WMD (IMS) Monday 08:00 – 17:00 BCEC Room 156AB
Digital Receiver Systems for Defense and Related Commercial Applications
Full-day workshop reviewed by MTT-16, MTT-9, IMS09

Organizer(s):
Lamberto Raffaelli, LNX Corporation; MTT-16.
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The prime motivators for employing digital receivers are functional and performance flexibilities as well as improved system capabilities. The rapid advances of sampling devices, FPGAs, embedded processors, and integrated circuits have expanded the use of digital receivers across a wide range of systems, both in defense and commercial applications, predominantly in communication systems. The technical challenges are in achieving performance requirements for wideband microwave systems, and staying within the size and power restrictions for commercial applications. This workshop will discuss digital receiver applications, implementations, and their challenges. With emphasis on wideband digital receivers as used in defense and radar systems, the discussions will straddle issues that are of interest to many engineers involved in military and commercial systems. The topics will outline applications non-communication signal analysis, radar receivers, signal processing receivers for direction finding, and communication receivers. Requirements and special technical challenges such as sensitivity, dynamic range, noise, bandwidth, signal density, mixed-signal electronics, and power consumption will be defined. Design examples of high-speed wideband sampling techniques, noise reduction themes, and wideband architectures will be given. The status and trends of device and IC technologies that impact the path to the next generation of systems will be provided. There will be allotted time for workshop attendees to engage in open discussions with the presenters.

Speakers:
1. Janusz Majewski, MIT Lincoln Laboratory, USA
“Digital Receiver System Design”

This paper presents an overview of the Digital Receiver Systems design used for the modern Radar , Telecommunication and Ultra-Wideband digital receivers and Software Radios. The short history of the receiver technology will introduce the subject, followed by the top level aspects of receiver architecture. These are the frequency plan for the receiver, link budget theory as well as system aspects that determine the requirements are presented. An overview of the receiver architectures; Regenerative, Homodyne and Heterodyne; and modulation methods will be presented. In this article will be also included methods of determining and the impact of different receiver's architectures on the system performance from the application perspective. In the conclusion, the source and impact of component non-linearities are evaluated, including dynamic range, harmonics and spurious signals. Receiver building blocks are discussed.

2. Werner Neuhaus, EADS, Germany
“Digital Receiver for Broadband Electronic warfare (EW) Application”

The Electro Magnetic environment, where an ESM or ELINT System has to perform its operation, is a complex, dense and high dynamic mixture of different signal types with different power levels and distributed over a wide frequency range. In order to deliver best information about Radar emitter in a complex and dense scenario, receiver with highest receiver sensitivity, large bandwidth, excellent parameter measurement and specifically signal separation capabilities also for timely overlapping signals are needed. This can only be provided by Wide band Digital Receivers. The presentation "Digital Receiver for Broadband EW Application" discusses

- General Requirements for ESM and ELINT receiver.
- Digital Receiver elements Ø Digital receiver performance characteristics
- Development Status of Wide Band Digital Receiver
- Advantages of Digital Receiver technology against Analogue Receiver technology
- Examples are presented to show analysis and visualization capabilities.

3. Andrea De Martino, Elettronica S.p.A., Italy
”Digital Receiver Applications in Electronic Warfare Systems”

Digital Receivers are becoming more and more fundamental devices in modern advanced Electronic Warfare (EW) Systems as, thanks to their structure, they are programmable and can perform a number of Signal Processing Functions (Algorithms), which provide such systems with performances not even imaginable in currently deployed systems. Examples of these novel functions are:

- Large Instantaneous Receiver Bandwidth
- Programmable channel bandwidth.
- High sensitivity detection of emitters
- Accurate measurement of emitter waveform instantaneous parameters
- Fine Analysis of emitter waveforms (intrapulse modulations or code)
- Accurate Direction Finding by exploiting various techniques, which can be used independently or in combination
- Fast accurate localisation of emitters

The paper deals with the implementation principles of the above functions and shows some results achieved with Digital Receivers employed in novel Elettronica SpA (ELT) Systems.

4. Geoff Dawe, Bitwave, USA
"Digital Receivers for Commercial Applications"

Digital Receiver technology has long promised an elegant solution to many receiver issues. Implementation in a digital CMOS enabling technology that improves with Moore's Law and flexibility through programming are just two of the major advantages of the approach. Currently though, the most popular commercial applications that use digital receiver technology are ones where power consumption is not a primary driver such as in base stations. Due to the fundamental limitations in the typically applied sampling technologies with respect to power consumption, digital receivers have not gotten traction in commercial handheld or portable devices. This is unfortunate because these market are of significant volume. This workshop presentation will focus on the trade-offs between the various digital receiver architectures with respect to the commercial portable wireless markets. Firstly, the candidate digital receiver architectures will be shown and reviewed.

5. John Kedziora, Kedziora Innovation Group, USA
"Phase Noise, Jitter, Stability and SNR: Navigating the Lexicon and How to Relate Hardware Measurements to System Performance"

Non Gaussian noise sources, especially 1/f noise, are an important and often incorrectly modeled contributor to system performance. The relationships between receiver noise floor, dynamic range, time stability, and 1/f noise has not been clearly addressed in literature in a compact format. The systems effects of noise sources and hardware performance measurements are commonplace; however, historically there has been a gap between language and tools of the hardware designers and system architects. Understanding how to effectively model, predict, and measure these phenomena in an integrated environment is needed to realize high performance designs. It is the intent of this tutorial to present a structured development of a common lexicon, measurement methods and an analysis toolset with examples. The focus will be on practical level relationships, where the cited references will provide an index for in depth derivations.

6. Mike Groden, LNX Corporation, USA
"Wideband Receiver with Wideband Track and Hold"

Wideband digital receivers are used in a number of defense and commercial applications. Defense applications include electronic warfare and electronic intelligence; commercial applications include software defined radios. In most applications, the dynamic range and information bandwidth are most important; however it is also useful to have a wide

analog bandwidth for sub-Nyquist sampling applications, where the signals of interest are higher than one-half the sampling frequency. This paper describes the design, fabrication, and test of a wideband digital receiver based on the Inphi 1821TH, track and hold amplifier and the LNX RX00103-008 Digital Receiver. The design will be characterized in terms of signal to noise, total harmonic distortion, and spurious free dynamic range over a range of input signal frequencies.

7. Mark Rosker, DARPA, USA
"Advanced Device and Integrated Circuit Technologies for Digital Receivers"

8. Gil Raz, GMR Research & Technology, USA
"Digital Compensation and Exploitation of Nonlinear and Channel Mismatch Errors in Wideband RF Receivers"

Dynamic range in RF receivers is of paramount importance for many applications. The trend towards wideband and small form factor sensors places a burden on RF devices and subsystems which often cannot be met, even when using state-of-the-art components. The use of digital techniques has been a major focus of our work towards improving the linear dynamic range of such systems. These techniques include compensation for harmonic nonlinear artifacts, as well as, multi-channel mismatch distortions, such as interleaved errors in multi-sampler ADCs. These techniques compensate for distortions originating anywhere in the receiver. We show measured real-time improvement of linearity in wideband systems of over 20 dB. We discuss the challenges and methods for overcoming them in achieving such results. In addition, we mention our work on exploiting distortions as a novel form of signal diversity. These techniques allow exploration of entirely new systems such as sub-Nyquist sampling systems.

9. Fred Harris, San Diego State University, USA
"Applications of Multichannel DSP Modulators and Demodulators"

This presentation will address the implementation of M-channel Polyphase Filter Banks and demonstrate typical performance parameters as well as a number of commercial systems implemented by the M-path process. One example is a channelizer for a 192 stereo FM channels for a cable plant. We will then address interesting variations of the standard equal bandwidth, equal spectral spacing channelizers. These include a method to decouple channel bandwidth, channel spacing, and output sample rates. One such example is a commercial 50 channel channelizer for a cable plant with channel spacing of 192 kHz, symbol rate of 128 kHz and output sample rate of 256 kHz. Other variants will include channelizers that accommodate non-uniform spectral spacing and channel bandwidths. A final area we will discuss is the use of multichannel processing in support of cancelling cross talk between image channels and suppression of third order Intermodulation distortion.