Through the Wall Detection and Localization of a Moving Target with a Bistatic UWB Radar System

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***Abstract*— This paper presents a method for detecting and locating a moving target behind a wall with a bistatic UWB radar system. This method not only can locate a moving target, but can also be used to estimate certain parameters of a wall (*dielectric constant and thickness*).**

I. INTRODUCTION

Nowadays, more and more laboratories of different countries do some research on the UWB (Ultra Wide Band) technology, because we realize its importance and efficiency. It is a radio technology which uses short duration pulses to spread energy over a wide bandwidth. The UWB technology has been developed a lot in decade, it provides a lots of operational capabilities of applications in different areas, especially in high-rate communication and high-resolution radar system. Through-wall detection is one of the best applications of UWB radar. This technology can be used for civil security and also for some military industry applications: bomb disposal, neutralization of aggressors, hostage rescue, etc.

According to the report about utilization of frequency for through-wall systems by the Federal Communication Commission (FCC), the frequency operated is limited below 960MHz or from 1.99GHz to 10.6GHz [1]. The low frequency has a good capacity to penetrate different kinds of materials, by contrast, the high frequency has a good spatial resolution but with low penetration capacity. Besides these two advantages, UWB radar system presents also some other advantages compared with conventional radar system: high power efficiency due to low transmit duty cycle, the possibility to identify targets due to the great number of emitting frequencies; and the noise robustness due to large bandwidth.

In this paper we present a bistatic UWB radar system based on the trilateration technology combined with the times-of-arrival (TOA) approach which is used to measure the propagation time delay, in order to obtain the real instantaneous position of a moving target.

II. DESCRIPTION OF LOCALIZATION TECHNIQUE

There are numerous localization methods which can be divided into two catalogs roughly: methods based on antenna processing; methods non based on antenna processing.

The methods based on antenna processing are consist of no parametric methods and parametric methods. The no parametric method is an application with the beams' formation directly for localization. For example: CAPON method [2]. The parametric method uses the signal modeling, but it is less robust to the model error. For example: maximum likelihood method [3], sub-space method [4] and covariance adjustment method [5].

The methods non based on antenna processing can be divided into monopulse method and noncoherent method. The monopulse method has the possibility to estimate the target's angular position with a simple antenna configuration. The noncoherent method is based on the envelope of the signals and does not include phase information. For example: Trilateration technique [6] and Back Projection technique.

In this article, we have chosen a noncoherent method based on trilateration technique for localization in the presence of known uniform wall. Because this method allows to decrease the limit of antennas' positions and the limit of processing.

A. Trilateration method integrated in Through Wall Localization

Trilateration technology is a method for determining the zone or the point of intersection of N spheres (N $\geq$ 3) by giving the center coordinates of these spheres [6].

In real conditions, during the propagation of signals, especially when the waves pass from a medium to another (with different conductivity and permittivity), some physical phenomena will occur, such as: reflection, refraction, diffraction and change of propagation velocity. In our scenario, characteristics of a wall are the main factors that affect the propagation of signals (strength and incidence angles, etc). The dielectric constant ϵ affects the propagation velocity of signal and the incidence angles.

During the trajectory of propagation, the signal passes through three layers of medium: air-wall-air. We consider the signal propagate velocity in the air to be c, the dielectric constant of air to be ϵ_1 (generally $\epsilon_1 = 1$), the dielectric constant of the wall to be ϵ_2, the thickness of wall d_w, all the factors above are considered known, so we can use the Snell-Descartes' law to calculate the propagation velocity in wall and the relationship between the incidence angle and the