A Research On Ultra Wideband (Uwb) Antennas For Wireless Communications

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Abstract : Federal Communications Commission (FCC) has allotted a bandwidth of 7.5GHz (from 3.1GHz to 10.6GHz) for ultra wideband (UWB) wireless communications, UWB is rapidly advancing as a high data rate wireless communication technology. In this paper requirements for the Ultra-wideband antennas for wireless system are discussed UWB applications are becoming very popular because of reliability, security and high speed data transmission over smaller distances. In these applications it is very much essential to have small size printed antennas for transmitting and receiving of UWB signals. The research into UWB transient antennas has also made significant contributions to the development and improvement of wideband continuous wave (CW) antenna designs. However, designing small size printed antennas with good performance is quite a challenging task.This paper gives a state of art on covering the areas of UWB fundamentals, antenna theory, and it focuses on UWB planar printed circuit board (PCB) antenna design and analysis. It also presents a summary of key UWB antenna concepts, as well as system and network considerations, and fundamental limits for UWB antennas. These antennas can be used in many applications like 4G, wireless body area networks, spectrum sensing in cognitive radio, wireless telemetry, telemedicine and RF energy harvesting. GPR, MIMO, wireless personal networks, wireless sensor networks and so on.

Index Terms **– UWB, Wireless communications, Slot antenna, Monopole antenna, PCB antennas,Ultra-wideband antennas for wireless system.**

I. INTRODUCTION

Ultra-wideband (UWB) communication systems have the promise of very High bandwidth, reduced fading from multipath and low power requirements. The main concept behind UWB radio systems is that they transmit pulses of very short duration accurately & efficiently.
An A**ntenna** is a transducer that converts guided electromagnetic energy in a transmission line to radiated electromagnetic energy in free space. Antennas may also be viewed as an impedance transformer, coupling between an input or line impedance, and the impedance of free space. To describe the performance of an antenna various parameters are necessary. In practice, there are several commonly used antenna parameters, including frequency bandwidth, radiation pattern, directivity, gain, input impedance, and so on.

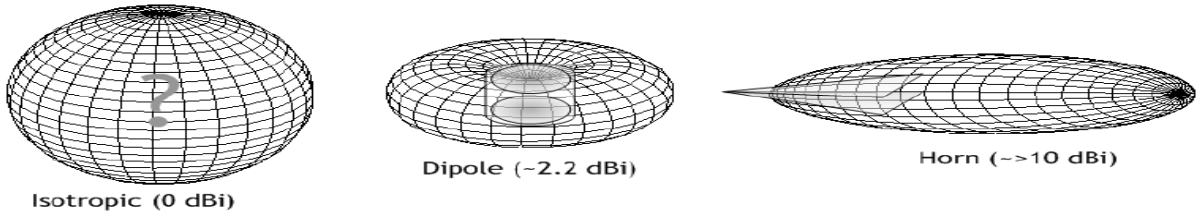

Fig 1.1: An isotropic antenna has a gain of 0 dBi by definition. A small dipole antenna typically has a gain of about 2.2 dBi, and a horn antenna may have a gain of 10 dBi or more.

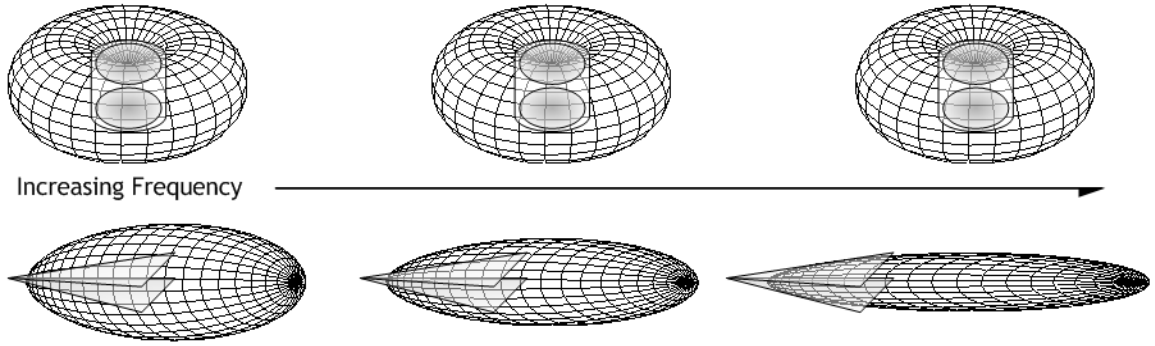

Fig 1.2: The pattern of a constant gain antenna remains fixed with increasing frequency (top), while the pattern of a constant aperture antenna narrows and gain increases with increasing frequency.

II. Motivation:

- The UWB technology has experienced many significant developments in recent years.
- However, there are still challenges in making this technology live up to its full potential.
- UWB antenna design is important in ensuring the design will not cause the pulse to spread when it is transmitted.
- Another aspect is to make sure that the antenna will be highly efficient in radiating electromagnetic energy. This is due to the fact that the transmit power used in UWB systems is very low (-41.3 dBm/MHz) & antenna needs to be broadband enough to handle the bandwidth requirements of UWB

2.1 Requirements of UWB antennas:

According to the FCC's definition,

- A suitable UWB antenna should be able to yield an absolute bandwidth no less than 500MHz or a fractional bandwidth of at least 0.2.
- The performance of a UWB antenna is required to be consistent over the entire operational band. Ideally, antenna radiation patterns, gains and impedance matching should be stable across the entire band.
- Directional or Omni-directional radiation properties are needed depending on the practical application. Omni-directional patterns are normally desirable in mobile and hand-held systems. For radar systems and other directional systems where high gain is desired, directional radiation characteristics are preferred.
- The antenna should be designed for optimal performance for overall system such that the overall device (antenna and RF front end) complies with the mandatory power emission mask given by the FCC or other regulatory bodies.
- A UWB antenna is required to achieve good time domain characteristics. For the narrow band case, it is approximated that an antenna has same performance over the entire bandwidth and the basic parameters, such as gain and return loss, have little variation across the operational band.

2.2 Few points about UWB:

2.2.1 Signal modulation scheme:

Information can be encoded in a UWB signal in various methods. The most popular signal modulation schemes for UWB systems include pulse-amplitude modulation (PAM), pulse-position modulation (PPM) , binary phase-shift keying (BPSK) etc.

2.2.2 Band assignment

- The UWB band covers a frequency spectrum of 7.5GHz. Such a wide band can be utilized with two different approaches: single-band scheme and multiband scheme.
- UWB systems based on impulse radio are single-band systems. They transmit short pulses which are designed to have a spectrum covering the entire UWB band. Data is normally modulated using PPM method and multiple users can be supported using time hopping scheme.
- The other approach to UWB spectrum allocation is multiband scheme where the 7.5GHz UWB band is divided into several smaller sub-bands as per FCC In multiband scheme, multiple access can be achieved by using frequency hopping.
- Single-band systems can achieve better multipath resolution compared to multiband systems because they employ discontinuous transmission of short pulses and normally the pulse duration is shorter than the multipath delay.
- While multiband systems may benefit from the frequency diversity across sub-bands to improve system performance. Besides, multiband systems can provide good interference robustness and co-existence properties.

III. UWB Antennas

- The disc monopole antennas have been demonstrated to exhibit UWB characteristics. These antennas have relatively large electric near ends fields that are prone to undesired coupling with near-by objects so slot antennas have relatively large magnetic near ends fields that tend not to couple strongly with near-by objects
- Printed slot antennas also exhibit UWB characteristics. They have feature low profile, simple structure, lightweight, ease of fabrication and wide frequency bandwidth.
- This type of antenna can take various configurations such as rectangle, circle, arc-shape, triangle, annular-ring and others. These printed slot antennas have been realized by using either micro strip line, or CPW feeding structure.
- In this paper the measurements of vertical disc monopole pair & slot antennas are observed.

3.1 Testing

For testing the antenna there are four main characteristics to be measured:

i) Standing Wave Ratio
ii) Efficiency
iii) proximity insensitivity
iv) Directionality.

- The standing wave ratio is determined indirectly from the reflection coefficient or S_{11} parameter of the antenna. The S_{11} parameter is immediately obtainable from the network analyzer. This measurement requires a setup that includes both a transmitter antenna and receiver antenna where the transmitting antenna has well know characteristics.
- The basic procedure to measure directionality is to rotate the receiver antenna in the field of the transmitter antenna and record the results over the entire 360° range.

IV. Results:

The measurements of the antenna system were carried out inside an anechoic chamber by using an HP8720ES vector network analyzer

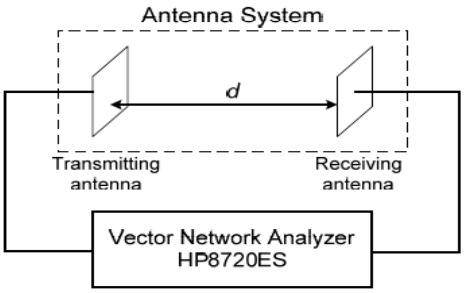

Fig 4.1: system set up

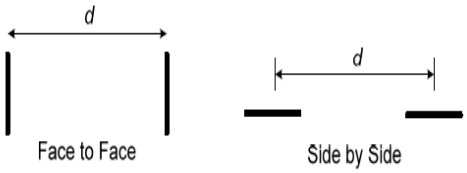

Fig 4.2: antenna orientation

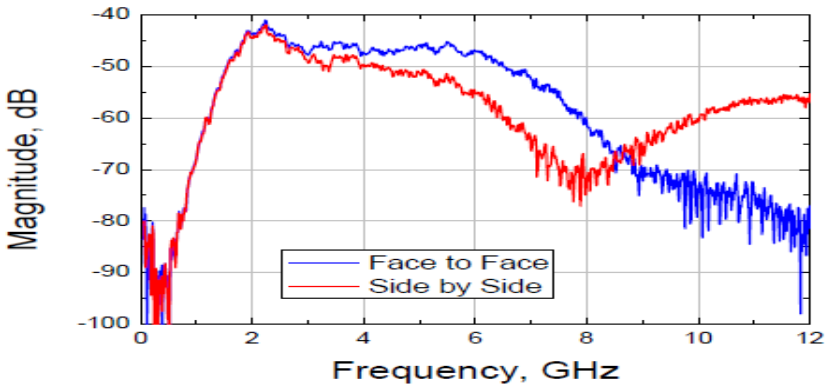

Fig 4.3: Magnitude of measured transfer function of vertical disc monopole pair

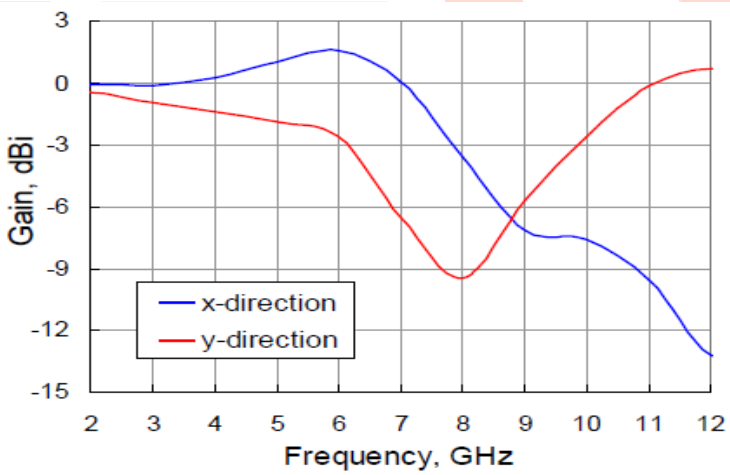

Fig 4.4: Simulated gain of vertical disc monopole in the *x* -direction and the *y*-direction

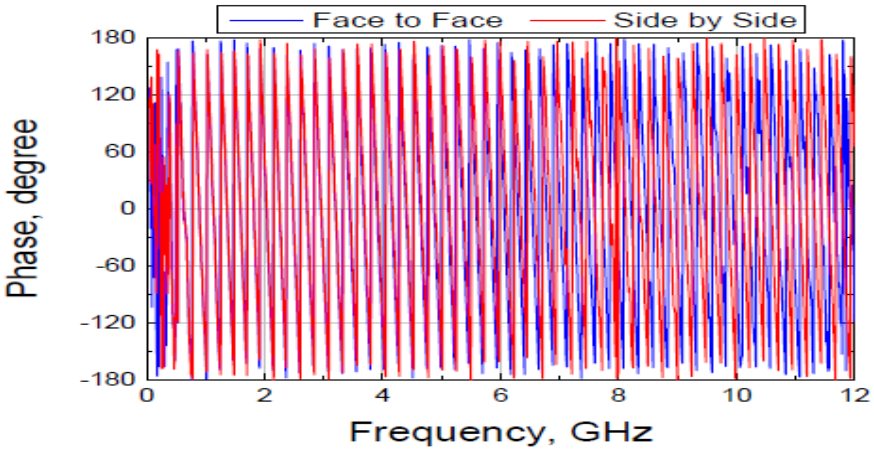

Fig 4.5: Phase of measured transfer function of vertical disc monopole pair

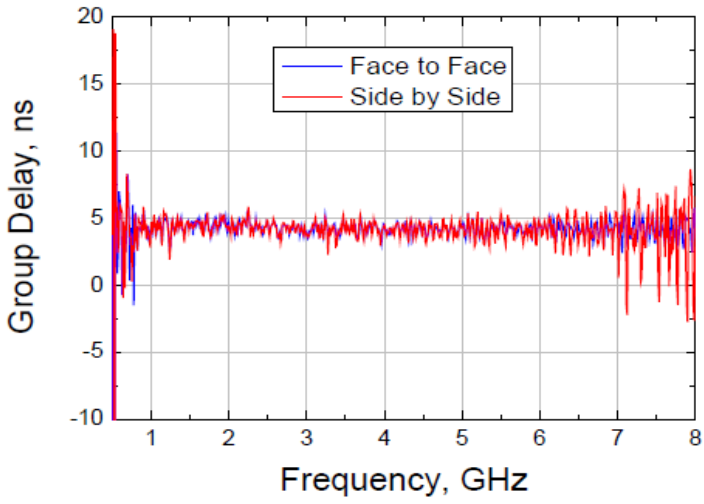

Fig 4.6: Group delay of measured transfer function of vertical disc monopole pair

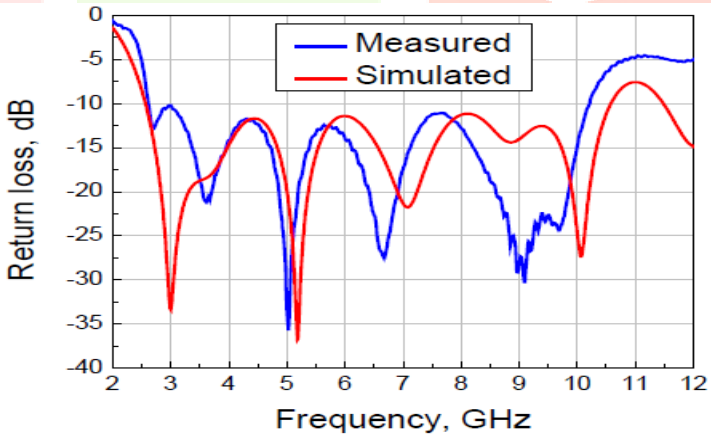

Fig 4.7: Measured and simulated return loss curves of microstrip line fed elliptical slot antenna

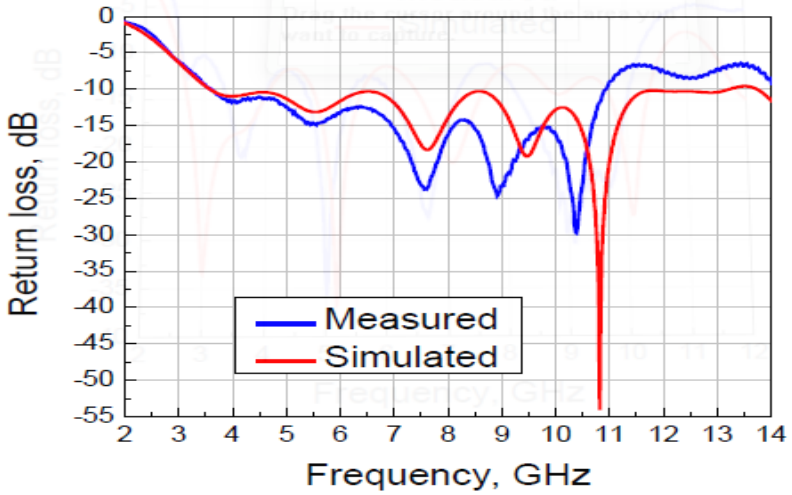

Fig 4.8: Measured and simulated return loss curves of microstrip line fed circular slot antenna

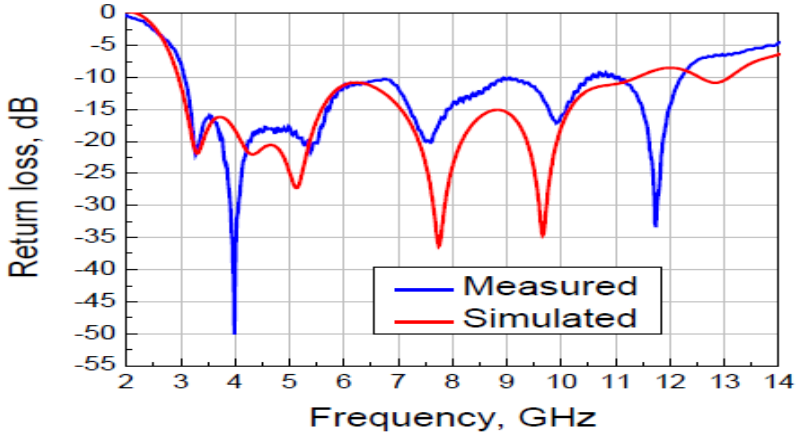

Fig 4.9: Measured and simulated return loss curves of CPW fed elliptical slot antenna

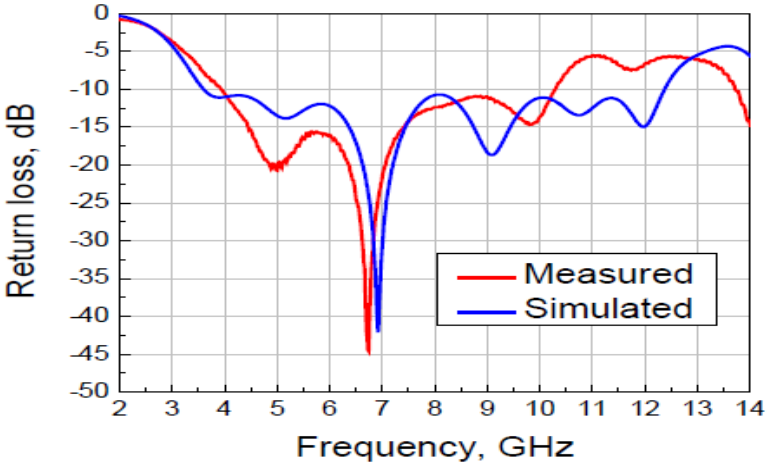

Fig4.10: Measured and simulated return loss curves of CPW fed circular slot antenna

Table 4.1 : Measured and simulated -10dB bandwidths of printed elliptical/circular slot antennas

	Microstrip line fed elliptical slot	Microstrip line fed circular slot	CPW fed elliptical slot	CPW fed circular slot
Simulated (GHz)	8 (2.6–10.6)	9.77 (3.45–13.22)	8.4 (3.0–11.4)	8.8 (3.5–12.3)
Measured (GHz)	7.62 (2.6–10.22)	7.44 (3.46–10.9)	7.5 (3.1–10.6)	6.55 (3.75–10.3)

V. Advantages of UWB

UWB has a number of encouraging advantages that are the reasons why it presents a more eloquent solution to wireless broadband than other technologies.

- As the channel capacity is in proportion to bandwidth. Since UWB has an ultra wide frequency bandwidth, it can achieve huge capacity as high as hundreds of Mbps or even several Gbps with distances of 1 to 10 meters.
- UWB systems operate at extremely low power transmission levels.
- UWB provides high secure and high reliable communication solutions. Due to the low energy density,

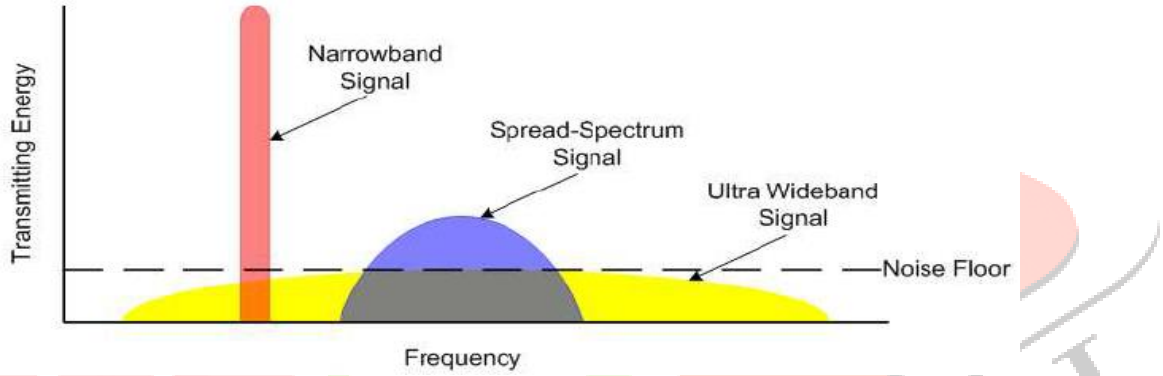

Fig 5.1: Ultra wideband communications spread transmitting energy across a wide spectrum of frequency

5.1 Applications of UWB

- UWB has the potential for very high data rates using very low power at very limited range, which will lead to the applications well suited for WPAN(wireless personal area network).
- The peripheral connectivity through cable less connections to applications like storage, I/O devices and wireless USB will improve the ease and value of using Personal Computers (PCs) and laptops.
- High data rate transmissions between computers and consumer electronics like digital cameras, video cameras, MP3 players, televisions, personal video recorders, automobiles and DVD players will provide new experience in home and personal entertainment.
- The use for sensor networks includes low cost, low power and multi functionality which can be well met by using UWB technology.
- High data rate UWB systems are capable of gathering and disseminating or exchanging a vast quantity of sensory data in a timely manner.
- positioning and tracking is another unique property of UWB. Because of the high data rate characteristic in short range, UWB provides an excellent solution for indoor location with a much higher degree of accuracy than a GPS.
- UWB can also be applied to radar and imaging applications.
- UWB short pulses allow for very accurate delay estimates, enabling high definition radar. Based on the high ranging accuracy, intelligent collision-avoidance and cruise- control systems can be envisioned

VI. Summary:

- In a UWB system, the antenna behaves like a band pass filter and reshapes the pulse spectrum. The antenna transmitting response is related to its receiving response by a temporal derivative. Consequently, the signal waveform arriving at the receiver usually does not resemble the input pulse.
- To obtain a high fidelity, the system transfer function is required to have high degree of similarity with magnitude with linear phase within the operating band. Moreover, the spectrum of source pulse needs to match the transfer function. Thus, the received signal waveform is determined by both the antenna system and the source pulse.

- The UWB technology will be the key solution for the future WPAN systems. Besides, extremely low power emission level will Circular disc monopole antenna originates from a conventional monopole by replacing the wire element of with a circular disc element.
- The antenna configuration has also evolved from a vertical disc to a planar version by using microstrip line and CPW feeding structure for the ease of integration with printed circuit board.
- Studies indicate that the disc element is capable of supporting multiple resonant modes and these modes are closely spaced. It is the overlapping of these resonances that leads to the UWB characteristic. The disc monopole operates in a pure standing wave mode at the first resonance, and in a hybrid mode of standing and travelling waves at higher order resonances. Besides, travelling wave becomes more dominant in the antenna operation with the increase of frequency. Therefore, it is essential to design a smooth transition between the feeding line and the antenna for good impedance matching over the entire operational bandwidth.

VII. Future Scope:

- It has been shown that both UWB disc monopole and elliptical/circular slot antennas operate in a hybrid mode of standing and travelling waves. A more detailed understanding of the travelling wave mechanism and the impedance variations could lead to improved design of UWB antennas
- This antenna measurements are carried out inside an anechoic chamber. However, in the future UWB systems, antenna might be embedded inside a laptop or other devices. Thus, the device effects on the antenna performances need to be investigated.
- UWB antenna with small size is always desirable for the WPAN applications, especially for mobile and portable devices. Future research may focus on finding out new methods to further reducing the sizes of UWB disc monopole and elliptical/circular slot antennas.
- UWB disc monopole and slot antennas with band rejection properties to avoid potential interference can be an objective of future work.
- UWB systems operate at extremely low power level which limits its transmission range. In order to enhance the quality of the communication link and improve channel capacity and range, directional systems with high gain are required for some applications. Therefore, research on UWB directional antenna and antenna array could be carried out.
- Good time domain performance is a primary requirement for UWB antennas. Studies can be carried out to investigate the antenna effect on the transmitted signal and improve the time domain behaviors by optimizing the antenna configuration.

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