Development of a Quasi Time Stretch Technology for Indoor Positioning System based on Pulse Modulated Ultra High Frequency Radio

Renhai Xiong[1], S. van Waasen[1, 2], J. Schelten[1], M. Schloesser[1], Carl Rheinländer[3], N. Wehn[3]
[1] Central Institute for Engineering, Electronics and Analytics – Electronic Systems (ZEA-2), Forschungszentrum Juelich GmbH, D-52425 Juelich, Germany,
[2] Communication Systems department (NTS), University of Duisburg-Essen, D-47057 Duisburg, Germany
[3] Microelectronic Systems Design Research Group (EMS), University of Kaiserslautern, D-67653 Kaiserslautern, Germany
r.xiong@fz-juelich.de

***Abstract*—Data acquisition of high speed signal is a major challenge in developing a high accuracy Indoor Position System (IPS) based on Ultra High Frequency (UHF) Radio. The proposed technology is developed to achieve a high time resolution for Time Difference of Arrival (TDOA) estimation in a hyperbolic position fix IPS. This device works as the interface component embedded in the distributed sensor nodes of the IPS and is dedicated to convert the incoming UHF signal down to low frequency typically less than 1 MHz that enables the use of conventional relative low speed ADC product. The circuit model is simulated in Advance Design System (ADS) environment. Performance of the Wilkinson power combiner is evaluated using High Frequency Structural Simulator (HFSS).**

***Keywords*—Data Acquisition; Ultra High Frequency; Indoor Positioning System;**

I. Introduction

Indoor Positioning System (IPS) is of great demand in various applications ranging from storage logistics to Ambient Assistive Living solutions [1] [2]. There is also a variety of IPS technologies [3]. The ultra-high frequency is targeting very high spatial resolution. For this high accuracy of Indoor Positioning System sensor network (Fig. 1) based on UHF radio, a high time resolution is required. With the objective of sub-millimeter accuracy for the IPS based on TDOA [4] [5], the proposed technology is developed to obtain a time resolution of 3 ps. This can be realized by direct sampling of the UHF radio signal, which in return requires high speed Analog-to-Digital Converter (ADC) device that is capable of 33 GSPS conversion rate. Unfortunately, that kind of high speed electronic ADC is not available nowadays. The photonic time-stretched ADC concept can be a possible solution [6] [7], but it requires a complicated optical frontend design and a large bank of electronic ADCs. I.e. 330 ADCs at 100 MSPS are required to accomplish an effective sampling rate of 33 GSPS. That number would be increased by 6 times if implemented into the depicted 6 sensors system [Fig. 1]. Moreover, as the typical aperture time of a relatively low speed ADC is in order of ns, the ADC should avoid directly sampling the UHF signal due to the signal distortion [8]. The proposed technology in this paper is developed to achieve an effective sampling bandwidth that is broad enough for sampling UHF signals using only one conventional ADC for each sensor. It is invented to convert the UHF radio (~GHz) signal that is modulated using periodic pulses down to low frequency (~MHz) and keep the timing information. TDOAs can be estimated based on the correlation between radio signals detected by the pairwise sensor nodes. The precision of the estimation depends on the time resolution achieved by the employed technology that stretches the pulse modulated UHF radio signal by factor N ($\sim O(10^3)$). Specifically, the time resolution is the result of ADC sampling interval divided by stretch factor N, without any interpolation process.

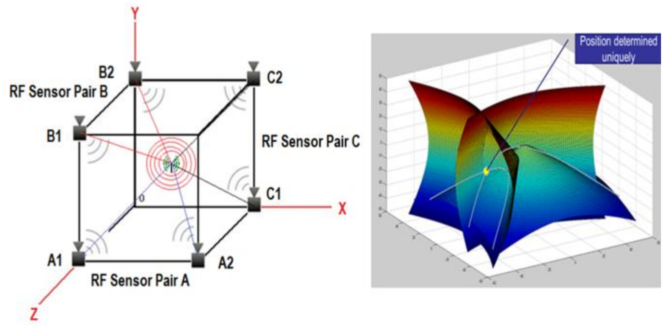

Fig. 1. Example sensor network for a hyperbolic position fix indoor positioning system. RF sensors are placed at known positions (left). The target emitter is located by TDOA information of pairwise receivers based on the hyperbolic positioning method (right).

The intuitive view of the developed component is probing the pulse modulated radio signal periodically and rebuilding a single period signal from the continuous N periods (Fig. 2).

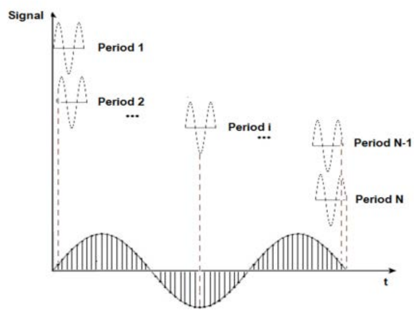

Fig. 2. Reconstruction of one wavelet from N signal periods

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