SOLUTIONS BRIEF

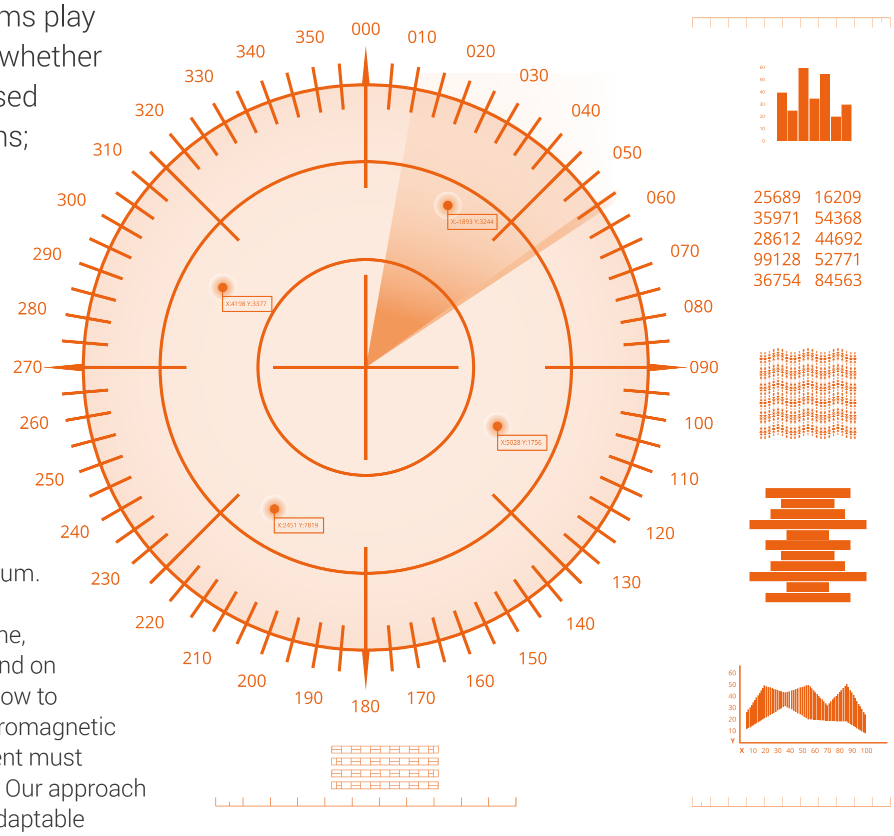
RFSoC for Radar and Electronic Warfare

abaco SYSTEMS

RFSoC for Radar and Electronic Warfare

Introduction

Today's radar and electronic warfare systems play a critical role in success on the battlefield: whether detecting enemy aircraft, ships, or land-based vehicles and jamming their communications; guiding missiles; mapping terrain; spoofing enemy radar and so on, dominating the electromagnetic spectrum is paramount for operational success.



Controlling the spectrum means our warfighter is kept safe, and our enemies are kept at bay. As the Department of Defense (DoD) notes in its 2013 Electromagnetic Spectrum Strategy call to action, success on the modern battlefield increasingly depends on dominating the electromagnetic spectrum.

"The Department of Defense's (DoD) air, land, maritime, space, and cyberspace operations increasingly depend on electromagnetic spectrum access… DoD must act now to ensure access to the congested and contested electromagnetic environment of the future. Specifically, the Department must adapt how it acquires and uses spectrum resources. Our approach must include acquiring more efficient, flexible, and adaptable systems while developing more agile and opportunistic spectrum operations to ensure that our forces can complete their missions ."

In early 2018, Air Force Secretary Heather Wilson said that there has been explicit recognition "of the re-emergence of great power competition" and that world powers such as Russia and China are "modernizing very quickly – they're modernizing their air defenses, but also their air-to-air capability is really modernizing across the board. It is the pacing threat for the U.S. Air Force because of the pace of their modernization."

Adversaries evolve

As our adversaries continue to evolve, so too do the technology requirements to counteract the threat. Radar and EW technology are no exception. As radar systems continue to increase their operational frequency ranges – more bandwidth means it's harder to jam or cause interference – electronic warfare systems also must cover a wider band of the spectrum. Additionally, the number of channels required per system is also increasing. Wider bandwidth and more channels means greater range and trackable targets.

http://archive.defense.gov/news/dodspectrumstrategy.pdf

https://www.military.com/dodbuzz/2018/02/15/air-force-wants-invest-heavily-next-gen-technologies.html

RFSoC for Radar and Electronic Warfare

VP430 RFSoC board.

As these trends for wider bandwidth and more channels proliferate, the need for a flexible hardware platform becomes greater and greater. FPGA-based digital receivers - the front end of a radar or EW system - that leverage FMC modules for analog-to-digital conversion systems have provided a flexible, high performance solution to current challenges.

The flexibility of the system derives from the ability to upgrade hardware pieces – like the FMC module – when the performance requirement changes, or when the next generation of technology is introduced. While flexibility at the hardware level can help overcome the stringent requirements for wider bandwidth, more channels and high adaptability, even greater flexibility could be provided if this flexibility could be pushed closer to the antenna.

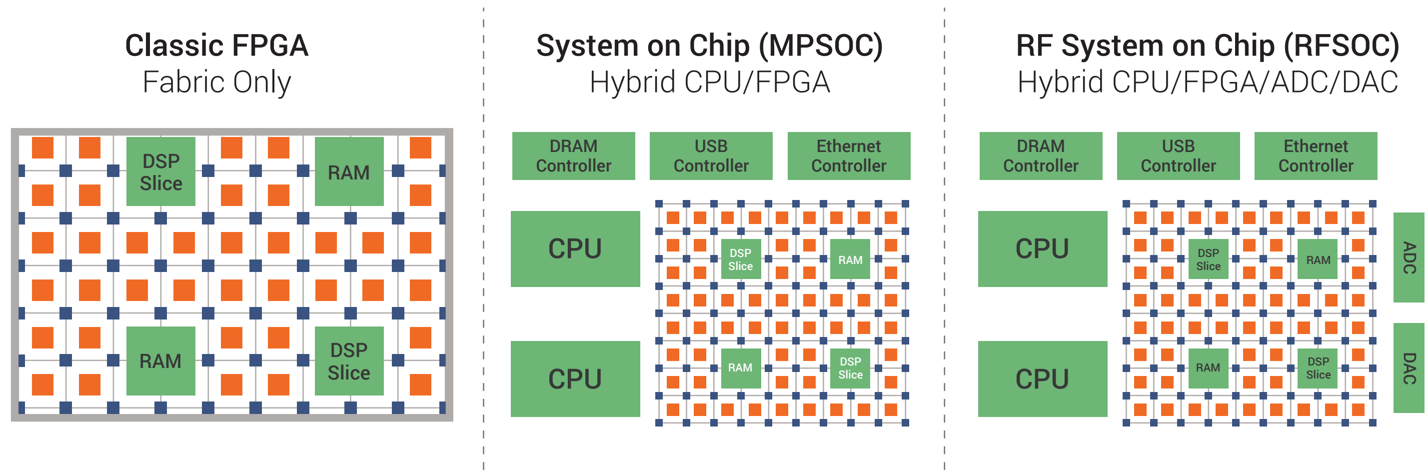
Xilinx innovation

The Zynq UltraScale+ RFSoC devices - a new innovation from Xilinx - provide such a solution. This family of devices features an integrated ADC (up to 16 12-bit channels sampling at 4.0 GSPS), DAC (up to 16 14-bit channels sampling at 6.4GSPS), configurable logic elements, multi-processor embedded ARM Cortex-A53 application processing unit (APU), and an ARM real time processing unit (RPU). Integrating all of these devices enables the shifting of many of the analog signal processing actions - that typically take place close to the antenna in a digital receiver - into the digital domain.

Doing so helps reduce the RF signal processing chain complexity, standardize on one set of flexible hardware to address a variety of applications, maximize input/output channel density without sacrificing wide bandwidth and leverage heterogeneous processing capabilities – all of this while taking advantage of the Zynq architecture's built-in security features that help keep IP safe.

The VP430 from Abaco, the first COTS 3U VPX board to feature an RFSoC device, provides a COTS solution that can provide the benefits of the RFSoC as well as enable data to be offloaded more efficiently and the benefits of COTS to be enjoyed: users get to deployment as quickly as possible while taking advantage of the lower cost of ownership, lifecycle support, and simplifying future technology insertions.

RFSOC vs. MPSOC vs. FPGA



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Reduce RF Signal Chain Complexity

Radar and EW systems with multiple channels suffer from a cost and complexity challenge, in that more channels means more expensive and large RF signal up/down conversion and signal conditioning. A common solution to this is direct RF sampling – a more flexible approach than traditional analog frequency translation and filtering. Direct RF sampling can be implemented in the digital domain, which draws less power and generally costs less.

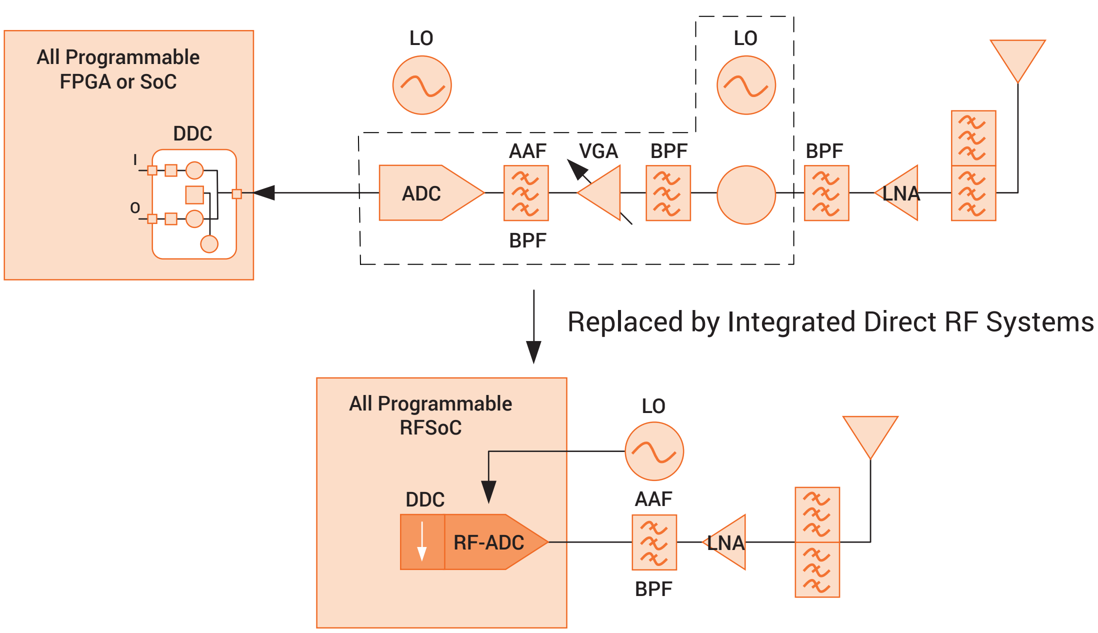
This means that the RF frond end can handle wider bandwidths than traditional analog technologies while consuming less power. Using very high sample rates in the data converter, as the RFSoC devices do, means that much of the analog filtering and conditioning can be done closer to the antenna, providing a simpler, more flexible front end than has been possible in the past.

The VP430, with an 8-channel ADC and 8-channel DAC, provides this benefit and helps minimize the need for complex up conversion and down conversion for many frequency ranges common in radar, communications, and electronic warfare. For radar and EW systems, this means there is more control over the digital signal processing at the software level so that the overall system can be adapted more rapidly as new threats emerge. This also lays the groundwork for truly cognitive radar and EW.

Additionally, since ADCs and DACs were historically separate devices from the programmable FPGA, a high speed interface was needed to communicate between the devices. In recent years, JESD204B has been a common high speed serial interface – but it comes at a cost in terms of latency and design complexity. For some radar or EW applications, the latency from JESD204B is too large, often ruling devices that use this interface out for system integration. The RFSoC helps overcome this. By integrating the ADCs and DACs into the device, the need for JESD204B is eliminated – simplifying design complexity and helping reduce latency.

RFSOC Technology – What's the big deal?

High IF Superheterodyne Receiver to a Direct RF-Sampling Receiver



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Maximize Input/Output Channel Density

In order to address the range of new threats to electromagnetic spectrum dominance, modern radar and electronic warfare systems require increasing numbers of channels and wider bandwidths. Abaco's VP430 has an 8-channel ADC and 8-channel DAC, making it one of the densest 3U VPX analog FPGA carrier boards in the industry with the ability to synchronize all 16 channels as well as multiple boards for even larger system applications. In previous generations of technology, this combination would have taken four times as many boards.

Heterogeneous processing capability.

Many radar and EW systems require both a streaming DSP with an FPGA and a general purpose processor for decisions and control. In the past, these processing requirements were handled by separate modules. Now, with the VP430, it is possible to get both functions in a single module by leveraging RFSoC technology.

This is particularly applicable for the growing demand for cognitive or smart radar/EW technology. Additionally, simplified integration with RF sampling devices removes the complexity of JESD204B high speed serial interfaces. This means that fewer programmable logic elements are consumed by basic functions like inter-device communication, leaving more computational resources available to application-specific IP than in the past.

Offload data more efficiently

In addition to gaining all the above-mentioned benefits of the RFSoC device, the VP430 can also help offload data more efficiently by taking advantage of an optional 8-channel VITA 66.4 fiber optic interface.

When a system includes many channels and extreme sample rates, there is always the problem of how to handle the firehose of data. Invariably, a system must decimate, process, or transfer the data in the FPGA. Many times, a system is limited to the data connection fabric. The VP430 has a traditional VPX data plane interface, allowing a x8 PCIe Gen3 connection to a host computer.

With eight ADCs sampling at rates over 6GSPS with two bytes per sample, even the modern PCIe Gen 3 high speed data connection is too slow for a direct transfer. To overcome this challenge, the VP430 includes – in addition to the PCIe Gen3 data plane - the option to be built with an 8-channel VITA 66.4 fiber optic interface for transfers of greater than 12 GBPS per channel.

Radar and electronic warfare systems of the future

Controlling the electromagnetic spectrum on the battlefield is essential to mission success. A major factor in capturing and maintaining that control is having the most advanced radar and electronic warfare systems.

Future systems must be powerful enough to monitor and manipulate wide bandwidths while also being flexible enough to adapt in as close to real time as possible. Leveraging technologies like the RFSoC can help give the armed forces the edge they need to be more adaptable than their adversaries.

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Americas: **866-OK-ABACO or +1-866-652-2226** Asia & Oceania: **+81-3-5544-3973**
Europe, Africa, & Middle East: **+44 (0) 1327-359444**
Locate an Abaco Systems Sales Representative visit: **abaco.com/products/sales**

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