xIlkogretim Online - Elementary Education Online,2021; Vol 20 (Issue 1): pp.2437-2446
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2021.01.274

Design of Extremely Wideband Antennas for High Data Rate Applications

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Abstract-In this paper multiple papers and the various characteristics of extremely wide band antennas and the applications of the same are analysed and compared. With a view to identify the benefits of usage of Extremely wideband antennas for high data rate application, this paper considers various studies that have been meticulously carried out in this area and summarizes for researchers to get a comprehensive view on various extremely wideband antennas and the design aspects.

Keywords: Wideband Antennas, high data rate

I INTRODUCTION

An antenna is an electronic component which can transmit as well as receive radio waves (electromagnetic waves) in all horizontal directions equally (omnidirectional antennas), or in a particular direction (directional, or high-gain, or beam antennas). Extremely wideband antennas (EWBA) are now getting recognized as a potential and capable, modern and future wireless communication systems. Extremely wideband antennas are the antennas which cover the frequency ranges from 3.2 - 10.6 GHz. These antennas can transmit data at a very high rate by utilising less power. These antennas are also comparatively quite cheap than the traditional antennas. One EWBA can replace several narrow band antennas which in turn reduces the number of antennas required. Super wide band and ultra-wide band antennas provide a path for short range high data rate wireless communication. Applications with high data rate and short range have a great demand for ultra-wideband (UWB) frequency band. However, recently there has been a trend of utilising the super wideband (SWB) range which offers pervasive service by covering both short and long-range data transmission. Having more advantages over narrow band, SWB contains all the advanced characteristics of UWB. Moreover, SWB offers increased channel capacity, greater time-accuracy and a superior resolution in comparison to UWB. Some of the applications of the super wide band are WiMAX (which has high transmission speeds and works over a long range), WLAN, Radar Technology (8 GHz to 12 GHz) and satellite communication (12.7 GHz to 14.4 GHz). Different types of SWB antennas are designed by the researchers accordingly. To extend the impedance bandwidth, several designs with different monopole shapes, such as triangular-ring, circular, rectangular, have been extensively studied. Replacing traditional wire antennas by planar antennas with large surface area enhances the impedance &bandwidth.

II Existing Research

The design for enhancing the impedance bandwidth of monopole antennas is based on generating more resonances by promoting vertical current content in the radiation patch. The 2:1 VSWR ratio bandwidth is over 25:1 which covers frequencies from 1.08 GHz to 27.4 GHz over the operating frequency band, the antennas transmit and receive in a wide range of directions. These features serve the purpose of extremely wideband spectrum monitoring. The egg-shaped SWB monopole antenna loaded with fractal complementary slot into its ground plane exhibits a 10-dB bandwidth of 172% with 13.06:1 ratio bandwidth. One of its main advantage is that it has a very low return loss of 79% and also, it's suitable for long range communication services. The elliptical patch SWB MIMO antenna has a large fractional bandwidth of more than 172.12% (2.2473-30 GHz). Its main feature is that this SWB MIMO antenna can be used for all types of UWB devices. It covers frequency bands and ranges for Wi-Fi, ISM and WiMAX. It has a very high fractional bandwidth of about 175% with return loss (RL ≥ 10 dB) can be achieved by using rectangular patch antenna which has 50 Ω Microstrip feed line and partial ground plane with three round grooves. One good advantage is that an omnidirectional radiation pattern is also obtained.

III State of Art

The main contributions of this paper are as follows.

1.) An overview of contemporary techniques used for Extremely wideband antennas designed to achieve wide bandwidth operation with high data rate applications

2.) This paper highlights the present challenges in achieving high gain, compact size and affordability

The design proposed is hexagonal shaped patch loaded antenna with CPW fed asymmetric ground plane. The working frequency ranges from 2.75 to 71 GHz, with large bandwidth ratio of 25.82:1.[1] A maximum and minimum gain of 12 dBi and 4 dBi at 71 GHz and 24 Ghz is obtained respectively. It is observed that when the number of iterations is increased the impedance matching also gets enhanced which in turn results to bandwidth enhancement, Figure 1. Shows the Prototype of the designed antenna.

Figure 1. Prototype of the designed antenna

The design proposed is a tapered Microstrip line feed with notch loaded elliptical ground plane. The operating frequency range is from 0.96 GHz to 10.9 GHz. The bandwidth ratio of 11.35:1. [2] This antenna enhances the lower operating frequency. The radiator covers wide range of frequency band like LTE 2600, Wi-Fi, WLAN& supports high data rate, Figure 2. Shows the Fabricated picture of radiating structure - Top

View.

Figure 2. Fabricated picture of radiating structure - Top View

The design proposed is a circular base loaded modified rectangular monopole along with a tapered Microstrip line feed. The antenna has a fractional bandwidth of 174.29%. The gain can be increased by increasing the frequency but the radiation efficiency decreases. [3]It is proved that this antenna is suitable for super wide band applications with the help of time and frequency domain analysis, Figure 3. shows the Prototype of proposed radiator – Topview.

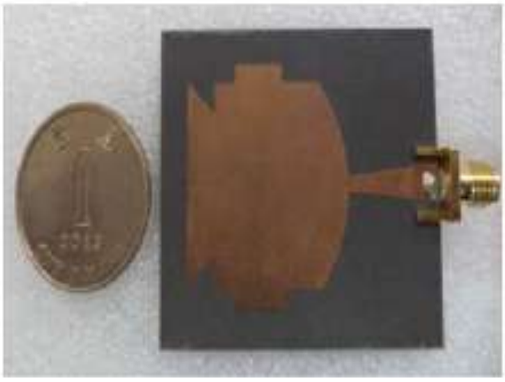

Figure 3. Prototype of proposed radiator – Topview

The design proposed in this paper is mainly a rectangular micro strip patch antenna with pentagonal tuning stub. The fractional bandwidth of this antenna is 125%. In KU region it possesses an additional frequency band which can be used for various wireless applications. [4]When compared to existing triangular model its dimensions are quite large. This antenna is capable of possessing UWB characteristics that makes it feasible for high data rate applications, Figure 4. Shows the Fabricated picture of radiating structure.

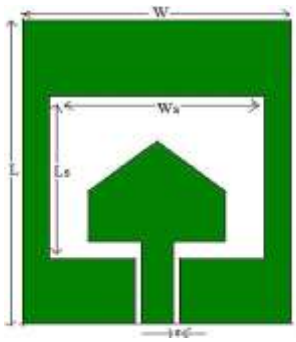

Figure 4. Fabricated picture of radiating structure

An antenna with a round patch and conventional co planar wave guide (CPW) – fed line is proposed. It is a single antenna that can work at various frequencies. It has a return loss of < 10 dB. [5]It does not require any carrier frequencies. In order to cover high band Wi-Fi & WiMAX frequencies, the design bandwidth is extended up to 5.9 Ghz. Its design and fabrication are quite challenging, Figure 5. Shows the Fabricated picture of radiating structure - Top View.

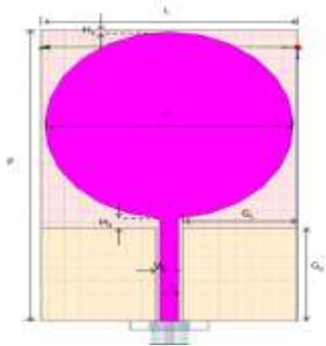

Figure 5. Fabricated picture of radiating structure - Top View

The design proposed is an ultra-wide band slot antenna with triangular tuning stub. The range of bandwidth is from 3.1 to 11.46 GHz. The VSWR is < 2. The return loss is <= -10 dB. It has smaller dimensions compared to the pentagonal shaped one. [6]Due to its properties of low power consumption, support of high secured data rate and simple configuration it receives much attention by the industries, Figure 6. Shows the Fabricated picture of radiating structure - Top View.

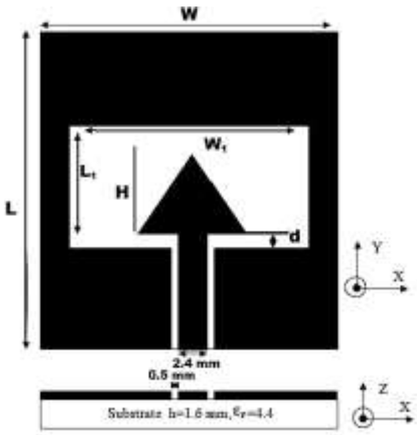

Figure 6. Fabricated picture of radiating structure - Top View

The design proposed is a planar monopole antenna which possesses half circular disc shaped radiator and rectangular shaped ground for SWB applications. It provides an impedance bandwidth of 187%. Its efficiency is > 80% and has a di electric constant of 2.65. [7]The combination of MIMO and extremely wideband technology offers a ready solution for high data rate applications, Figure 7. Shows the Prototype of the designed antenna.

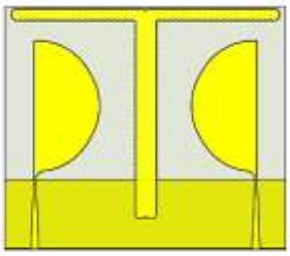

Figure 7. Prototype of the designed antenna

The design proposed is a pair of monopoles printed antennas without a curved slot. The working frequency range is between 3.1 to 10.9 Ghz. When the antennas are placed very close to each other, wideband transmission at 1Gbps is achieved. [8]The use of local oscillator and frequency mixer can be eliminated with the use of WBT system. More sophisticated equipment is required in order to estimate the Bit Error Rate (BER) for longer digital patterns.

Figure 8. Prototype of the designed antenna

The design proposed consists of mushroom cells and a hybrid Frequency Selective Surface (FSS) ground plane fed by micro strip line through a slot cut onto the ground plane. When compared to the traditional patch antenna it has a low Radar Cross Section (RCS) and higher gain. [9]The operating frequency is from 4.7 to 6.04 GHz. A good consistent radiation performance is observed. By changing the shape of antenna, the incident wave can be deflected away from the desired direction. The working bandwidth of this antenna is quite low, Figure 8. Shows the Prototype of the designed antenna.

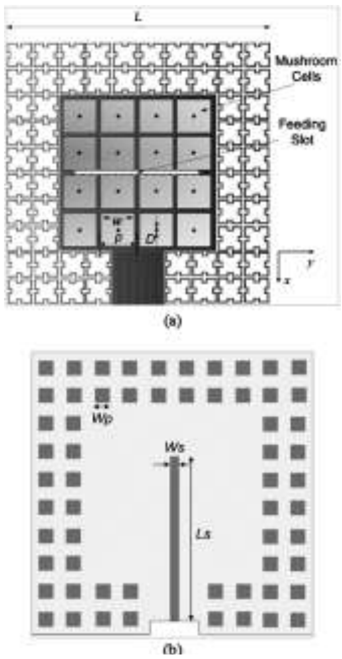

Figure 9. Prototype of the designed antenna

The design proposed is a circular shaped patch antenna which has a rectangular slot in the ground plane. The working frequency ranges from 2.4 GHz to 28.4 GHz and has a bandwidth ratio of 12:1. [10]The midband impedance between 16 – 24 GHz is not desirable. The authors of this paper have planned to assess the performance of the antenna in the near future,Figure 9. Shows the Prototype of the designed antenna.

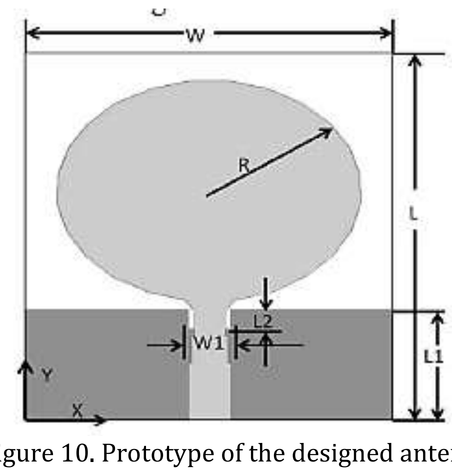

Figure 10. Prototype of the designed antenna

The design proposed is an antenna of hexagonal shaped metallic patch with rectangular slot. The antenna operates at the frequency range of 3 – 35 GHz, with a bandwidth ratio of 11.6:1. The antenna is compact and has stable radiation pattern. The hexagonal shaped compact size is prototyped for SWB applications. This helps to achieve the desired wide impedance bandwidth.[11] It is easy to fabricate and is compact in size, Figure 10. Shows the Prototype of the designed antenna.

Figure 11. Prototype of the designed antenna

The design proposed is an antenna with triangular tapered feed line and radiating patch. The antenna operated at the frequency range of 2.5 – 80 GHz, with a bandwidth ratio 32:1. A gain of 6 dBi and 2 dBi at frequencies 25 GHz and 2.5 Ghz respectively is achieved. [12]It is suitable for low frequency wireless applications like Bluetooth and GPS, Figure 11. Shows the Prototype of the designed antenna.

Figure 12. Prototype of the designed antenna

The design proposed is a monopole antenna which consists of a partial circle radiating patch on top of the substrate and trapezoid shaped ground plane on the bottom of the substrate. The operating frequency is between 1.3 GHz to 20 GHz. A gain of 5 dBi & 2 dBi at 20 GHz & 1.3 GHz is achieved.[13] The efficiency of this antenna is 98.8%. It has a fractional bandwidth of 175.58%. It can be used for both short range and long-range communications, Figure 12. Shows the Prototype of the designed antenna.

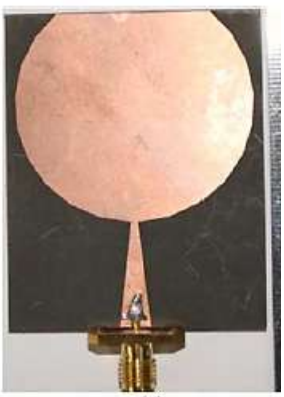

Figure 13. Prototype of the designed antenna

The design proposed is a diamond shaped slot with modified edges and truncated corners. The working frequency range is from 3 – 20 GHz and a gain of 4-5 dB is achieved. [14]It shows significant improvement in gain (4-5 dB) over the entire frequency range. It is suitable for applications operating in UWB X, K and Ku bands, Figure 13. Shows the Prototype of the designed antenna.

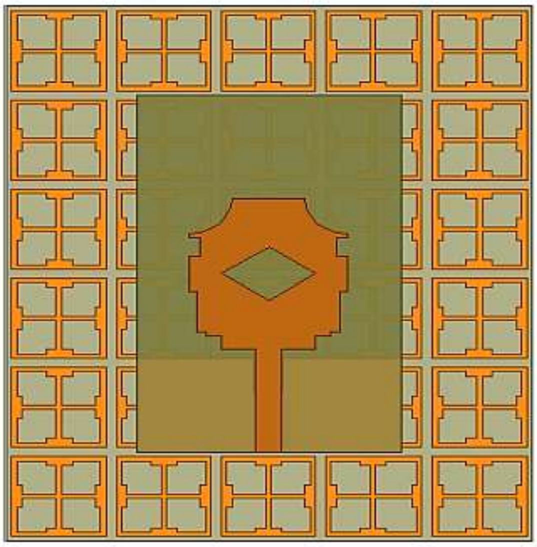

Figure 14. Prototype of the designed antenna

The design proposed is a monopole antenna consisting of a trapezoidal shape radiator, taper feed line and a semi-circular shape ground. The working frequency is from 1.42 GHz to 90 GHz with a bandwidth ratio of 63.3:1. [15]The antenna shows better performance for wideband ap2plications and has high bandwidth dimension ratio over the existing structures, Figure 14. Shows the Prototype of the designed antenna.

Figure 15. Prototype of the designed antenna

The design proposed is a hut shaped radiating patch with a diamond shaped slot at the centre. It operates in the frequency range of 0.92 GHz to 22.35 GHz with a bandwidth ratio of 24.8:1. The gain of the antenna decreases with the increase in frequency from 2 – 12 GHz. [16]The antenna design is simple and is easy to fabricate. It is suitable for both UWB and SWB applications, Figure 15. Shows the Prototype of the designed antenna.

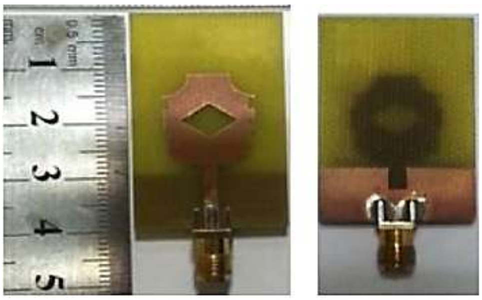

Figure 16. Prototype of the designed antenna

The design proposed is an equilateral triangle with a circular radiator inscribed with elliptical ground plane. The working frequency of 1.4 GHz – 20 Ghz. It has a return loss < -10 dB [21]. It is used for wireless communication such as GPS, Wi-Fi, Bluetooth, PCS – 1900 and UWB applications. It is suitable to be integrated into a microwave circuitry for planar structures, Figure 16. Shows the Prototype of the designed antenna. [17]

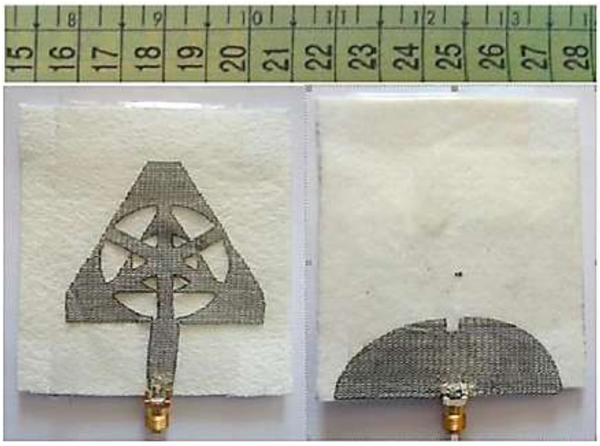

Figure 17. Prototype of the designed antenna

The design proposed is compact star triangular antenna fed by a Microstrip –feedline. The working frequency ranges from 0.5 GHz – 30 GHz with the bandwidth ratio of 60:1. A semi elliptical ground plane is loaded with rectangular notch to achieve good impedance matching [20]. Along the frequency range of 1-14GHz, the gain is stable, but fluctuations are observed in the frequency range of 14-30GHz. It is used for communication application such as RADAR, Mine Detection & RFID devices, Figure 18. Shows the Prototype of the designed antenna[18].

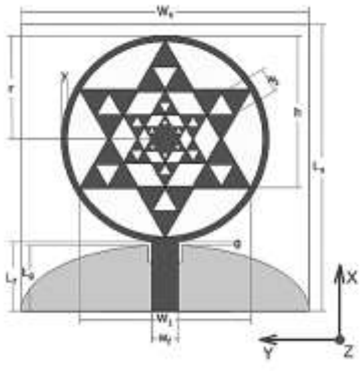

Figure 18. Prototype of the designed antenna

IV Future Trends

The focus towards reducing the size of the antenna with improved radiation performance could be a further step of this design [19]. The antenna satisfying all the necessary characteristics is an attractive candidate for Wireless Personal Area Network (WPAN) based communications supporting an extremely wide impedance bandwidth. This work maybe further extended to the design of extremely wideband antennas using textile substrate. Currently it's been observed that lower gain is obtained at lower operating frequency. It needs to be tested at higher frequency and also a study needs to be done on the efficiency and needs to be experimentally validated. In order to know how efficient, the proposed antenna is in radiating or receiving the radio waves at a desired frequency, radiation efficiency, time domain analysis check may be carried out.

V Conclusion

In this review paper we have compared various proposed models from multiple research papers based on their design characteristics as given in Table 1. It has been observed that dimensions as well as the choice of substrate material plays a key role in designing of extremely wideband antennas, this also affects the data rate. We compared the antenna's performance parameters like fractional bandwidth, working frequencies, bandwidth ratio, and gain (in dBi). It has been found that the fractional bandwidth increases with decrease in the surface area. It has also been observed that antennas which are having a fractional bandwidth around 114% or greater than 114% are capable for high data rate applications. Extremely wideband antennas have many applications in Global Positioning System (GPS), Bluetooth, Wireless Local Area Network (WLAN), Global System for Mobile Communication (GSM) and Satellite Communication System. We hope that this reviews paper will help in guiding researchers in future to select or choose the appropriate antenna design parameters to obtain desirable gain, fractional bandwidth.

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