WaveCaster™ Software-Defined Radio

Improve performance, increase flexibility, reduce time-to-market and decrease development cost for your next wireless solution.

Introduction

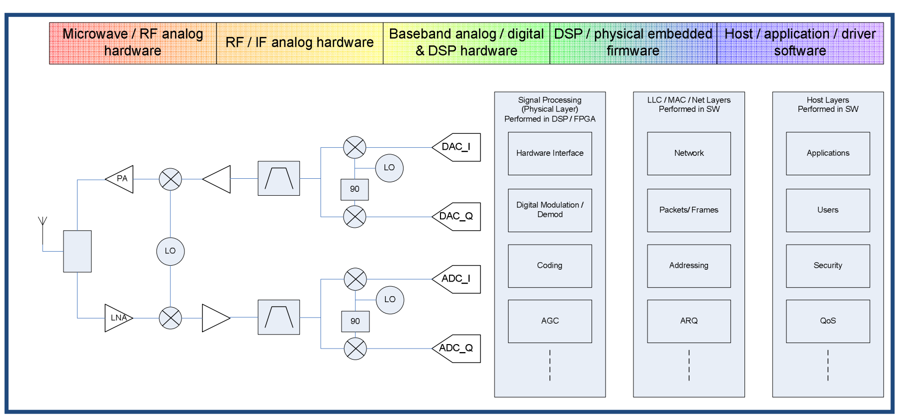
A former U.S. president once said that "information is the oxygen of the modern age." This statement is becoming ever more pertinent as time and technology progress. The ability to manage information in a world of quickly evolving technology is essential.

The world of information exchange is so much bigger than smart phones or even the Internet. From processing your lunch order at the local fast food restaurant to securing never-before-seen photos of a rock on planet Mars, an immeasurable segment of our existence depends upon the proper management and accurate communication of information. Even the most niche products often require some kind of capability to communicate. This need has made communications systems ubiquitous in the vast array of ever-evolving embedded applications.

The backbone of any communications system is the ability to transfer information using signals, whether they are electrons through wires, light through optics, or electromagnetic waves through space. Information is constructed into signals at the source, transferred to a new location, and then reconstructed to convey the original information to the recipient. The job of the communications system is to create the pipe within which to transfer the information. There has been a continuous effort to increase communication systems efficiencies by packing more information into a smaller pipe that can also convey the information over a larger distance. This effort to increase channel capacity has complicated information signal processing. The need to differentiate the desired signal from noise or other adjacent "packed-in" signals has imposed the requirement to process the signal to ensure accurate information is conveyed.

The Advent of Software-Defined Radio

The communications signal processing of most systems has traditionally been complex enough to necessitate hardware-only solutions that are tailored to fit the specific application (i.e., that type of pipe). In the past, it was not considered cost effective for most applications to use a software-based solution. Over the past decade, however, the cost of computing power has decreased to the point that software processing of communications signals is not only cost effective, but has become almost essential to keep pace with the appetite for increased channel capacity. The combination of lower cost and improved performance has opened the door to a new paradigm in the era of information exchange: the introduction of Software-Defined Radio (SDR). Despite the name, SDR platforms are not only suitable for radio (wireless) systems, but are also appropriate for wire- or optical-based communication systems



A Typical SDR Block Diagram

as well, as we will see in this paper.

Hardware systems, as the name implies, tend to be “hard-coded” or fixed in function. A hardware solution for a given communication channel requires prior knowledge of the nature of the channel and once applied is - in general - a fixed solution. Modification of a hardware-only solution requires replacing the hardware. Given that software is, by definition, “soft,” solutions employing software only can be modified with relative ease using a field upgrade. In reality, most modern systems are not only hardware or only software but rather are a hybrid of the two; SDR is a great example of this.

SDR aims to take the analog communication signal and convert it to or from numbers (i.e., the digital domain) as late on the transmitter side and as early on the receiver side as possible. This approach allows the smallest possible amount of pipe-specific hardware. Once hardware signal processing is converted to software in the digital domain (i.e., digital signal processing, or DSP), many advantages arise because the processing becomes purely mathematical. Some of the benefits of SDR are:

- SDR can improve performance over hardware-only techniques in the following ways:

  Analog hardware is subject to performance variability (e.g., component tolerances, temperature variance, etc.). Software does not suffer the same limitations.

  Analog hardware is susceptible to external interference, and internal (unintentional) distortions. Once a signal is converted to numbers, these problems are eliminated.

  Software techniques improve channel capacity and performance (e.g., through tighter filtering, channel coding, etc.). Software techniques are limited only by the computing horsepower necessary to process the signal (in terms of speed and/or numerical precision).

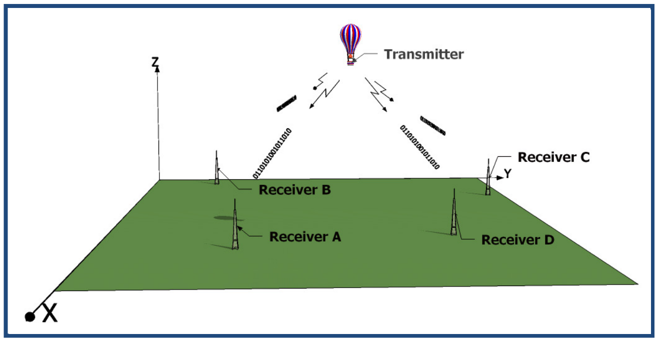
- SDR can increase the flexibility of a product. As stated earlier, changes to the communication pipe can occur through software upgrades or even in real time if an SDR approach is employed. This ability to adapt to changing requirements makes SDR extremely valuable.

- SDR can reduce time to market and development cost for makers of embedded products that require some form of information exchange. This may not be true for the first development cycle of SDR because the first cycle will inevitably contain development of the software signal processing algorithms as well as the hardware to run the SDR protocols. However, once a hardware platform is developed which utilizes devices that can take advantage of SDR capabilities (i.e., it has maximum flexibility to be used in a broad range of applications), then subsequent products (or upgrades) can leverage the platform to minimize hardware development. This allows for efforts to be focused on the new communications algorithms and cuts out a very large portion of the cost and schedule involved in designing new hardware.

To show the advantages of SDR by way of example, two real-world applications follow:

Case Study 1: Object Position Information

The primary function for the products developed by Company A is to determine the location of objects within a geographic region. In order to avoid collisions, each object transmits a radio signal that can be received by numerous ground stations, and that information can be combined to determine position by way of multilateration. Without going into the full operation of the system, suffice it to say that multilateration depends on a very accurate measurement of the transmit signal’s time of arrival, having minimal variation in delay over time.



Multilateration Using a Beacon

Traditional ground station receiver hardware for this platform utilized an approach that limited the ability of the architecture to take full advantage of SDR techniques. This limitation occurred because the communication format used a nonlinear modulation technique, and the analog hardware contained a limiter as well as all of the filter selectivity needed to meet the communications requirements.

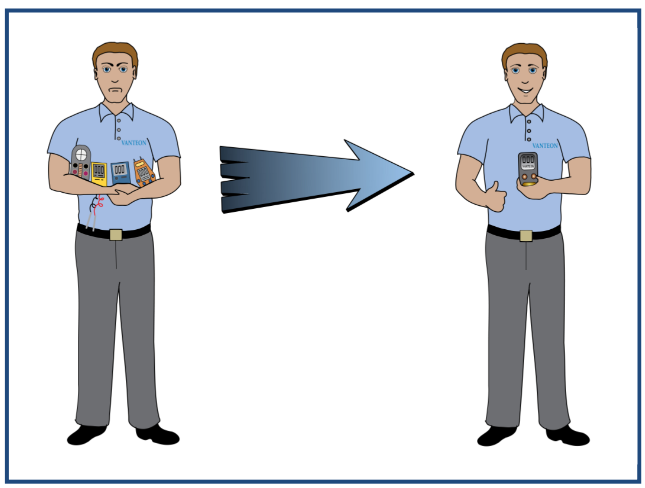
When the customer decided to use what was previously a data communications protocol to also determine position via multilateration, the platform lacked sufficient performance to maintain the required delay variation. The problem was that analog hardware has tolerances and dependencies on temperature and other external factors. These artifacts increased variation of signal delay through the hardware. To minimize these effects, SDR techniques moved much of the signal processing into the world of software. This was done by developing an SDR platform that avoided components that were subject to a variation in delays (e.g., narrowband filters), and by removing hardware signal compression devices (i.e., limiting). A high-performance SDR platform with a wide dynamic range and excellent sampling characteristics was utilized to directly sample the intermediate frequency signal. Wideband hardware filters were employed to allow all narrowband selectivity to be performed in the digital domain where functionality does not depend on tolerance, temperature, aging, and other external factors.

In this case study, SDR techniques enhanced system performance to the stringent levels required for an accurate multilateration function. In addition to the improved performance and the ability to bring the product to market, Company A also has plans to leverage the same hardware platform in new products that use very different signal processing techniques. This is accomplished as a result of the flexible nature of SDR and its ability to be tailored to varying communication channels (pipes). Since the hardware platform is reusable, Company A can reduce development cost and time to market by eliminating a large portion of the development cycle.

Case Study 2: Wireless Object-Containment System Analysis

Company B develops a variety of systems for object containment (e.g., within a defined region). The installation technicians had difficulty troubleshooting the large number of differing systems because each one uses a different combination of modulation and coding schemes.

Company B determined that it needed a tool for installation personnel to help facilitate the troubleshooting of the vast array of containment systems. Due to the nature of the problems encountered (such as interference and broken underground antenna loops) the tool needed to incorporate spectral analysis as well as signal demodulation capabilities. To accommodate future growth, the tool also needed the flexibility to analyze signals from systems yet to be invented and to do so with minimal redesign. This requirement made the use of an SDR system highly desirable. In addition to the flexibility requirement, the analyzer needed the capability of receiving and decoding a number of signals simultaneously for quick detection of the type of system deployed at the site.


Merge Multiple Products into One

For this application, the company used a field programmable gate array (FPGA) for the SDR to facilitate the use of complex parallel-processing paths. In an FPGA, a separate receiver was instantiated for each type of signal. In addition to all of the signal receivers, spectral analysis was performed at the same time as demodulation using a single device.

The utilization of SDR in this system provided a level of flexibility that could not be obtained using a hardware-only receiver solution. As future containment systems are deployed by Company B (either through new product development or competitive acquisitions) the installer tool can support the new system with a simple software upgrade, whereas a hardware solution could not. This capability provides longevity to the product, reducing long-term costs of doing business for Company B, and reducing the time to market for the deployment of future system support to installers.

Use of SDR also improved analysis performance over the hardware-only systems. Digital signal processing techniques were able to provide better noise and interference rejection capabilities, as well as provide very effective mathematical analysis capabilities such as Fourier Transform processing for spectral analysis.

Conclusion

Software-Defined Radio is a very effective technique for improving performance and reducing development costs and time to market while increasing flexibility over traditional hardware-only communications systems. SDR in embedded products can open doors to information exchange in markets that have previously been dominated by hardware solutions as a consequence of stringent system requirements. SDR used in these new applications can integrate communication systems without the fear of near-term obsolescence. The world of information exchange is an area of ever-evolving standards in a push to increase channel capacity to its limits. In such a world, the ability to reconfigure a communication system to use the latest and greatest communication techniques without upgrading hardware is a very valuable asset. SDR provides just that ability.

About Vanteon

Since 1985, Vanteon has been helping our clients bring quality assured electronic and software intensive products to market faster. Vanteon's breadth of expertise covers technically advanced digital imaging, digital video, wired, and wireless products.

Vanteon's WaveCaster™ series of modular SDR platforms offer low cost, scalable solutions. The first in the series, the WC1, is based on a computational core composed of a Blackfin® Processor by Analog Devices and a Xilinx® Virtex®-5 SXT FPGA coupled with a library of target-agnostic software/gateware modules for radio operations. Common interfaces, such as 10/100 Ethernet and USB 2.0, provide for traditional wired connections to local devices. Dual RF inputs and outputs allow for optional multiband, full duplex or MIMO operations, with frequencies up to 450MHz and a software-controlled bandwidth up to 40MHz. A tri-band RF board provides half-duplex operation in the common ISM bands of 900MHz, 2.4GHz and 5.8GHz. Contact Vanteon for a product brief containing more details.

Vanteon has the skills and experience to accelerate your development cycle and offers a proven Software Defined Radio platform that can be the starting point of your next product.

VANTEON® ELECTRONIC DESIGN

For more information call 888.506.5677, email us at request_info@vanteon.com or visit us at www.vanteon.com.