Frequenz *Focused Topic* on Software Radios

Editorial

Wireless information transmission is not imaginable without Maxwell's equations. However, after their publication, it took 13 years until Heinrich Hertz in 1886 succeeded in experimentally demonstrating the existence of electromagnetic waves. Another 15 years later, in 1901, Guglielmo Marconi sent the first radio message across the North Atlantic. At the same time the commercial utilization of radio technology began, first in UK with the Marconi Company. In Germany on May 27, 1903, the Gesellschaft für drahtlose Telegraphie m.b.H. (Telefunken) was established. The relevance of radio communication continuously grew according to the implementation of broadcast, emergency, police, and military communication. Accordingly, the radio industry became a major economic factor in many countries.

After World War II, essential initiatives for the development of digital transmission technology started from the US. In 1947, William B. Shockley, John Bardeen, and Walter Brattain invented the transistor at the Bell Laboratories and so established the fundament for the rapid development of microelectronics. In 1948, Claude E. Shannon, also at Bell Labs, published the seminal ideas of information theory. With a paper printed in 1949, he formulated the sampling theorem that represents the theoretical precondition for the development of digital signal processing.

Of course, it again took considerable effort to refine the theoretical foundations as well as the major components of digital systems in order to operate first commercial systems. During the mid seventies, first developments of digital short wave receivers were launched. In 1992, when Joseph Mitola III coined the notion of *Software Radio*, at least in Germany digital systems were in operation since several years that, despite of being bulky in volume, may be characterized as multi standard receivers.

It is now more then ten years ago when in 2000 the First Karlsruhe Workshop on Software Radios was opened. At this time the development of Software Radios was at its starting point. Today, there is a well established market for Software Defined Radios (SDR) and the focus of many research projects is on applications of SDR technology. This also became visible during the **Sixth Karlsruhe Workshop on Software Radios** that happened on March 3/4, 2010, where 30 academic and industrial contributions were presented by authors from eleven countries. With the present *Focused Topic* of FREQUENZ, extended versions of six of these papers are published to a broader audience.

With their work on *Hardware Optimized Sample Rate Conversion for Software Defined Radio*, Carina Schmidt-Knorreck, Raymond Knopp, and Renaud Pacalet touch a topic that is essential in SDR development since the number of different standards that should be supported is continuously growing. Usually, a SDR is built of two main components, the baseband module and the radio module. Both are connected by an interface that is physically realized by an optical fiber. When receiving a signal, the radio module transforms it to baseband and analog-to-digital (A/D) converts it, using a fixed sampling rate. To be able to optimally process the received signal, the baseband module has first to adapt the sampling rate according to the signal's standard. The authors present a generic, flexible, fractional and hardware optimized sample rate conversion architecture in the context of SDR.

In base station systems, baseband module and radio module are sometimes separated over a longer distance (e.g. up to some kilometers). Therefore the system clock has to be distributed over the fiber optic interface connecting both modules. The paper *Analysis of Clock Distribution and Delay Management for IMT-Advanced Distributed Wireless Base Station Systems* by Christian F.A. Lanzani, Gustavo B. Bergamo, and Morten Hoegdal investigates this problem as well as the delay management coupled with it. In their work both well established interface definitions, OBSAI (Open Base Station Architecture Initiative) and CPRI (Common Public Radio Interface), are taken into account.

A myth about Software Defined Radio is that waveforms may easily be ported from one hardware platform to another. In practical terms, the problem is, that the baseband processor of an SDR usually is composed of General Purpose Processors (GPP), Digital Signal Processors (DSP), and Field Programmable Gate Arrays (FPGA). Therefore, porting of applications for SDR is not as easy as for Personal Computers. The paper *Porting of Waveforms: Principles and Implementation* by Stefan Nagel, Michael Schwall, and Friedrich K. Jondral starts with a formal description of the porting process. Subsequently, two SDR hardware platforms, Lyrtech's Small Form Factor (SFF) SDR and the Universal Software Radio Peripheral (USRP) are introduced. An OFDM waveform, based upon IEEE 802.11g is defined and implemented on the USRP. The main contribution of this paper is a detailed description of the porting process for this waveform from the GPP dominated USRP to the heterogeneous DSP/FPGA platform of the SFF SDR. Lessons learned in this project are presented and performance drawbacks for platform independent development and code generation for GPP and DSP are summarized.

With their paper *DVB-T2 – A Software-Defined Radio Implementation*, Alexander Viessmann, Christian Kocks, Christoph Spiegel, Andreas Waadt, Guido H. Bruck, and Peter Jung present the implementation as well as a performance analysis of a SDR TV broadcast receiver supported by a platform developed at the Chair of Kommunikationstechnik of the Universität Duisburg-Essen. The most challenging requirements of a DVB-T2 implementation are the FFT block sizes of up to 2^{15} samples, the 256QAM, and the LDPC coding with a block size of 64 800 bit. Due to the strict modular concept, based on the SDR paradigm, the platform presented here is not only able to support a HDTV broadcast receiver but is furthermore well suited for research on and development of future wireless communication systems in general.

In Cognitive Radio (CR) systems, Specific Emitter Identification (SEI) may help in detecting primary users by an overlay system as well as in identifying malicious users of wireless networks that try to gain access to a base station by spoofing network security information. On the basis of cyclostationarity contained in modulated signals, Peter H. Sahmel, Jeffrey H. Reed, and Chad M. Spooner in their contribution *Eigenspace Approach to Specific Emitter Identification* develop a feature extraction process based on the signal's eigenvector/eigenvalue decomposition. The features obtained form the basis for a reliable detection by the CR system.

Recently, Dynamic Spectrum Access (DSA) gained more and more interest by network operators and regulators and started a paradigm shift in spectrum allocation. DSA seems to pave the way to a more efficient use of the scarce resource frequency. With DSA, radios on the one hand get more flexibility in spectrum access but, on the other hand, interferences between users or between networks have to be minimized. In their paper *A Monitoring Network for Spectrum Governance*, Roel Schiphorst and Cornelis H. Slump point out that DSA and spectrum governance are two sides of the same medal. The paradigm shift in spectrum access also requires a change in spectrum governance. This implies that also new approaches in network monitoring are necessary. The authors discuss a new spectrum governance philosophy and introduce a mobile monitoring system recently tested in the Netherlands that is based on RFeye sensors of CRFS (Cambridge, UK).

Please enjoy reading the papers published in this FREQUENZ *Focused Topic* on Software Radios. We want to take the opportunity to thank all attendees and authors of the Sixth Karlsruhe Workshop on Software Radios for their contributions and fruitful discussions. Moreover, we thank the authors of this *Focused Topic* for their additional efforts in shaping their manuscripts for a journal publication.

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