1] that will provide simultaneous high data rate and low power consumption. The Federal Communications Commission (FCC) in the United States conditionally waived unlicensed operation of the personal UWB products in the private sector. UWB brings the convenience and mobility of wireless communications to high speed interconnects in devices throughout the digital home and office. Modern UWB systems use other modulation techniques, such as orthogonal frequency division multiplexing (OFDM), to occupy these extremely wide bandwidths. UWB's combination of broader spectrum and lower power improves speed and reduces interference with other wireless spectra. The FCC has mandated that UWB radio transmissions can legally operate in the range from 3.1 GHz up to 10.6 GHz, at a limited transmit power of -41dBm/MHz. Consequently, UWB provides dramatic channel capacity at short range that limits interference. The paper introduces multi circular blade antenna designs and comparison for ultra wideband 2~13 GHz antenna parameters, such as return loss, radiation patterns and frequency domain responses. In this paper, the primary design is an ultra thin, low profile and multi vertical circular metal planes antenna that incorporated ground plane for measurement. Most wideband antennas do not simultaneously meet omni-directional and low VSWR requirements, essential for applications such as UWB channel sounding. The proposed antenna consists of a square ground plane and a circular blade that is defined as a combination of a finite circular and a planar sphere metal to be soldering above the ground plane base with 50 ohm SMA connector. We constructed a prototype antenna for the FCC approved UWB frequency band (3.1-10.6 GHz). The prototype antenna was successful because it demonstrated

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omni-directional radiation and low VSWR between 2 GHz and 13 GHz. This prototype antenna could therefore be used in the next generation of UWB wireless system measurement applications.

3. Antenna Design

This antenna can be considered either as a rounded finite monopole antenna or as a simplified half finite circular tapered slot antenna with ground plane. Assuming 50-ohm excitation, the optimum half planar cone angle is 23 degree that gives the lowest maximum VSWR, as showed in Fig. 1. UWB Antenna design theories are based on broadband and frequency independent antennas concept and radiation principle [2]. In this design, the circular curve is a broadband antenna type. The antenna is a non-resonant type antenna and low-Q radiator with input impedance the remains essentially constant over a wide frequency range. The UWB antenna is well matched to free space providing a smooth circular metal, and wave along the tapered curve to transition and radiated from the guided wave on the input transmission line to free space wave propagation. A simple RF probe fed circular blade UWB antenna is proposed, using a 50 ohm SMA RF probe as feeding structure and compared return loss and radiation characteristics of the different multi circular blades UWB antenna radiators effects. The designed UWB antennas with single and orthogonal multi circular blade radiating elements are presented and their bandwidth characteristics with respect to geometrical parameters have been investigated. The multi circular for with one blade ($\alpha = 180^\circ$), two blades ($\alpha = 90^\circ$), three blades ($\alpha = 60^\circ$) and four blades ($\alpha = 45^\circ$) design, as shown in Fig. 2. Optimal design provides an antenna diameter of 30 mm circular metal, which could be the smallest planar antenna reported to satisfy the specification for VSWR < 2 at 3.1~10.6 GHz. Measured results have been presented for the return loss and gain patterns in the bring direction as a function of frequency. The proposed antenna features a compact size, wide impedance bandwidth, and consistent radiation patterns over the ultra wideband frequency spectrum. The characteristics of the proposed antenna, in frequency domain responses, are measured and compared. It is demonstrated that minimum radiation distortion to the UWB performance could be expected. A prototype antenna was constructed and its VSWR and radiation characteristics were measured. The proposed antenna shows lower VSWR than a finite circular metal of the equivalent size across most of the bandwidth. There was a good correlation between the measured and the calculated radiation patterns observed.

4. Results

This presentation discusses the effects of these relatively small UWB antennas on the VSWR and gain measurements. The results of the EM analysis of the antennas present a measured bandwidth suitable for ultra-wideband antenna use. For an ultra-wideband (UWB) system, the antenna with wide bandwidth able to cover from 3.1 to 10.6 GHz is required. It has been already proposed several types of wideband antennas that cover whole frequency range. In this design, the diameter of circular blade element measures is 30mm, which is the smallest size reported for UWB (3.1~10.6GHz) or Wi-Max (2~11GHz) applications. The size of the required ground plane is 100mm. The antenna satisfies VSWR <2 for the entire UWB frequency. We present new low profile multi circular blades for UWB monopole antenna referred to as the SMA RF probe feed. The measured results presented show that the antenna has low input reflection coefficient or VSWR, as shown in Fig. 3. On the other hand, since UWB system covers from 3.1 to 10.6 GHz is very wideband; it is necessary to suppress the interference from current distribution of antenna itself geometry using some of high frequency band above 5~10 GHz. In this multi circular blades UWB design not only to enhance antenna bandwidth, but also to improve the polarization integrity. Pattern measurements of the azimuth radiation pattern of ultra-wideband antennas shown the omni-direction patterns improve and keep the pattern integrity at higher frequency as shown in Fig. 4 ~ Fig. 7. The measured data with peak and average in azimuth cut, as shown in Table 1~4.

5. Conclusion

In this paper, the improved UWB monopole antenna which consists of multi-connected circular plates is presented. The VSWR characteristics and radiation pattern of the antenna are measured and compared. The proposed structure of UWB monopole antenna exhibits multi-frequency and optimum broad bandwidth frequency at 3.1~10.6 GHz and the radiation patterns are almost omni-direction in band. Wide bandwidth characteristics can be achieved and frequency domain as well as single circular blade monopole UWB antenna is well investigated with fairly well.

6. Reference

[1] L. Yang; and G. B. Giannakis, Ultra-wideband communications: an idea whose time has come, IEEE Signal Processing Magazine, pp.26 – 54, Nov. 2004
[2] C. A. Balanis, Antenna theory analysis and design, John Wiley, c1997

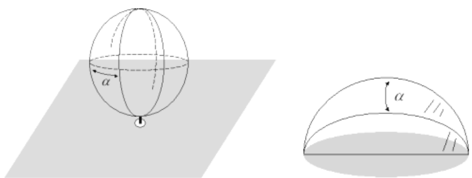

Fig. 1 Multi circular blades UWB structure and half sectional drawing

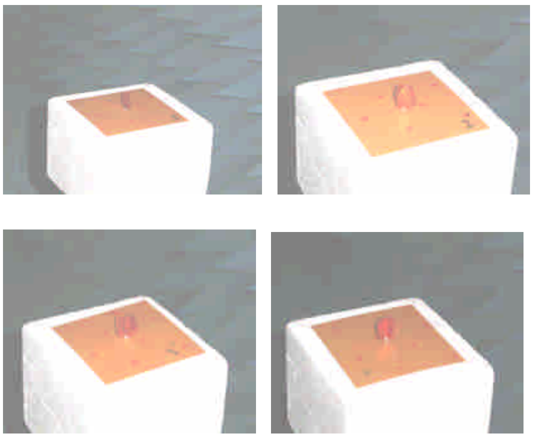

Fig. 2 Practical multi circular blades UWB antennas structures

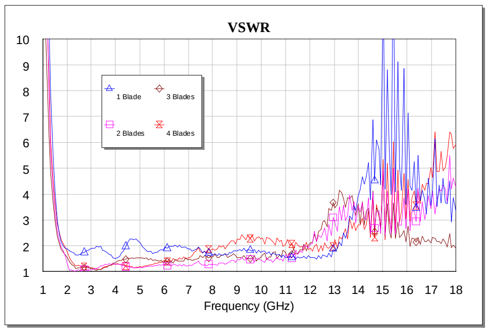

Fig. 3 VSWR of measured data

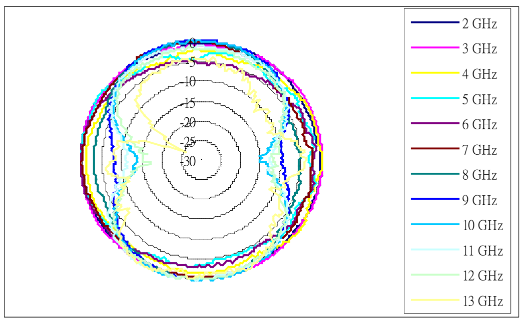

Fig. 4 One circular blade UWB antenna

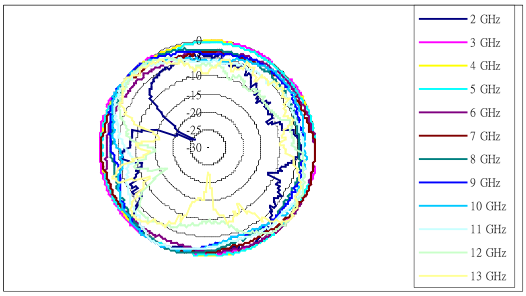

Fig. 5 Two circular blades UWB antenna

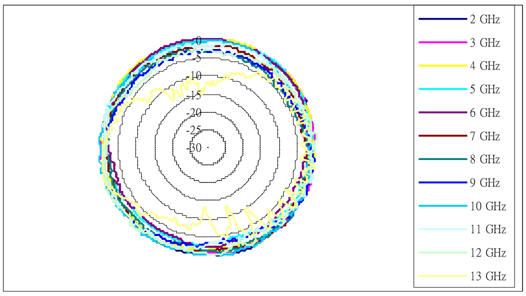

Fig. 7 Four circular blades UWB antenna

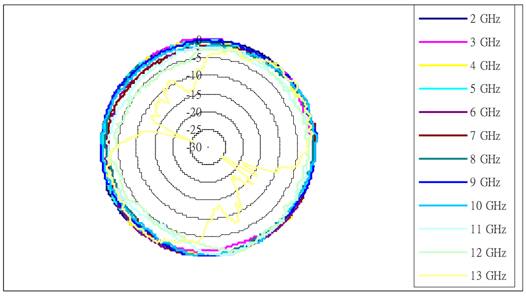

Fig. 6 Three circular blades UWB antenna

Table 1. One circular blade UWB antenna

AUT (1)	Frequency (GHz)	2	3	4	5	6	7
STANDING-VP	Peak (dBi)	-0.20697	-0.21937	0.4841	0.38955	0.29656	-3.10486
	Average (dBi)	-0.8595	-0.71544	-1.3458	-1.80538	-2.31895	-4.48252
AUT (1)	Frequency (GHz)	8	9	10	11	12	13
STANDING-VP	Peak (dBi)	-0.62947	0.72649	0.55122	-0.4529	-1.79737	-2.70791
	Average (dBi)	-2.90479	-1.794544	-2.13979	-3.35685	-5.34434	-7.4596

Table 2. Two circular blades UWB antenna

AUT (2)	Frequency (GHz)	2	3	4	5	6	7
STANDING-VP	Peak (dBi)	0.62217	0.09347	0.408826	-1.75514	-3.83502	-2.8162
	Average (dBi)	-4.12952	-0.35163	-1.51078	-2.4807	-5.54343	-4.28369
AUT (2)	Frequency (GHz)	8	9	10	11	12	13
STANDING-VP	Peak (dBi)	0.48788	1.66193	-0.24698	-1.62568	-3.80179	-4.89632
	Average (dBi)	-2.06882	-0.83311	-2.822154	-4.951324	-8.70303	-10.0953

Table 3. Three circular blades UWB antenna

AUT (3)	Frequency (GHz)	2	3	4	5	6	7
STANDING-VP	Peak (dBi)	0.04946	-0.42758	0.49977	-2.79187	-4.68709	-1.152
	Average (dBi)	-0.60297	-1.51634	-0.14236	-3.48783	-5.8357	-2.61004
AUT (3)	Frequency (GHz)	8	9	10	11	12	13
STANDING-VP	Peak (dBi)	0.70007	0.79853	-0.49316	-1.62535	-3.72938	-2.83486
	Average (dBi)	-0.63539	0.097392	-1.65696	-4.13656	-7.01079	-7.05154

Table 4. Four circular blades UWB antenna

AUT (4)	Frequency (GHz)	2	3	4	5	6	7
STANDING-VP	Peak Gain (dBi)	-0.00639	-0.08523	0.35298	-3.29774	-3.3621	-1.66083
	Average (dBi)	-0.69893	-0.635	-0.38241	-4.93464	-5.21615	-3.4293
AUT (4)	Frequency (GHz)	8	9	10	11	12	13
STANDING-VP	Peak (dBi)	0.51678	1.27744	-2.14245	-3.69529	-4.66943	-3.32607
	Average (dBi)	-1.81909	-0.95684	-3.03301	-5.147408	-6.45594	-7.83834