E-ISSN: 2706-8927
P-ISSN: 2706-8919
IJAAS 2019; 1(1): 91-94
Received: 23-05-2019
Accepted: 26-06-2019

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Study the design of an antenna for ultra-wideband system

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Abstract
In this paper prerequisites for the Ultra-wideband receiving wire and contrasts between thin band and ultra-wideband reception apparatuses for remote framework are examined. Additionally a novel printed circle receiving wire with acquainting an L shape partition with its arm is introduced. The radio wire offers incredible presentation for lower-band recurrence of UWB framework, running from 3.1 GHz to 5.1 GHz. The radio wire shows a 10 dB return misfortune data transmission over the whole recurrence band. The radio wire is planned on FR4 substrate and took care of with 50 ohms coupled tightened transmission line. It is discovered that the lower recurrence band relies upon the L part of the circle reception apparatus; anyway the upper recurrence limit was chosen by the shape transmission line. In spite of the fact that with straightforward math, the outcomes are agreeable.

Keywords: Antenna and ultra-wideband system

Introduction

There are numerous issues associated with planning UWB frameworks, for example, reception apparatus plan, impedance, spread and channel impacts, and balance strategies. Planning the UWB reception apparatus can be one of the most testing of these issues. UWB radio wires must cover an amazingly wide band, 3.1 GHz to 10.6 GHz for the indoor and handheld UWB applications, have electrically little size, and hold a sensible impedance coordinate over the band for high proficiency. Likewise, they are needed to have a non-dispersive trademark in time and recurrence, giving a restricted, beat term to improve a high information throughput.

The UWB innovation offers a few favorable circumstances over customary correspondences frameworks. For example, there is no transporter recurrence. Rather, UWB emanates planned "beats" of electromagnetic vitality. In this way transmitter and collector durable goods can be made basic, which is fundamental for the compact gadgets. There is a wide scope of uses for UWB innovation, which incorporates remote correspondence frameworks, position and following, detecting and imaging, and radar.

Reception apparatus plays a basic undertaking in UWB framework, which is not the same as narrowband framework. UWB frameworks send amazingly restricted heartbeats on the request for 1 ns or less bringing about transfer speeds more than 1 GHz or more. Nonetheless, the plan and creation of elite communicating/accepting receiving wires frequently present critical difficulties in the execution of these frameworks.

The test lies in the improvement of a reception apparatus, fit for taking care of these rapid heartbeat trains. The plan of a UWB reception apparatus is troublesome, on the grounds that the partial data transmission is in reality enormous, and radio wire must cover different octave transfer speeds so as to send beats that are of the request for a nanosecond in length.

Since information might be contained looking like the UWB beat, reception apparatus beat mutilation must be kept to a base. From a framework plan viewpoint, the motivation reaction of the reception apparatus is exceptionally compelling, on the grounds that it can adjust or shape the sent or got beats. Practically speaking, endeavor must be made to restrict the sufficiency and gathering postpone twisting underneath certain edge that will guarantee solid framework execution.

The reason for the current examination is to build up direction for the UWB radio wire planners, make notes on the essential boundaries of UWB recieving wires, and give a case of UWB reception apparatus.

Antennas for Wireless system

There are several different types of wireless antenna [1], divided into two main groups: directional and omnidirectional, which might be used in narrowband or wideband systems. Directional antenna is suitable for long distance communications as they have focused beam with high gain, while Omni-directional antenna covers a wide area with reasonable gain. Hence, Omni-directional antenna is suitable for short distance and indoor environments, such as office or room. Wireless antennas may be classified into two separate classes, narrowband and wideband. The narrowband class demonstrates tremendous smallness for a given operating bandwidth. The wideband class possesses extreme bandwidth capability, capable of covering multiple octaves. Both classes achieve performance very near to the theoretical Chu-Harrington limit [2], indicating that they are as small as possible for the exhibited bandwidth. The ChuHarrington graph is a theoretical limit concerning the volumetric size of an antenna element to its quality factor or T bandwidth of operation. This relationship gives the antenna designer an approximation of a switch between size and desired bandwidth.

There are many issues involved in designing of UWB systems, such as antenna design, channel model, and interference. UWB antennas must cover an extremely wideband of 3.1-10.6 GHz (lower band 3.1-5.1 GHz, upper band 5.85-10.6 GHz) for the indoor and handheld applications, have electrically small size, and high efficiency. In addition, they are required to have a non-dispersive characteristic in time and frequency domain, providing narrow pulse duration to enhance a high data throughput. Antennas in the frequency domain are typically characterized by radiation pattern, directivity, impedance matching, and bandwidth [3]. However, there are certain requirements for the antennas in the wireless system regardless of ultra-wideband or narrowband same as regulatory issues, antenna gain, antenna efficiency, and group delay of antenna.

Antenna gain and Antenna size

The required gain is decided by link budget, which is calculated by taking into account the required channel quality. As mentioned above a directional antenna will provide high gain in narrow field with large size radiator, while an omnidirectional antenna has low gain in wide field with small size of radiator. It should be kept in mind the regulatory issues, when high gain directional antenna is in use, because the peak radiated emission limit must meet the regulatory limit. Therefore, transmit power must be decreased, when using a high gain directional antenna. In view of the fact that regulatory limits are defined in terms of Effective Isotropic Radiated Power (EIRP), system designer should try to keep EIRP as much as possible constant and close to the regulatory limit. The EIRP is where $P_{TX}(f)$ is the transmitting antenna power and $G_{TX}(f)$ is the transmitting antenna gain.

EIRP (f) P_{TX} (f) G_{TX} (f) (1)

Wireless systems needs antennas with small geometrical dimensions. An antenna is said small when its geometrical size is small compare to the operating wavelength and can be fit into a radian sphere of $\lambda/2n$ [4], [5]. Particular consideration should be taken in the time of small antennas design, as small antennas are inefficient by nature and have high quality factor. The electrical size of a small Omni-directional antenna may in point of fact be considerably larger than the physical area of antenna. This follows from the ability of electromagnetic waves to couple to objects within about $\lambda/2n$ [6]. Therefore, even a small physical size antenna can receive or transmit electromagnetic radiation.

Antenna size, Bandwidth and Group delay

The Chu-Harrington limit [2] has investigated basic limits on antenna size, efficiency, and bandwidth and re-examined by McLean [5]. This limit is related to the quality factor of small antenna, which is inverse fractional bandwidth of antenna too. That means, small antenna provides narrow bandwidth, due to high quality factor. Generally the antenna bandwidth is limited by size relative to the wavelength. But, a small antenna could be made wideband by reducing its internal reflections at its discontinuities. Due to finite size of antenna, it is impossible to make an antenna without discontinuities. It is possible to make an antenna as wideband as possible by constructing a gradual transition between the metal surface of the antenna and free space. This can be done in different approach, such as antenna shape, surface resistance or reactance [7-8].

An antenna in UWB system can be analyzed as a filter by means of magnitude and phase responses. When a signal passes through a filter, it experiences both amplitude and phase distortion, depending on the characteristics of the filter. By representing the receiver/transmitter antenna as a filter, we can determine its phase linearity within the frequency band of interest by looking at its group delay. Group delay is the measure of a signal transition time through a device. It is classically defined as the negative derivative of phase versus frequency given by

$$\text{Group Delay} = \frac{d\theta(\omega)}{d\omega} \qquad (2)$$

The phase response and group delay are related to the antenna gain response. The group delay variation induced by the radiation pattern of the antenna appears to be a very important parameter in the overall receiver system performance, since it can bring relatively large timing errors. An antenna gain plot without null, means a linear phase response, hence a constant group delay.

L-loop antenna

Based on the above explanation a planar antenna namely L–Loop antenna (patent applied for) is designed. The proposed design is described in detail, and simulation results of the antenna are presented. The simulation results have been obtained from Method of Moments (MoM). The structure of L-loop antenna is illustrated in Fig. 1. To have a linearly polarized radiation the total length of outer limits of the square loop antenna should be in one wavelength [3]. Designing the antenna for 3.1 GHz will give the wavelength of $\lambda 0$ = 96.77 mm. The present antenna composed of a single metallic layer and printed on a side of a FR4 substrate with dielectric constant of εr = 4.4, loss tangent of $\tan\theta$ = 0.02, and thickness of 1 mm. A coupled tapered transmission line is printed in the between the metal surface of the antenna and free space.

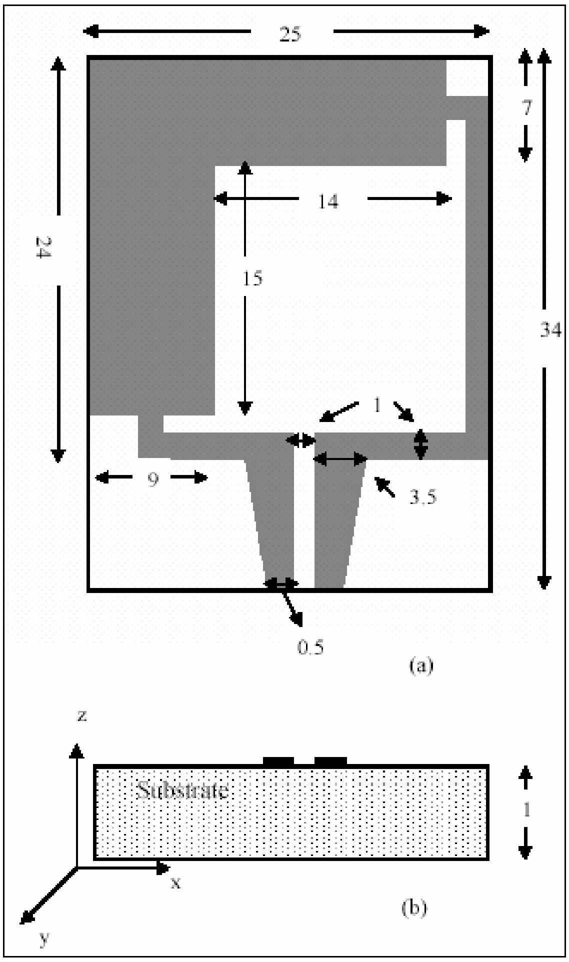

Fig 1: a) Top view, b) Side view of the antenna structure (Unit: mm)

The tapered transmission lines have shown good impedance matching over a wide range of frequency [9-14]. The geometry of the taper is chosen to minimize the reflection and optimize impedance matching and bandwidth. Moreover, the use of taper in the antenna structure can make more magnitude of pulse due to more radiation near to the feed point.

The achieved impedance bandwidth is in the order of 2 GHz (3.1-5.1 GHz) for VSWR ≤ 1.6, as illustrated in Fig. 2. The antenna gain is illustrated in Fig 3. It is observed that the designed antenna achieved almost more than 1.4 dBi gain in the entire frequency. Fig. 3 shows that the designed antenna gain variation is less than 0.8 dBi in the total frequency band. For UWB antenna, the most difficult part is to maintain the stability of the radiation pattern across the frequency band.

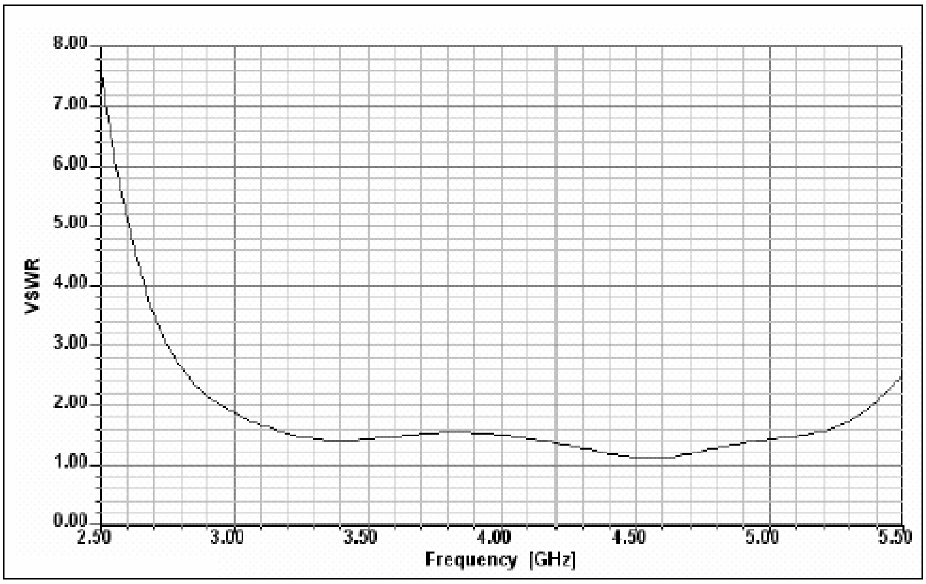

Fig 2: VSWR of proposed antenna

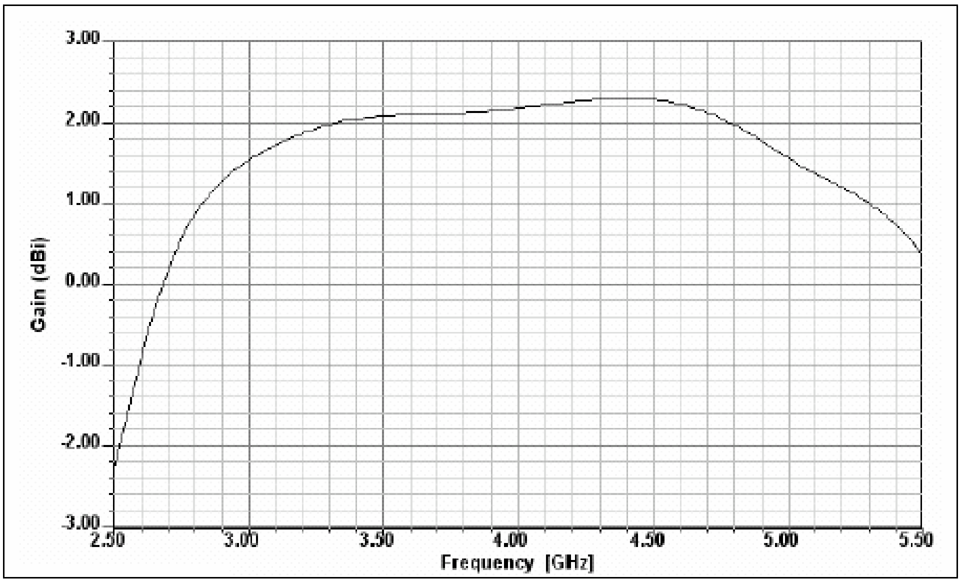

Fig 3: Gain of proposed antenna

Conclusion

A principle point of this examination was to comprehend the significant parts of UWB radio wire plan and how they are identified with the framework execution. UWB radio wires ought to be planned with detail of level plentifulness and straight face reaction over the ideal data transmission. For UWB framework reception apparatus is the noteworthy aspect of the framework. Its qualities affect the general framework execution. A UWB L-Loop receiving wire was introduced in this work. It was shown that by acquainting a L design with the printed rectangular circle radio wire an impedance transfer speed of 2 GHz can be accomplished. The proposed radio wire has brilliant execution for lower band of the UWB framework and has the appealing highlights of little size, minimal effort, and simple to design.

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