Workshop on Innovative Circuits, Systems and Applications for Local Position Estimation

Abstract

Global positioning systems have already reached a high market volume in different application areas. The next great leap forward are systems for local position estimation. There are a vast amount of different usage scenarios offering new market potentials for established companies as well as growing start-ups. The possibilities reach from autonomously guided vehicles to cultural guiding, from industrial automation to medical healthcare.
The workshop features different aspects of localization systems. The heart of FMCW time-of-arrival systems is the frequency synthesizer. Design consideration and realized RFICs will be presented. Furthermore novel mobile tags based on active reflection will be shown. Local Positioning Systems for different application scenarios will be addressed. The monitoring of vital parameters by means of distance measurements will be shown. Furthermore systems for industrial environments with strong multipath will be presented. Newest technologies are shown which enhance the robustness substantially.

Chair: Thomas Ussmueller, University of Erlangen-Nuremberg, Institute for Electronics Engineering

Presentations

Topic: Synthesizer for FMCW based Localization in Wireless Sensor Networks
Speakers: Melanie Jung, Thomas Ussmueller, Robert Weigel
Affiliation: University of Erlangen-Nuremberg, Institute for Electronics Engineering
Abstract: Since wireless technologies have entered the field of consumer applications and wireless access is widely available, the number of utilizations of wireless products have increased. Initial development in sensing systems occurred during the last two decades. Wireless sensor networks are a huge field of interest in industrial and academic research, as applications like selforganized sensor networks, location based services and guiding are in high demand and show promising future prospects. This presentation motivates the use of wireless sensor networks with exemplary application scenarios. An overview of several synthesizer concepts for frequency modulated continuous wave (FMCW) radar will be given. And the state-of-the-art is compared. The talk focuses on synthesizer concepts based on fractional-n phase-locked loop (PLL) architectures. For better understanding of the architecture, the single elements will be considered. To round up the presentation actual research results are presented.

Topic: Indoor Positioning System using an Integrated Active Reflector
Speakers: Silvan Wehrli
Affiliation: Electronics Laboratory, Swiss Federal Institute of Technology Zurich (ETH Zurich)
Abstract: This workshop presentation presents an indoor localization system based on a frequency modulated continuous wave (FMCW) radar in the ISM band at 5.8 GHz. The localization system is

capable of detecting multiple reflectors at the same time, and no synchronization between base stations is needed. An integrated active pulsed reflector behaves as a backscatter by regenerating the incoming phase with phase coherent start-up at a constant frequency. The base station determines the distance to this reflector with a round-trip time-of-flight (RTOF) measurement. The active pulsed reflector is built around a switchable and tunable oscillator. The circuit has been fully integrated in a 0.18-um CMOS technology. Outdoor measurements revealed a 1D positioning accuracy of 15 cm, while in a harsh multipath environment with omnidirectional antennas a positioning accuracy of 32.88 cm was measured. The measurement results agree well with the predicted simulated results.

Topic: IR-UWB Radar Sensor for Ultra-Fine Movement Detection and Vital Sign Monitoring
Speaker: Bernd Schleicher[1], Andreas Trasser[1], Mario Leib[2], Wolfgang Menzel[2], Hermann Schumacher[2]
Affiliation: [1]Ulm University, Institute of Electron Devices and Circuits, Albert-Einstein-Allee 45, 89081 Ulm, Germany
[2]Ulm University, Institute of Microwave Techniques, Albert-Einstein-Allee 41, 89081 Ulm, Germany
Abstract: The hardware platform of an impulse-radio ultra-wideband (IR-UWB) radar system is presented, which conforms to the 3.1-10.6 GHz frequency band allocated by the FCC for indoor applications. The system is built using a four channel direct digital synthesizer (DDS) for trigger signal generation and an inexpensive data logger for data acquisition. The core part of the radar sensor comprises two Vivaldi-type UWB antennas, an impulse generator IC having an output waveform similar to a fifth Gaussian derivative with $\sigma = 51$ ps, as well as a fully monolithic correlation receiver. The correlation receiver consists of an UWB low-noise amplifier, a template impulse generator and a four-quadrant Gilbert-cell multiplier all integrated in a single chip. The impulse generator and the correlation receiver are fabricated in a 0.8 µm Si/SiGe HBT semiconductor technology from Telefunken Semiconductors GmbH. Besides a detailed presentation of the sensor's hardware components, two possible measurement principles will be discussed, validated by detailed measurements and compared. The sensor can be used for a movement detection having a deviation of below 1 mm and is suited for the monitoring of human vital signs.

Topic: RESOLUTION - A hybrid AoA and TDOA radiolocation system for difficult indoor environments
Speaker: Andreas Ziroff
Affiliation: Siemens AG
Abstract: Angle of Arrival (AoA) and Time difference of arrival (TDOA) are well known approaches for Radiolocation Systems. Especially in indoor scenarios with strong multipath channels, evidence shows, that Hybrid Systems that integrate both, TDOA and AoA techniques might be beneficial to increase robustness and accuracy in indoor scenarios. Such a hybrid system based on 5,8 GHz FMCW is proposed and will be discussed in more detail. The performance achieved in indoor environments will be discussed and the suitability of the system concept to a wide variety of applications will be shown. Impact of system parameters like measurement bandwidth and array size of the antennas used are shown.

Topic: Network based Vehicle-to-Infrastructure and Vehicle-to-Vehicle Localization
Speaker: Randolf Ebelt, Hendrik Millner, Martin Vossiek
Affiliation: Institute of Electrical Information Technology, Clausthal University of Technology, Germany
Abstract: Localization using time-of-flight based sensor nodes has many industrial applications such as logistics and collision avoidance of vehicles. An overview of the challenges of three-dimensional localization will be given since the achievable quality of localization is very sensitive to issues like

multipath propagation and the geometric structure of the sensor net. Subsequently, approaches to improve the robustness of vehicle-to-infrastructure localization are presented.

Topic: Radar-based Localization and Detection Systems for Near-field SAR and Security Applications
Speaker: Marc Loschonsky, Ling Chen, Olga Rogall, Uwe Burzlaff, Leonhard Reindl
Affiliation: University of Freiburg, IMTEK-Institute for Microsystems Engineering, Laboratory for Electrical Instrumentation
Abstract: Radar-based Localization and Detection systems can deliver potential improvements within Search and Rescue Missions for detection of trapped or buried people as well as in modern civil security applications for critical infrastructures protection in near-field ranges covering primary zones of interests. Developments of several technical approaches were tested and approved in their typical environments and their characteristics and results are presented and discussed in this contribution.