Complete platform, sophisticated tools accelerate SDR exploration, development

Software-defined radio (SDR) is an increasingly viable and important communications system. In principle, it allows a single hardware design to support communications across a variety of formats, protocols, and frequencies, including GSM base stations, LTE base stations, MIMO designs, and more.

A basic SDR architecture looks relatively simple, at least "on paper." Just digitize the amplified RF signal directly, without the need for down conversion and a local oscillator, or any hardware driven tuning, and then process the digitized results using various algorithms. However, for hardware and software engineers who want to investigate its potential, evaluate its suitability, and even develop products for their application, there's been a challenge: getting all the hardware and software pieces in place and ready is difficult and frustrating. The demands on the components of the analog signal chain are quite stringent in terms of bandwidth, dynamic range, number of bits, and other performance parameters.

The ability to provide the SDR platform has been complicated by need for overlapping discrete channels in the analog front end (AFE) to support coverage across the very wide RF spectrum of interest, which can span from around 100 MHz to several GHz. As a result, the component cost in board space, number of devices, power dissipation, and dollars for a wideband SDR implementation can outweigh any potential SDR benefits. Further, without adequate tools and support, even having that basic development hardware and software is insufficient.

Figure 1. The AD9361 from Analog Devices is optimized for the user tunable wideband, low noise needs of a flexible SDR design.

An Analog IC Changes the Situation

These were the issues Ettus Research,™ an established leader in SDR for over a decade, faced when they embarked on the design of their Universal Software Radio Peripheral (USRP™), a fully integrated, direct conversion transceiver which can be configured for multiple formats, protocols, and frequencies. Their goal was to produce an efficient, cost-effective, easy to use device for a low cost market.
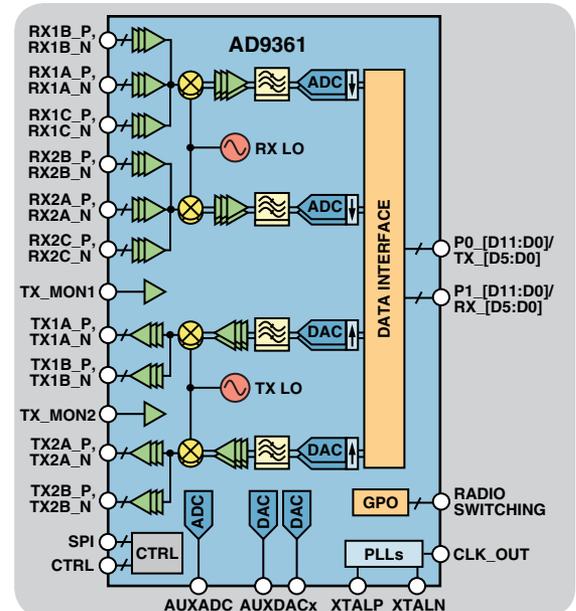
"The AD9361 RF Agile Transceiver is a complete RF transceiver solution on a single chip—it's an RF architect's dream device. We combined the AD9361 with a Xilinx Spartan-6 FPGA, USB 3.0 interface, and comprehensive software support to create one of the industry's easiest to use and most flexible software-defined radio solutions."

Matt Ettus, President of Ettus Research,
a National Instruments company

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They also wanted to support MIMO (multiple input/multiple output), an advanced technique that is getting increasing attention as a path to increased performance, higher data rates, and lower bit error rates. Their primary hardware challenge was meeting the front-end requirements in a single, wideband, high performance signal chain, since using spectrum overlapping AFE channels in parallel would have been too complex and costly.

Fortunately, Ettus's need coincided with the availability of an RF IC that is specifically tailored for what this SDR required, the AD9361 RF Agile Transceiver™ from Analog Devices. This 10 mm × 10 mm device with dual independent channels—Figure 1—has user tunable RF bandwidth from 200 kHz to 56 MHz, and 12-bit resolution, along with other features and performance that are needed to build a signal chain spanning 70 MHz to 6 GHz. Using this component reduced the entire AFE into a single, relatively simple circuit.

The final SDR design resulted in two closely related products. The basic B200 1 × 1 channel and B210 2 × 2 channel (for MIMO applications) USRP platforms—Figures 2 and 3—are easy to use and supported by a robust software ecosystem designed with a comprehensive C++ API. Each unit includes an open and reprogrammable Spartan®-6 FPGA for data processing, along with a SuperSpeed USB 3.0 port for connectivity. Note that the AD9361 is so cost effective that it is used in both the 1 × 1 and 2 × 2 designs; the 1 × 1 design just does not provide the additional support for the second channel in the pair.

These fully integrated, direct conversion transceivers can be configured for experiments and evaluation of signals in FM and TV broadcast reception, prototyping a GSM base station with OpenBTS,® developing with GNU Radio GPS, Wi-Fi, ISM, and more. An available USRP Hardware Driver™ eases software prototyping in GNU Radio, and enables user participation in the open-source SDR community.

Figures 2 and 3. The USRP B210 and B200 provide a platform for low cost SDR experimentation, as a fully integrated, single board, Universal Software Radio Peripheral with continuous frequency coverage from 70 MHz to 6 GHz.

An additional advantage of using the AD9361 in this design is operational flexibility. Critical parameters such as gain and bandwidth are not fixed in advance by the hardware design. Instead, they can be set and even changed "on-the-fly" by the software and processor via an SPI port interface. This allows the algorithm to optimize hardware performance for specific band, bandwidth, SNR, and format of interest, without compromise or accepting suboptimal trade-offs.
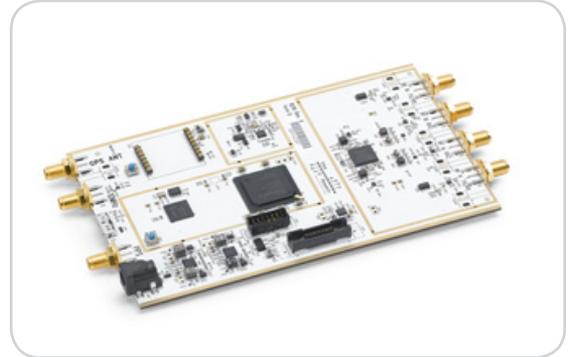
The USRP B200 real-time system throughput is benchmarked at 61.44 MSPS quadrature providing up to 56 MHz of instantaneous RF bandwidth to the host PC for additional processing using the GNU Radio SDR design environment. Full support for the UHD (USRP Hardware Driver) software allows seamless code reuse from existing designs, so users can immediately begin developing with GNU Radio, prototype their own GSM base stations with OpenBTS, and easily transition code from the B200 to higher performance, industry-ready USRP platforms.

The Power of SDR Dramatically Revealed

It's one thing to promote the virtues of software-defined radio as a concept, but it's a much more powerful thing to see and read about what SDR can do in reality. To tangibly demonstrate this, Balint Seeber, an applications engineer at Ettus Research, recently took a B200 unit and laptop on a weeklong day and night exploration of the San Francisco area.

Unlike earlier explorers who looked at geographic details, his travels instead were focused on the RF environment around him. He reveals the many interesting signals and hidden worlds he discovered in a detailed interview here.

For too long, SDR has been an attractive mystery to many designers who want to fully understand what it can do for them across a wide array of application categories. With products such as the B200 and B210 from Ettus—made possible by highly integrated, extremely wideband RF agile transceiver ICs such as the Analog Devices AD9361—engineers can explore and adapt SDR, thus reducing the mystery while increasing the attraction.

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