Wireless Indoor Localization Using Dynamic Monopulse Receiver

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***Abstract*—This paper proposes a dynamic monopulse receiver (DMR) for wireless indoor localization. By electrically steering the radiation beams to N discrete angels, N sum-difference (Δ-Σ) curves can be generated in the desired field of view (FOV). The target angle can be precisely estimated using the proposed selection-and-average algorithm. The 1-D and 2-D localization experiments were conducted, which demonstrate precise location with mean distance error as low as 0.33 m for 75% cumulative probability.**

I. Introduction

Indoor localization technologies are becoming increasingly important in emerging next generation mobile applications. Examples of these applications include tracking assets within large warehouses or monitoring people in living communities, etc. Key to each application is the capability to accurately locate and track an individual or asset. Different technologies, such as ultrasound, infrared, etc., have been proposed with individual strengths as well as limitations. Among those solutions, the RF-based technique has been highly suggested owning to its possible adaptation to existing accessible wireless devices.

The triangulation positioning using the RF-based technique can be estimated either by distance measurement (lateration) or by angle measurement (angulation). Lateration is usually derived by computing the received signal strength (RSS). However, the position estimation may not be particularly accurate and requires to constructed RF-to-location signal strength databases, such as RADAR [1] approach (based on the 802.11 standard).

In this work, we used angulation positioning. The monopulse technique [2-4] is well known by its high-accurate angle measurement, and has been widely used in radar systems for precise tracking. Traditionally, it required both the magnitude ratio and phase information from received sum (Σ) and difference (Δ) signals to estimate target's angular position. Figure 1(a) shows the typical comparator formed by a 3-dB branch-line coupler associating with a constant 90° phasor. In typical monopulse operation, the system requires high-directivity antennas (usually by array or reflector antenna) to reach <1° angle resolution. However, the high-accuracy monopulse system is difficult to implement in an indoor environment owning to bulky antenna size and narrow localization field-of-view (FOV).

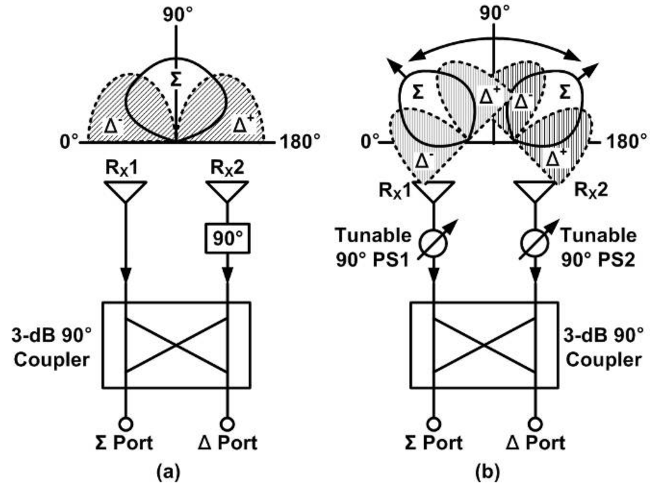

Fig. 1. (a) Conventional monopulse comparator, (b) Proposed steerable dynamic monopulse comparator.

In this paper, we propose a novel RSS-based dynamic monopulse receiver (DMR) with new localization concept, which provides a 2.8° average angle resolution over a 90° localization FOV. The proposed DMR system consists of a steerable comparator, a RSS indicator (RSSI) module and a micro control unit (MCU). Different from the conventional monopulse comparator, the proposed comparator has an additional pair of tunable 90° phase shifters, as shown in Fig. 1(b). By electrically adjusting the phase difference of those phase shifters, the radiation beam can be steered, and thus distribute numerous Δ-Σ curves in desired FOV. The target's angular position can be estimated by the RSS readings only from each individual steered beam with no need of phase inforamtion. In addition, the localization error can be minimized by averaging the data. To the best of the authors' knowledge, this is the first demonstration that employs dynamic monopulse in positioning application based on RSS information.

II. Proposed Dynamic Monopulse Receiver

A. Selection-and-Average Localization Algorithm

Similar to the conventional monopulse system, the target angle is determined by the sum (Σ) signals and difference (Δ)