Jump Starting RFSoC Technology for Radar and Mil-Aero Applications

Embedded Tech Trends
January 2019

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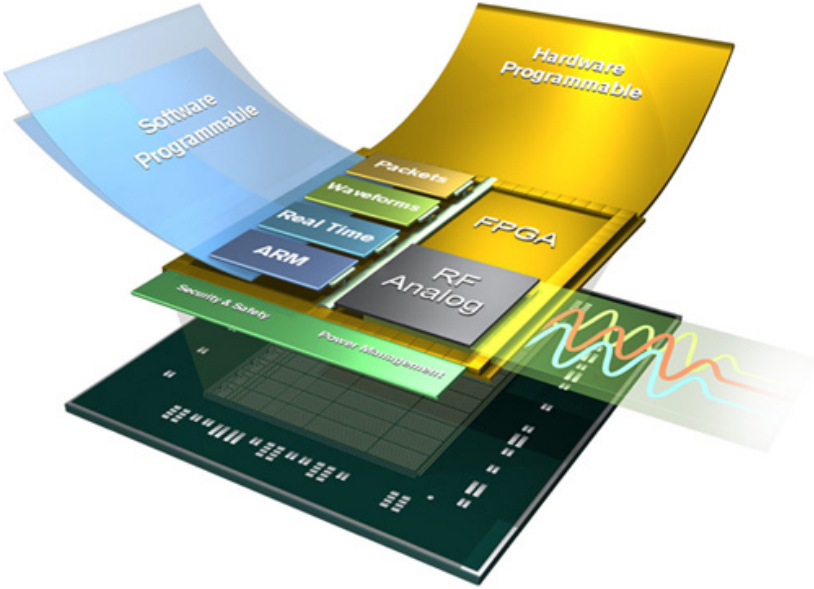
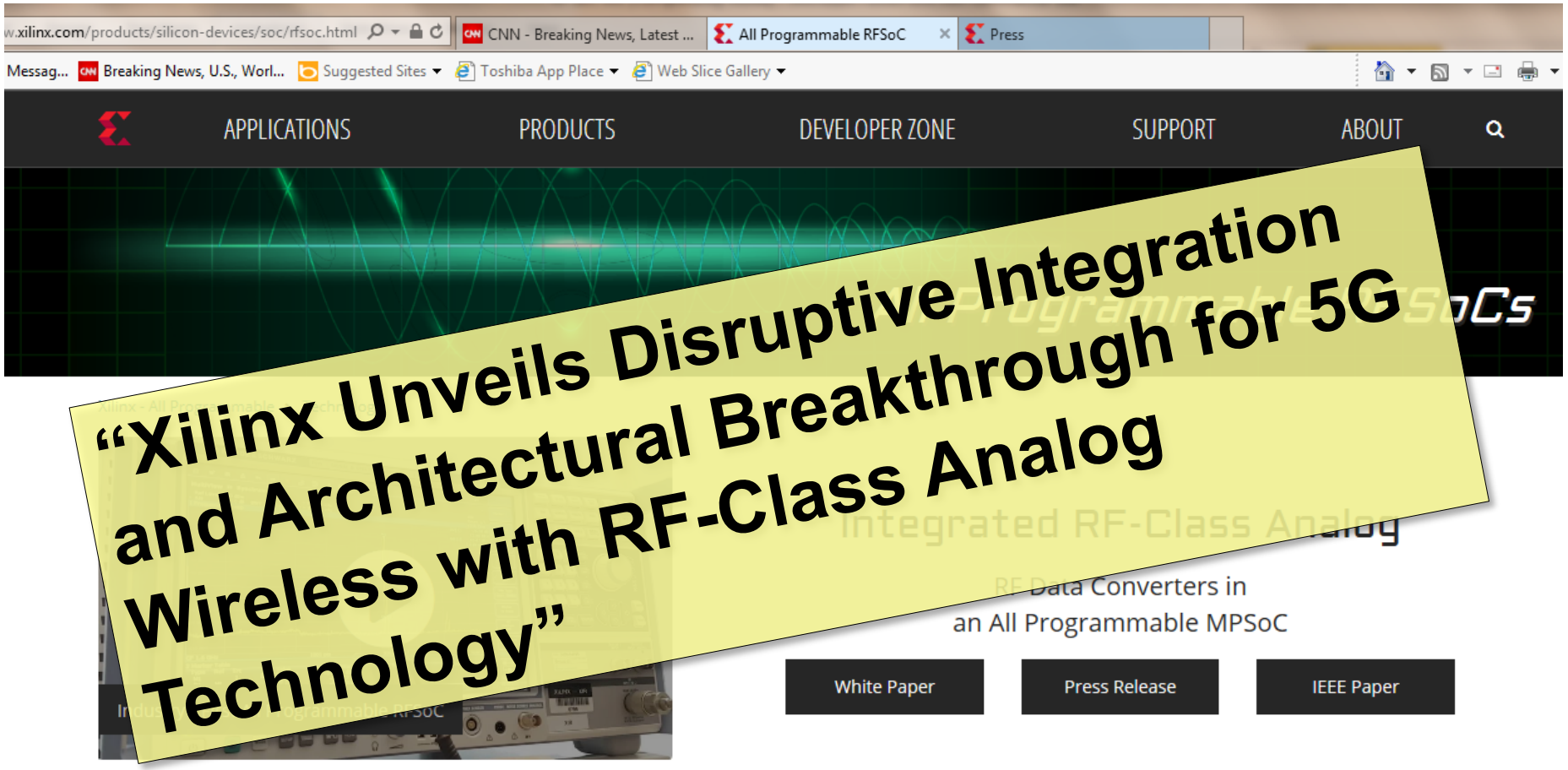
Pentek, Inc.

RFSoC – Radio Frequency System on Chip

- Xilinx RFSoC Overview
- RFSoC Market Opportunities
- RFSoC Design Challenges
- RFSoC Module Concept
- RFSoC Module Migrates to Other Form Factors
- QuartzXM RFSoC Module
- Summary



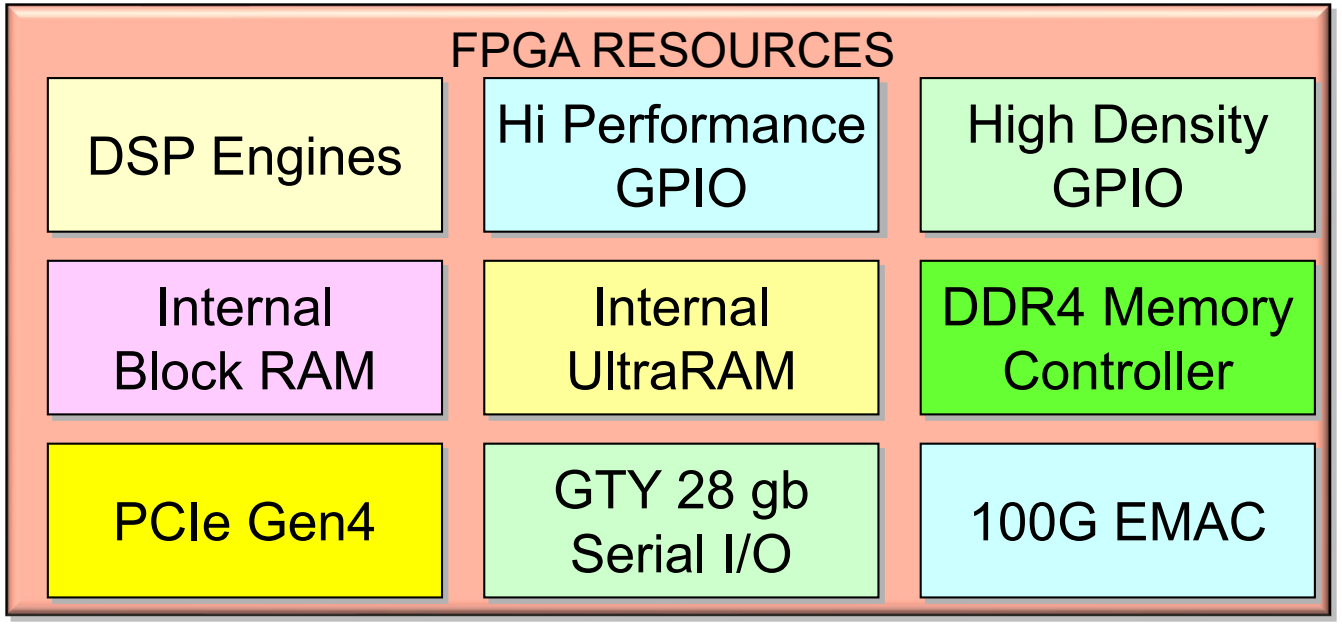
February 2017: Xilinx Announced RFSoC



"Xilinx Unveils Disruptive Integration and Architectural Breakthrough for 5G Wireless with RF-Class Analog Technology"

Xilinx UltraScale+ FPGA Resources

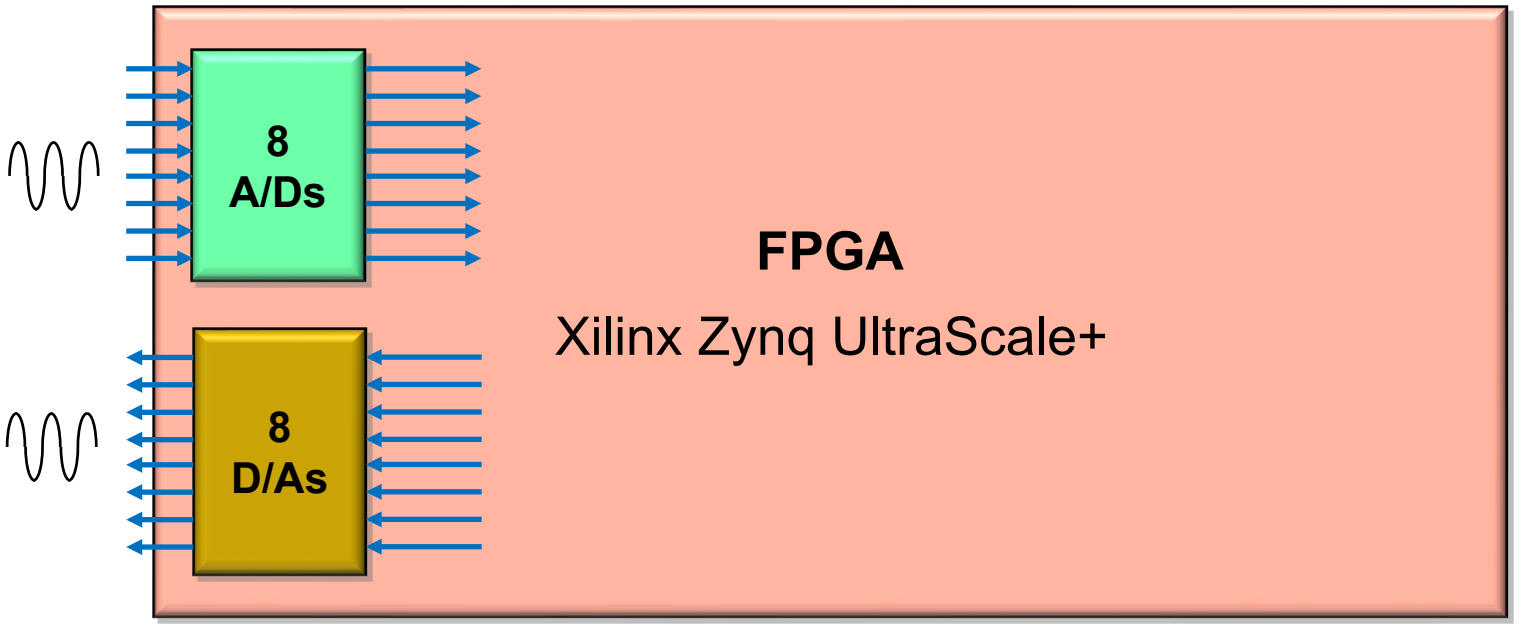
- 16 nm FPGA Fabric – Logic Cells, DSP Engines, Block RAM, etc.
- Advanced Real-Time Digital Signal Processing Engines
- Extensive General Purpose I/O for Peripherals



- Fast Internal Memory and Controller for External DDR4
- PCIe Gen4 System Interface
- Enhanced 28 gb GTY Serial I/O and MAC for 100 GbE

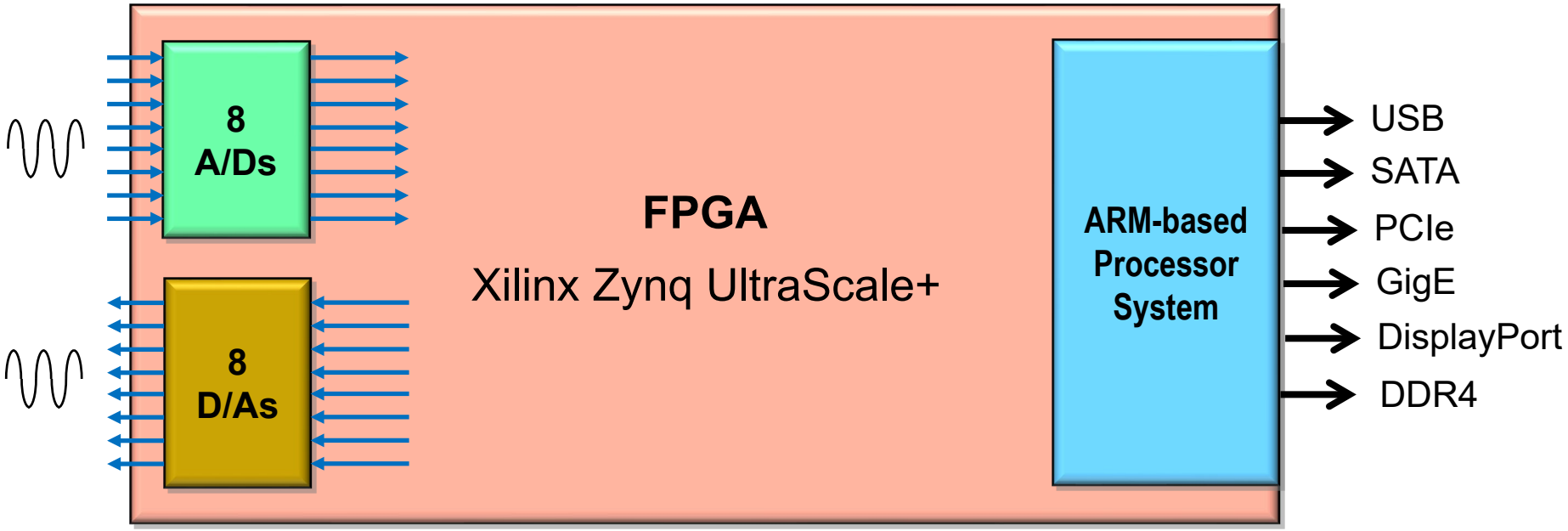
Integrated Data Converters in the FPGA

- A/Ds and D/As are connected directly to FPGA fabric
- Lowest latency parallel interfaces



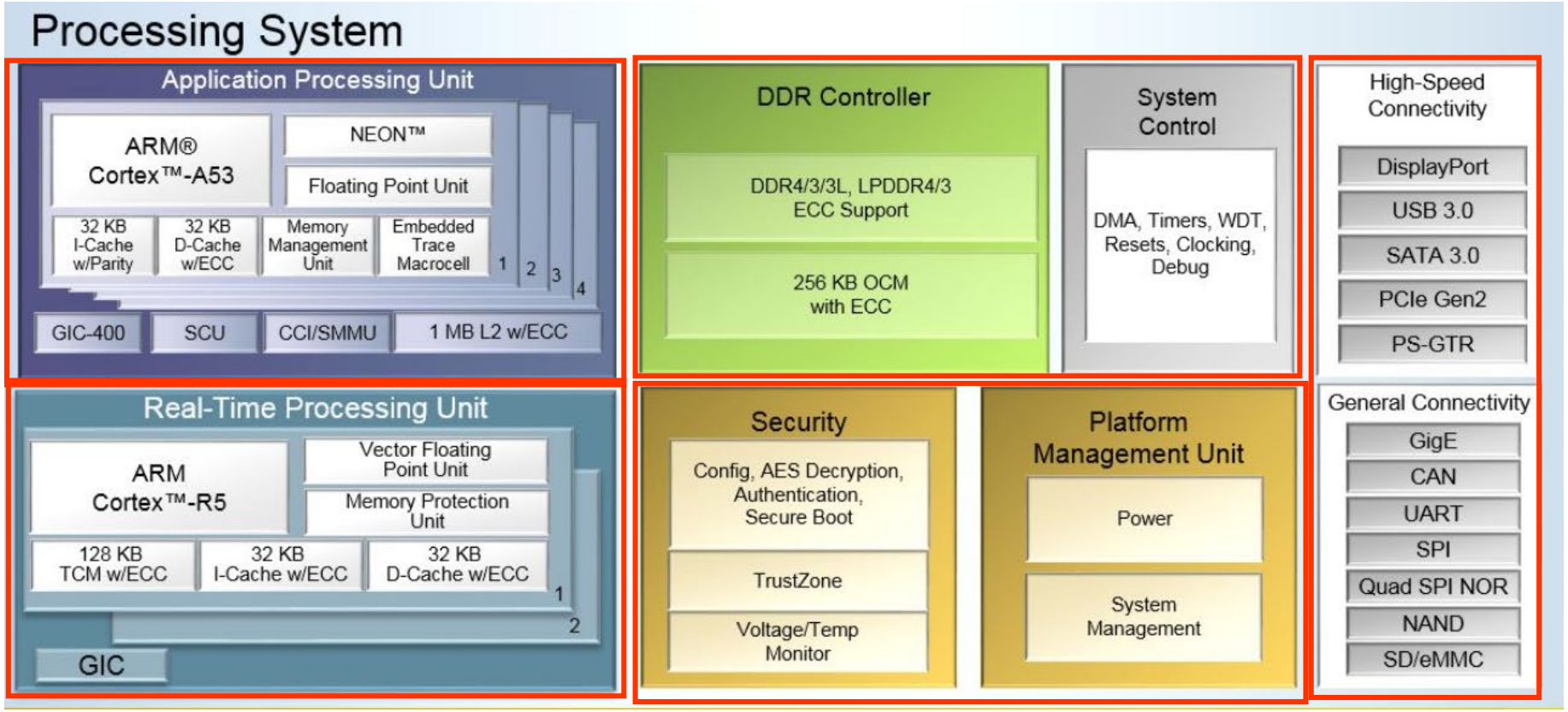
- 8 A/Ds: 12-bit, 4 GHz with integrated Digital Downconverters
- 8 D/As: 14-bit, 6.4 GHz with integrated Digital Upconverters

ARM Processor Resources



ARM Based Processor System

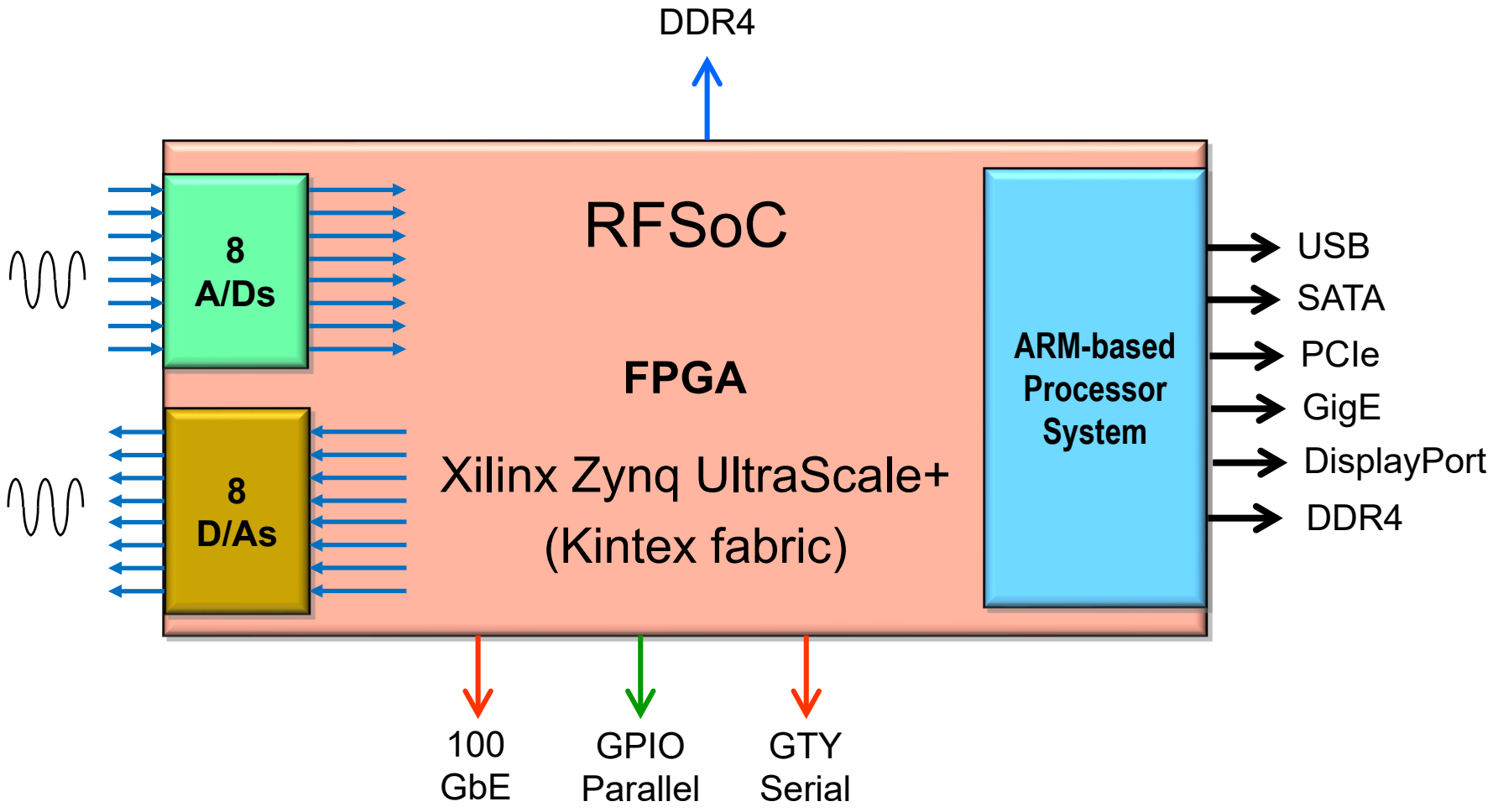
- Application Processor: Four 64-bit ARM Cortex-A53 cores
- Real-Time Processor: Two ARM Cortex-R5 real time cores



- DDR4 Memory Controller and System Controller
- Security Manager and Platform Management Unit
- High-Speed Connectivity and Processor I/O

RFSoC – Complete RF System on Chip

- Complete 8-Channel RF Transceiver, DSP and Control Processor sub-system on a single monolithic chip!



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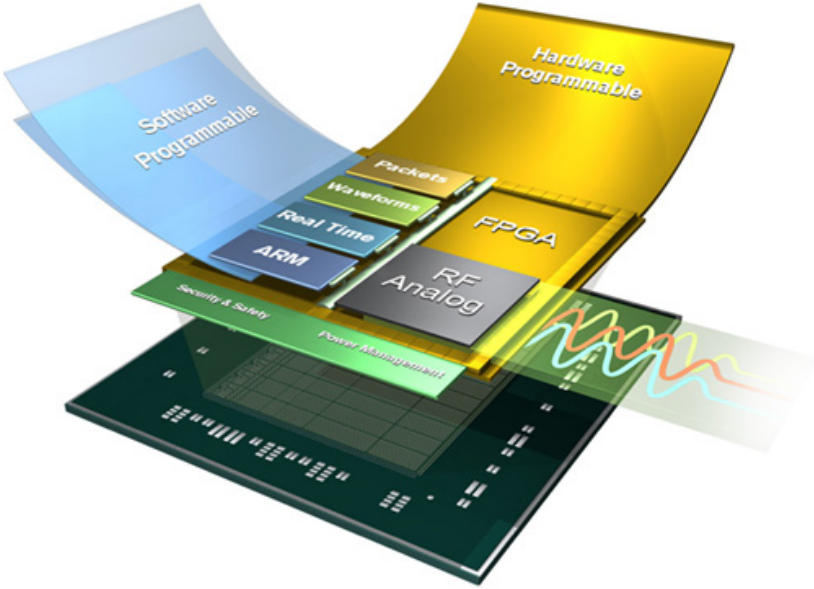


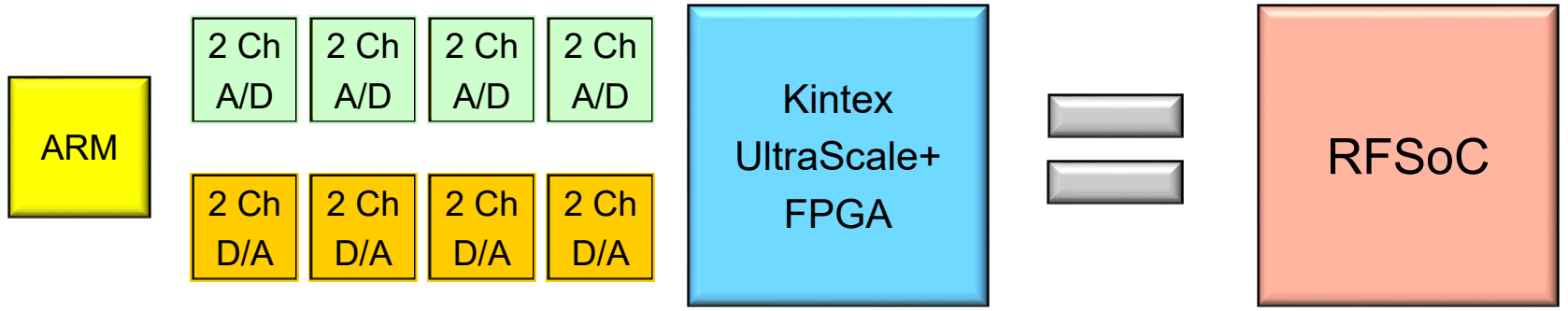
RFSoC Market Opportunities

- Radar
  - Tactical battleground and airborne monitoring, classification, and tracking of targets
  - Fire control systems
  - Multi-function Phased Array Radar (MPAR) initiative combines U.S. weather and radar networks
  - Common Module beamformer for DARPA Arrays Commercial Time Scales (ACT) program
- EW and Countermeasures
  - Low latency applications
  - Jamming and Spoofing
- Communications
  - SATCOM and Military / Airborne Radios
  - Phased array transceivers
- SIGINT
  - Monitoring, Interception, and Analysis
- 5G Wireless & Cable Remote PHY
  - Remote radio head for Massive-MIMO, wireless backhaul, and fixed wireless access
  - Implements DOCSIS 3.x PHY Spectral Efficiency requirements for distributed broadband digital networks

How Does RFSoC Change Mil-Aero Embedded Market?

- Reduced size and footprint
  - About 50% less compared with discrete data converters, FPGA & processor
- Reduced power
  - About 30-40% total power savings
- Reduced cost
  - About 40-60% total cost savings
- Reduced latency
  - About 70% less delay than JESD204 data converters

- Moves SDR closer to the antenna
- Wideband digital RF transceiver links
- Longer missions for UAVs
- Smaller & smarter unmanned vehicles
- Less weight for airborne systems
- Improved density for phased arrays
- Better dynamic range for signals
- Low latency improves countermeasures
- Remote monitoring and sensing
- Economic practicality of new applications



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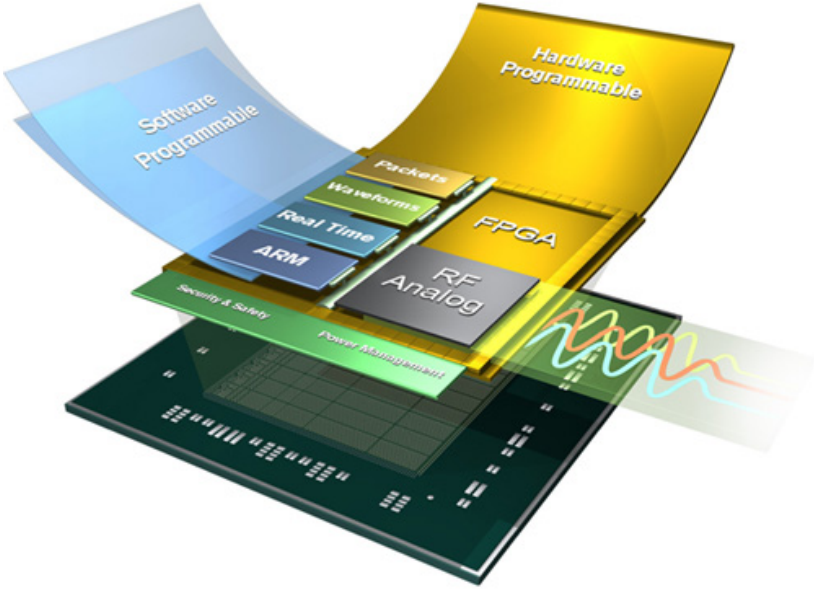
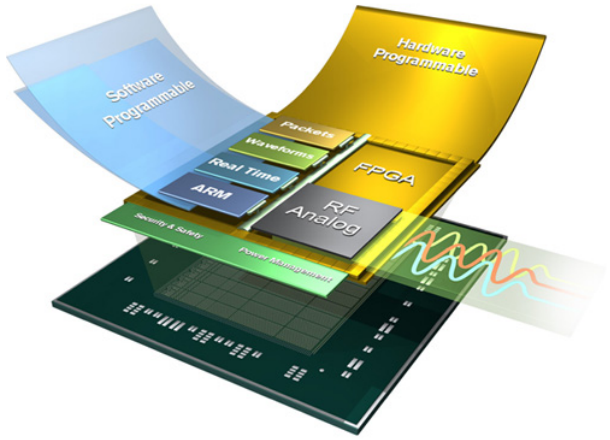
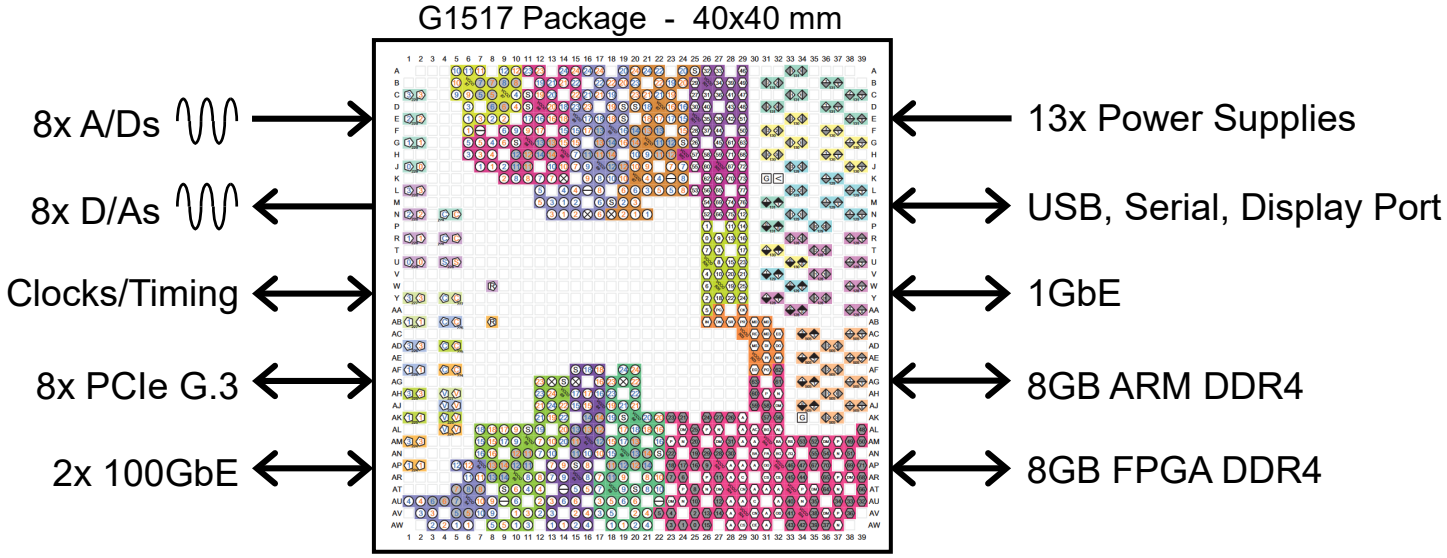


RFSoC: Board Level Design Issues

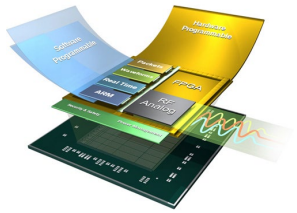
- RF Signal Integrity
  - 16 Analog RF Signals with GHz Bandwidths
  - Spurious digital signal pickup
  - Crosstalk between analog channels
  - Signal path integrity and impedance
- Clock Management
  - Data Converter Sample Clocks
  - FPGA Fabric and Gigabit Serial Links
- Gigabit Serial Links – 28 Gbit GTY
  - Signal path integrity and impedance
  - Bit error rate considerations
- Power Supply Requirements
  - RFSoC chip requires 13 different power supplies
  - Analog supplies must be extremely clean
- ARM Processor I/O
  - USB, Serial, Display Port, GbE
- 2400 MHz DDR4 SDRAMs
  - 8GB FPGA and 8GB ARM
- Thermal Management
  - Air- or conduction-cooling provisions

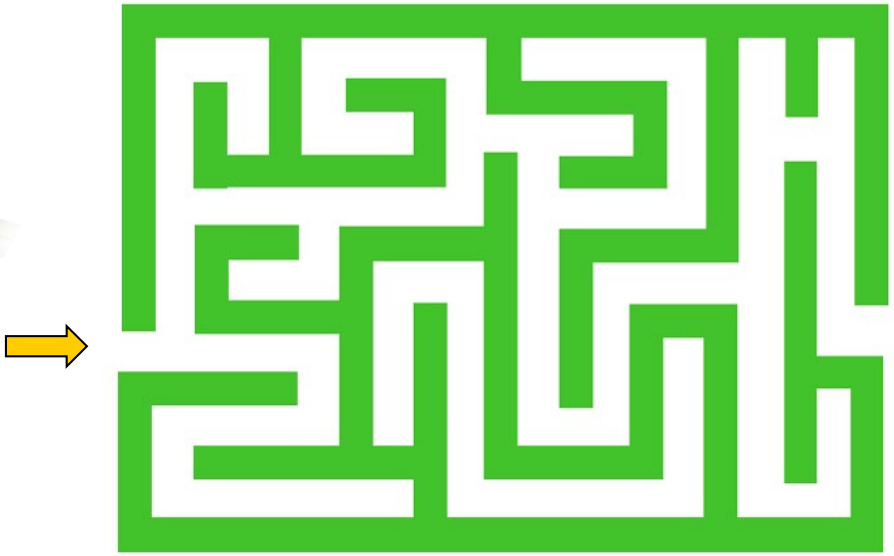




Design Strategies for RFSoC

- What's the shortest path from RFSoC chip to a Deployed Product?
- How long will it take to deal with all these RFSoC design Issues?
- How can I get a running start to cut development time?





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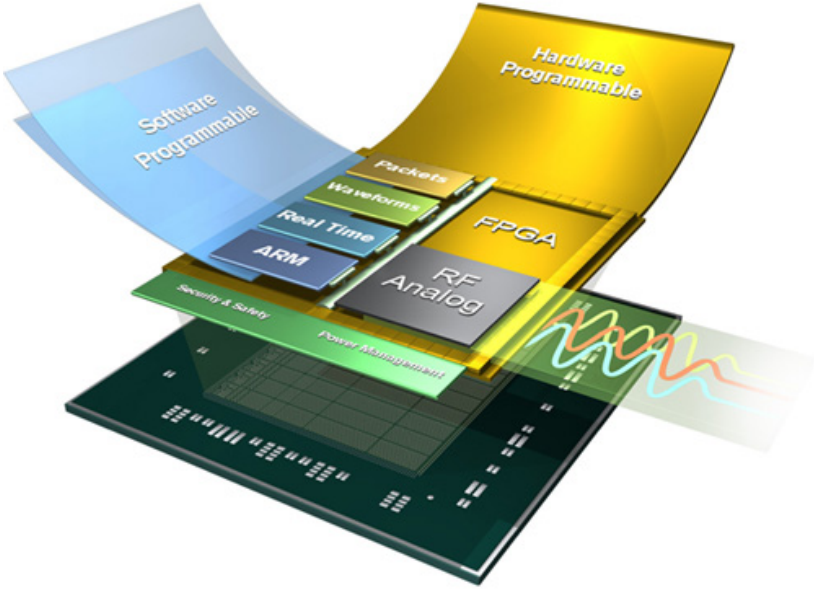
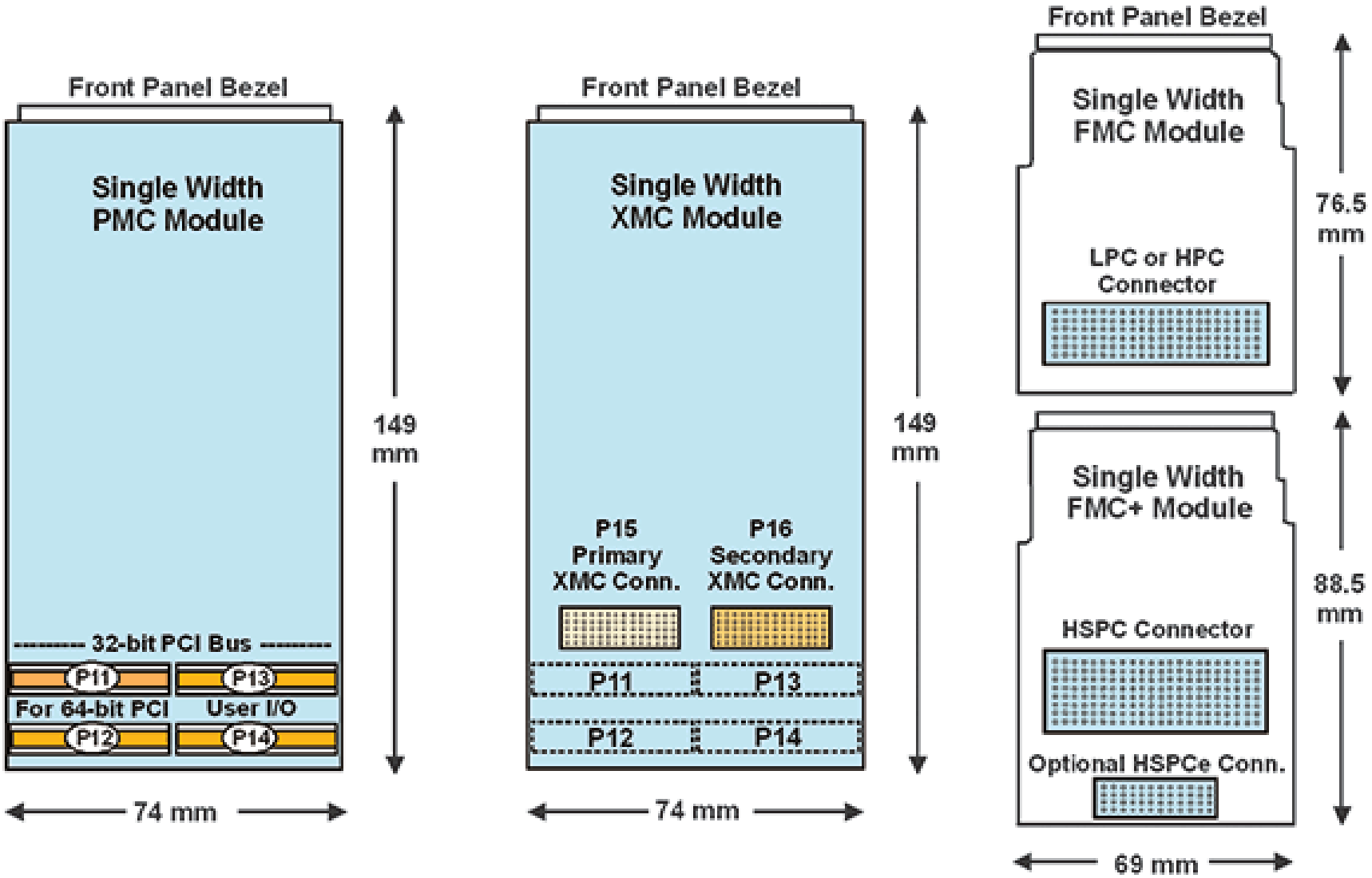
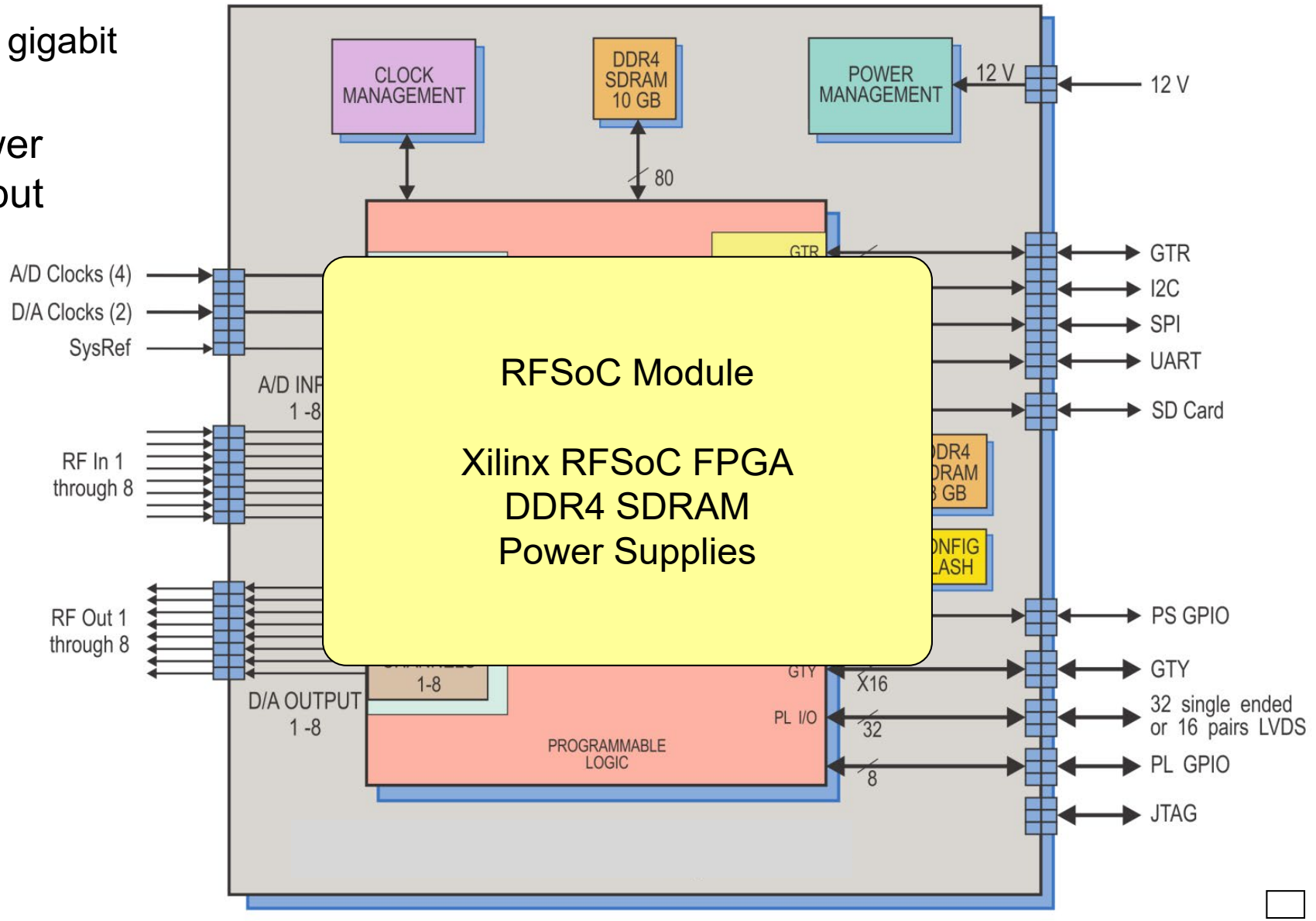


Mezzanine Designs Abound in Embedded Systems



RFSoC Mezzanine Module Concept

- Digital & RF Connectors
  - Preserves integrity of RF and gigabit serial signals
- Generates all 13 RFSoC power supplies from single +12V input
- FLASH for FPGA Configuration code
- DDR4 memories for FPGA & ARM processor
- Maintains PCB constraints for bypassing, filtering, & geometries
- Includes RFSoC clock management
- Health monitoring facilities
- Excellent path for addressing SWaP requirements



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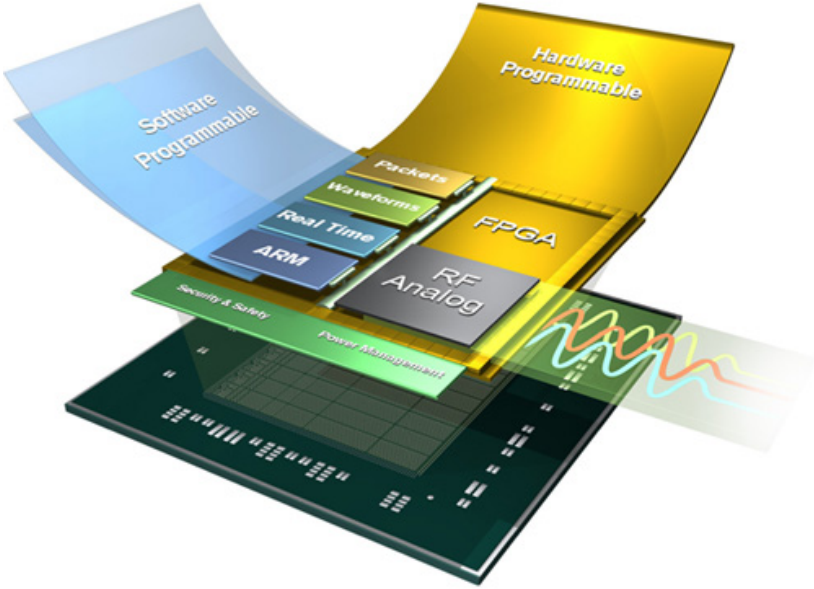


Carrier Example: 3U VPX Platform for RFSoC Mezzanine

- VITA 66.x Optical Backplane VPX I/O
  - Several full- and half-width blind-mate optical connector types
  - Provides high bandwidth data paths between boards and chassis

Photo: Elma

- VITA 67.x Coax Backplane VPX I/O
  - Several multi-position connector types – up to 12 coax signals
  - RF signal bandwidths to 40 GHz
  - Eliminates front panel signal cables

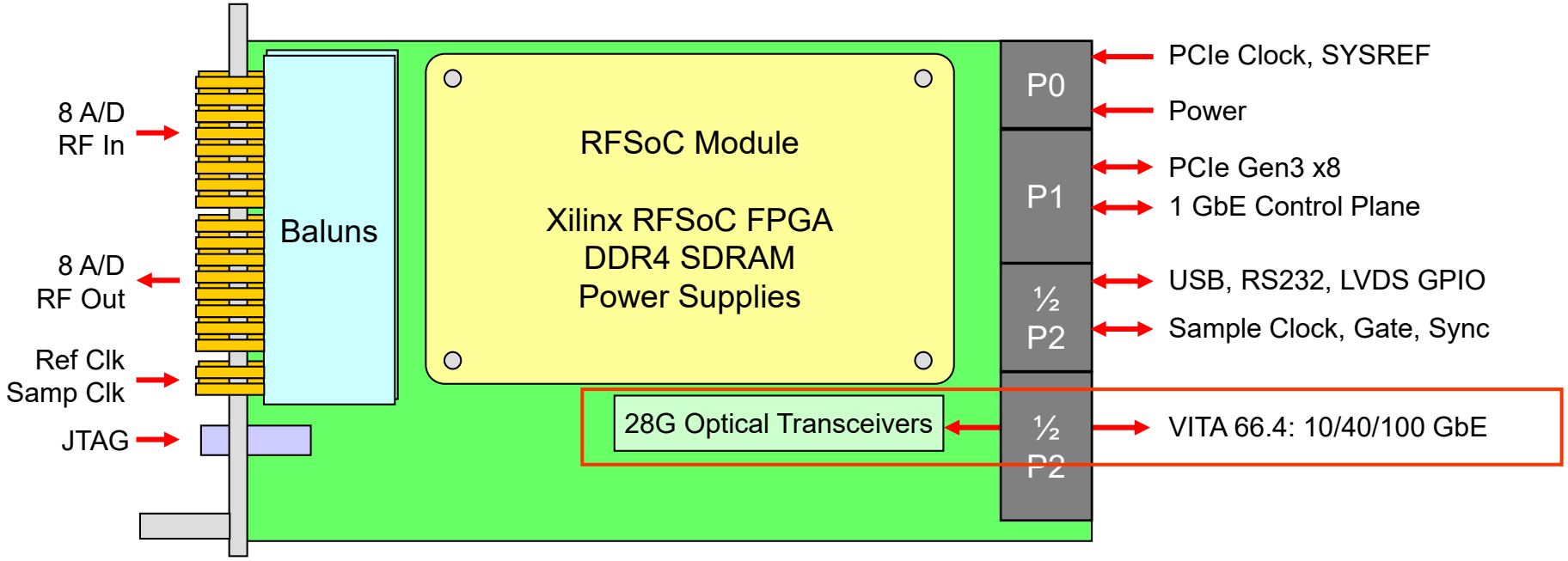
Photo: SV Microwave

- VITA 65.0 & VITA 65.1 OpenVPX - 2017
  - Major enhancements reflect widespread use and adoption of OpenVPX
  - New Card, Slot and Backplane Profiles
  - Radial Backplane Clock distribution ensures precision timing and synchronization across boards
  - Provision for a 100 MHz reference clock
  - New definitions of combinations of VITA 66.x optical and VITA 67.x coaxial backplane I/O

Photo: TE Connectivity

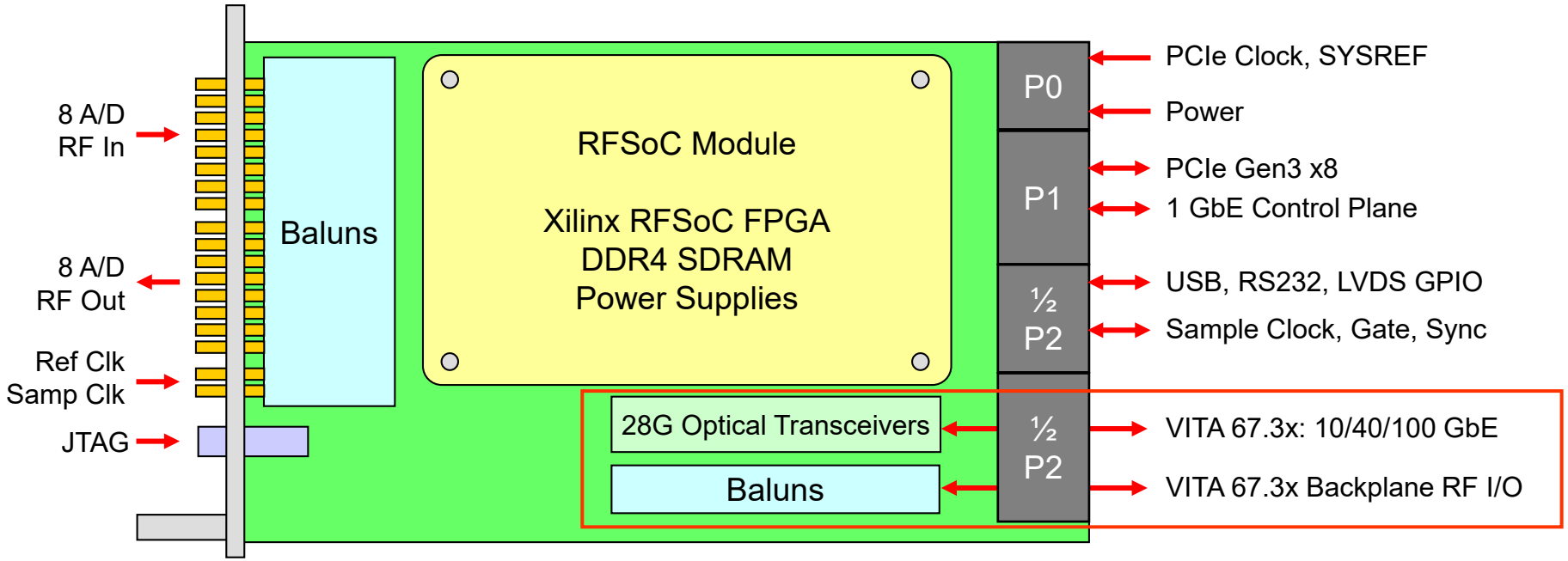
RFSoC Mezzanine Module on 3U VPX – Front Analog I/O

- Open Architecture Form Factor Supporting Industry Standards
  - VITA 65.1 OpenVPX
  - VITA 66.4 Optical Serial Backplane I/O
- Complete functional sub-system on one 3U VPX module
- Scales easily to support high-channel count systems
- Synchronization across multiple modules



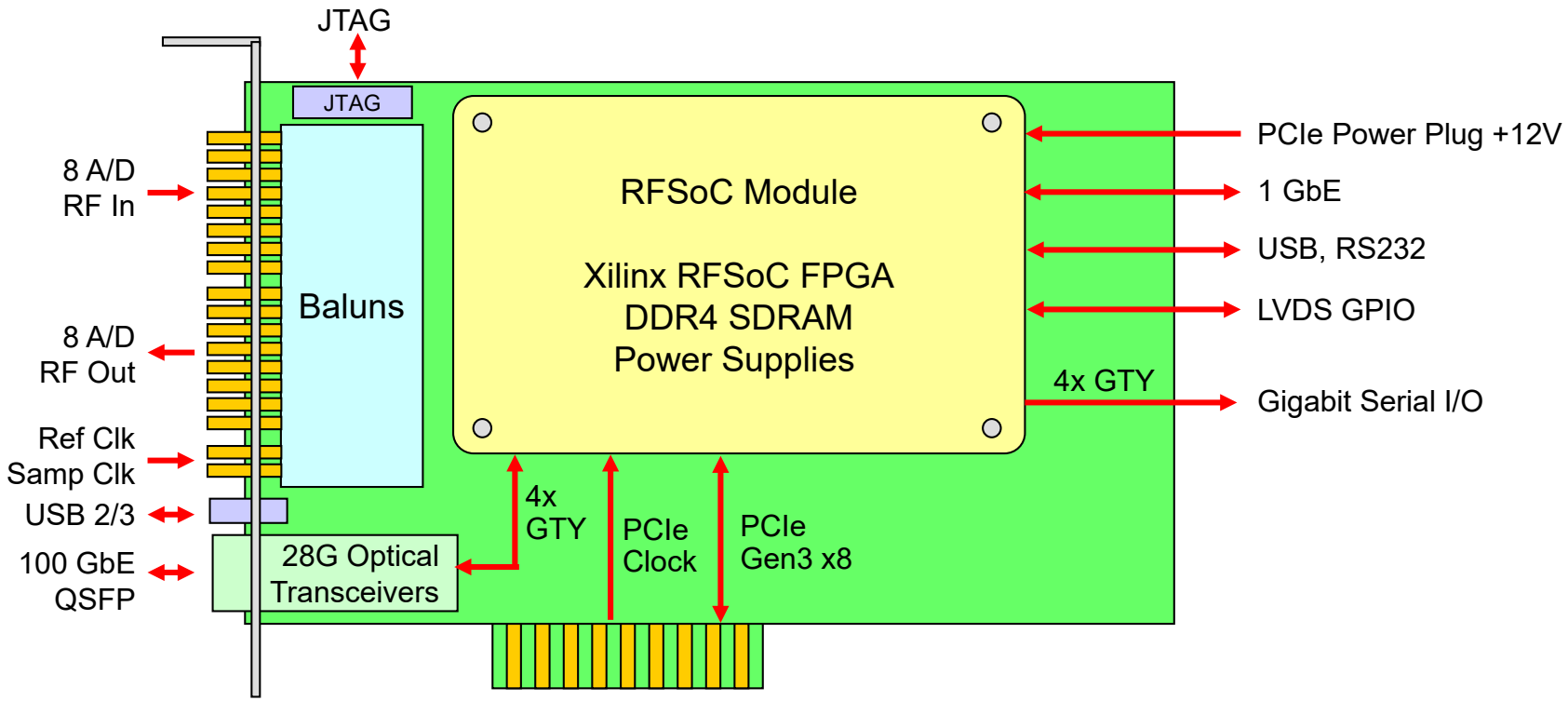
RFSoC Module on 3U VPX – Backplane Analog I/O

- Similar except analog RF I/O connects through backplane
- VITA 67.3 defines several possible RF backplane & optical connector formats
- Simplifies system integration and maintenance tasks
- Improves reliability by eliminating cables



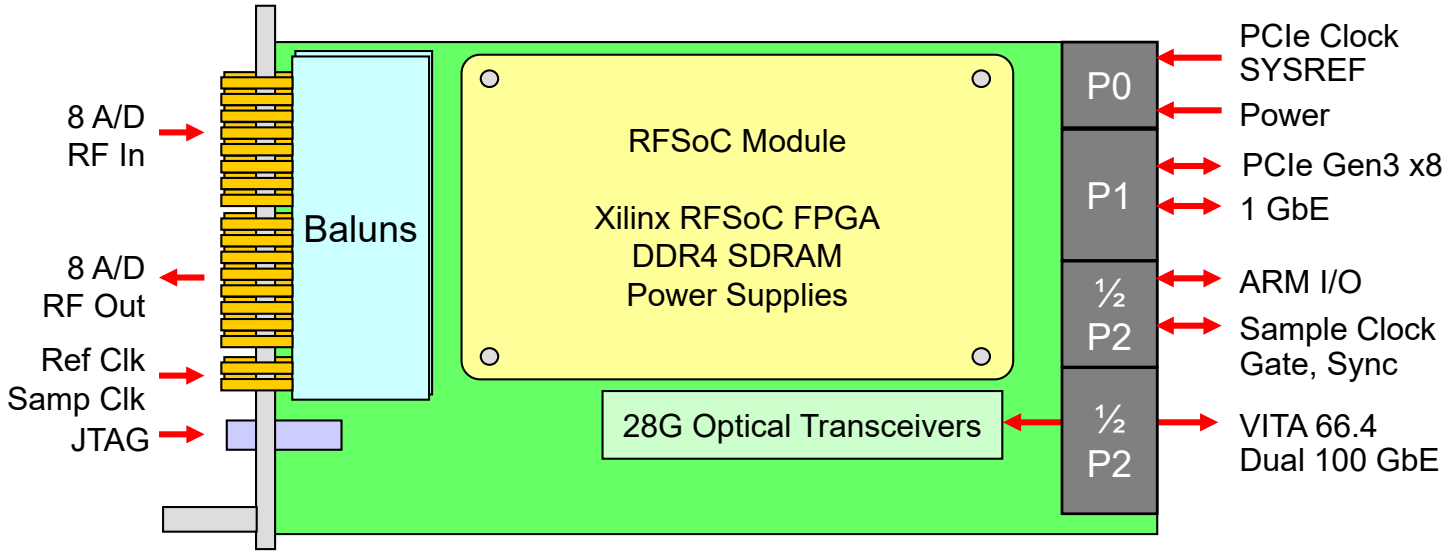
RFSoC Module on PCIe

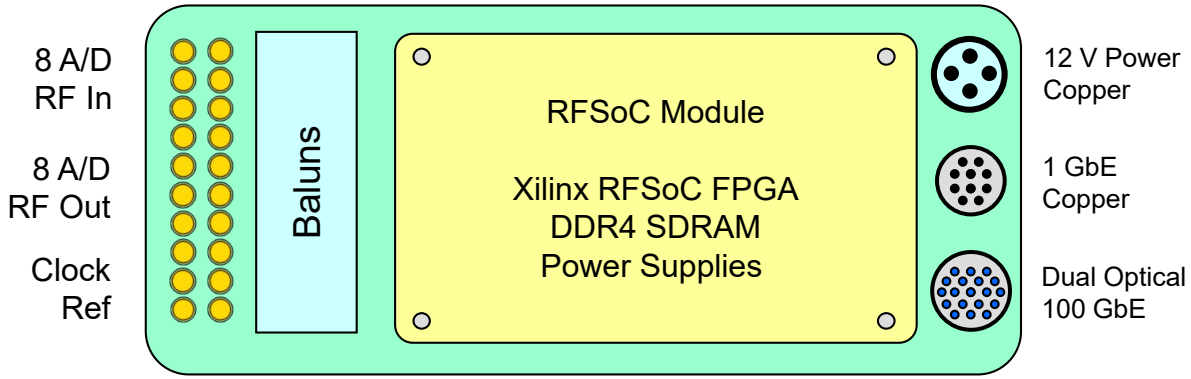
- Allows RFSoC development tasks in a low cost PC platform
- Perfect for software and FGPA development seats
- Perfect for continuation engineering and support
- Supports deployed applications for benign environments



Migrating RFSoC Module to Custom Platforms

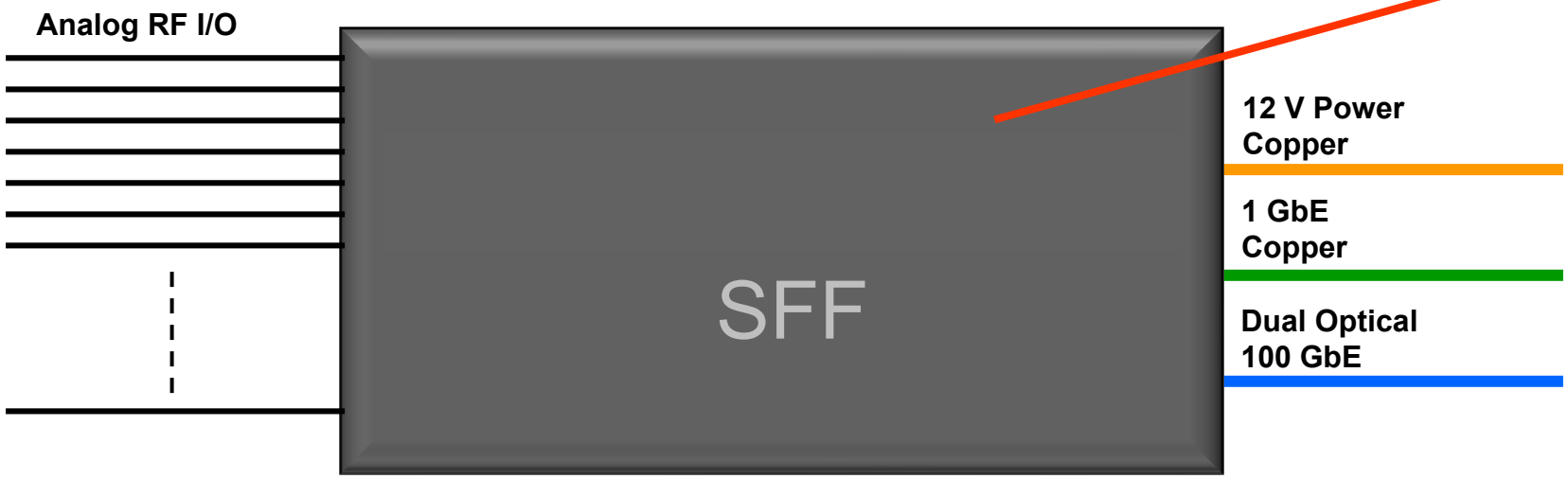
- Development Strategy
  - Start with standard open-architecture product VPX or PCIe
  - Develop software and IP for custom form factor application
- Custom Carrier Design
  - Use RFSoC Carrier Design Package
  - Pin definition, design rules, layout guidance and design review
  - Attach RFSoC Module
- Support and Reference
  - Keep PCIe or VPX development system for support, enhancements, and new designs

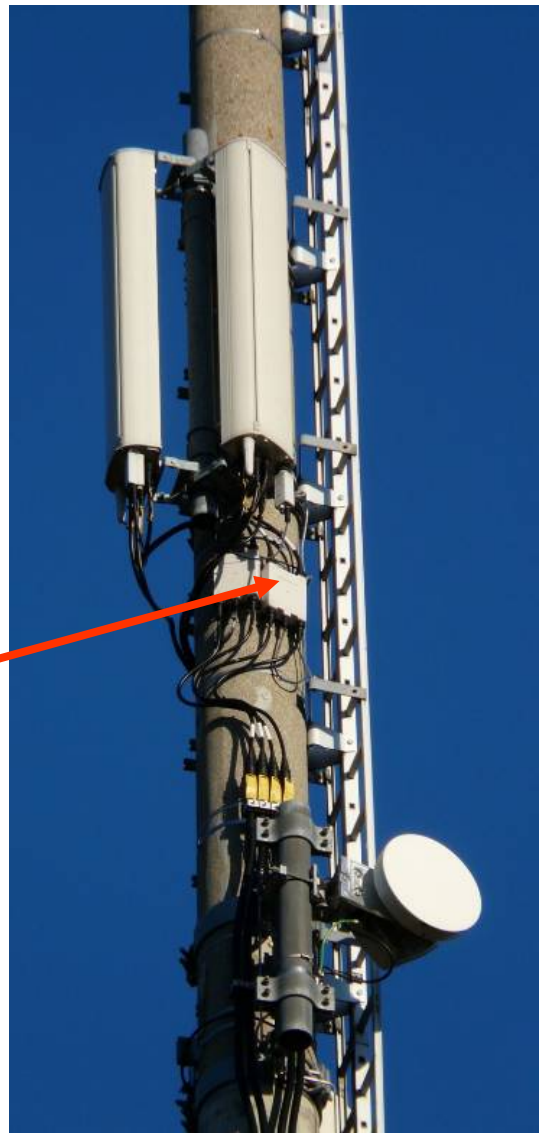




Small Form Factor Remote RFSoC Sub-System

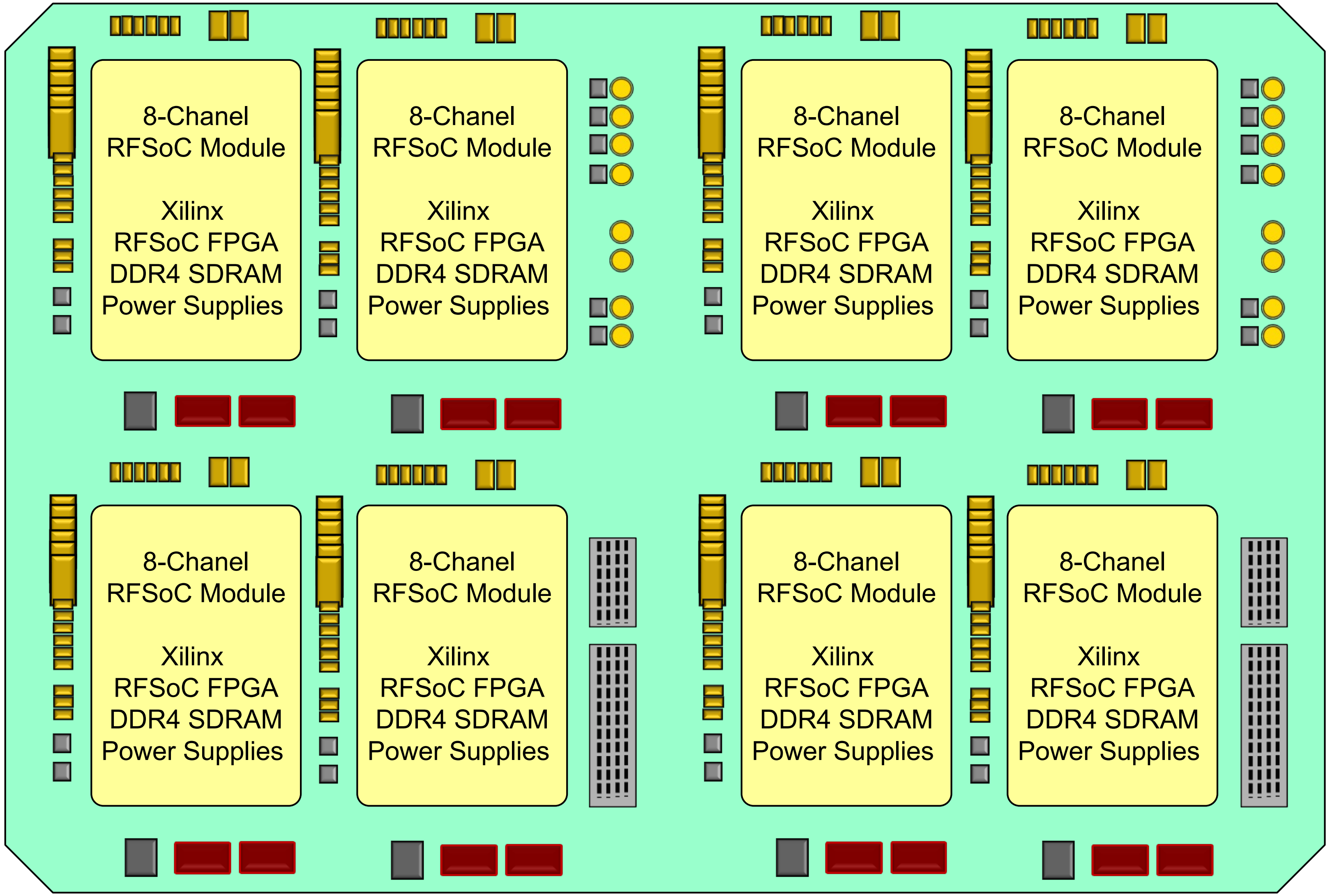
- Install it within a suitable SFF sealed enclosure
- Analog RF I/O over coaxial copper cables
- Wideband Digital RF over dual optical 100 GbE
- Control and Command over 1 GbE copper
- 12V power over copper
- Mount the unit on a mast near the antenna
- Complete 8-channel RF transceiver sub-system





Migration to Complex Phased-Array Antenna Systems

- Custom 64-channel circuit board assembly behind phased-array antenna system



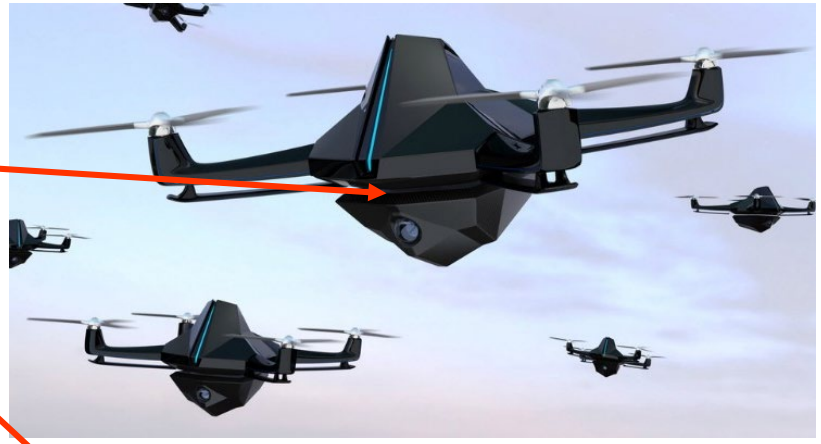
64-Element Phased Array MIMO Antenna
TAOGLAS

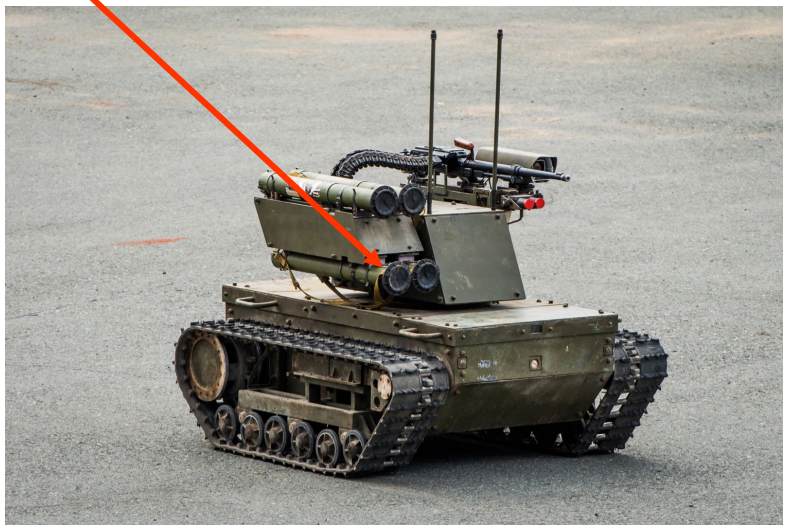
RFSoC Module Enables New Deployment Platforms

- SWaP Optimized RFSoC Module is Ideal for Small Unmanned Vehicles and Weapons

RFSoC Module

Xilinx RFSoC FPGA
DDR4 SDRAM
Power Supplies





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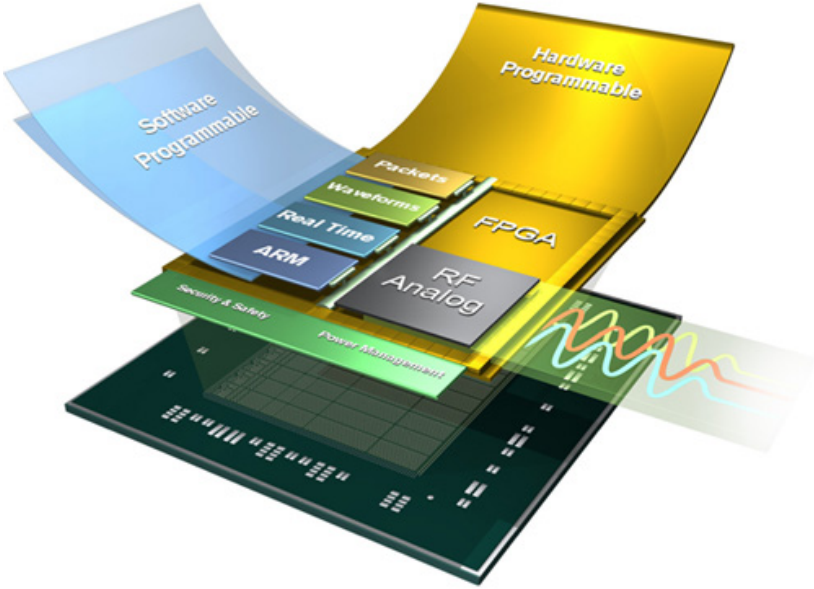
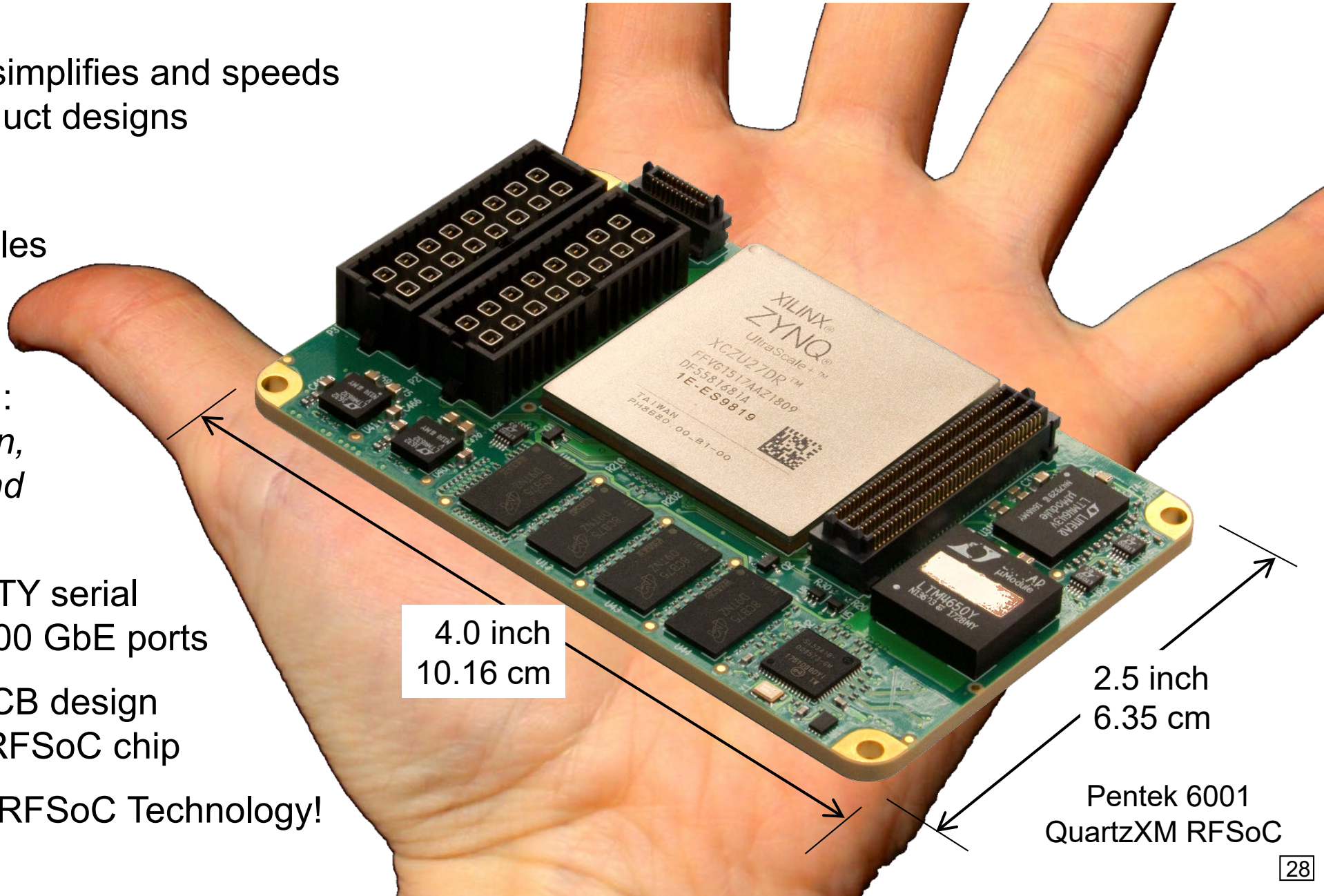


Pentek QuartzXM RFSoC e**X**press **M**odule

- Mezzanine module simplifies and speeds custom RFSoC product designs
- 28 layer PCB
- Over 4000 drilled holes
- Uses advanced PCB fabrication techniques including: *sequential lamination, backdrilling, blind and buried vias, etc.*
- Supports 28Gbps GTY serial interfaces for dual 100 GbE ports
- Eliminates critical PCB design issues required for RFSoC chip
- Speeds adoption of RFSoC Technology!



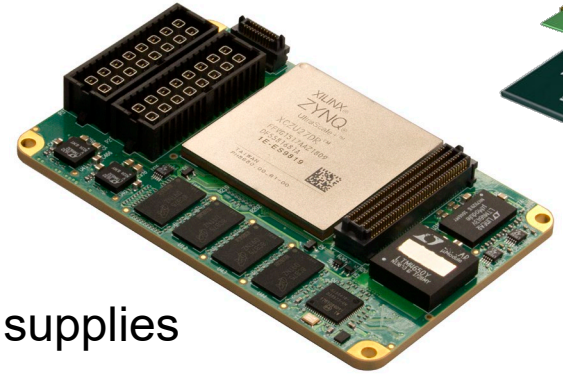
QuartzXM Carrier Design Package

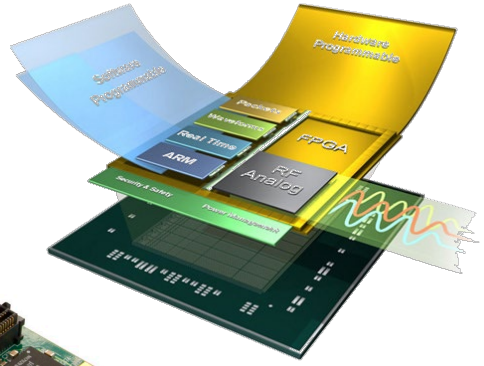
- All documentation needed for a customer to design his own carrier
- Complete design documentation of 3U VPX QuartzXM Carrier
  - 3U VPX carrier product serves as a proven reference design
  - Schematics, PCB artwork, and 3D mechanical models
  - PCB stack-up recommendations
  - PCB design guidelines and routing rules
- Definition and Specifications of QuartzXM module
  - Pin definitions and electrical specifications of all signals
  - 3D mechanical models and thermal profiles
- Operating system and bootstrap guidelines
- Additional electrical and mechanical engineering guidance

Pentek 5950 3U VPX
Quartz RFSoC

RFSoC Development Strategies and Resources

- Xilinx RFSoC Offers Extreme Integration for Mil-Aero Applications
  - A/D, D/A, FPGA, ARM Processor, Flexible I/O
  - Low Latency for wideband RF signals
- Pentek QuartzXM Simplifies System Design
  - Small footprint for high density applications
  - High performance RF and digital connectors
  - Complete RFSoC infrastructure - DDR4, clocks, & power supplies
  - Carrier Design Package for custom deployed form factors
- Xilinx Vivado Tools
  - FPGA development tools
  - ARM processor OS and development tools
- Pentek Navigator FDK and BSP Tools
  - API command processor for ARM
  - Factory installed IP: timing, DMAs, PCIe, dual 100 GbE
  - FPGA IP AXI-4 library functions
  - Starter application examples installed
- Speeds development cycles, saves costs



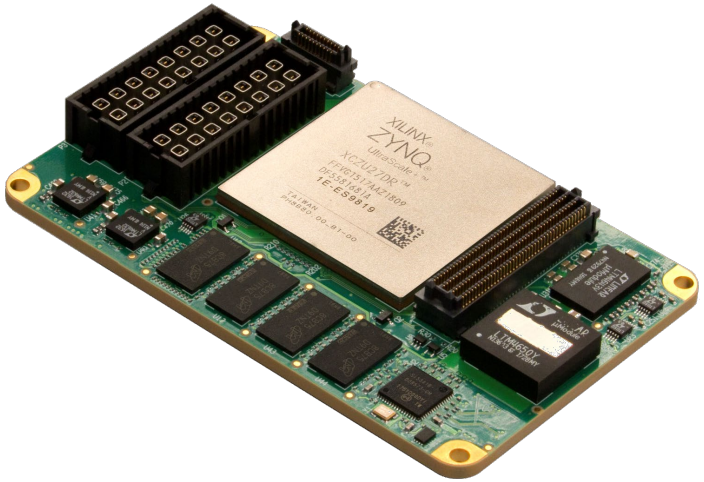


2018 4-STAR BEST IN SHOW AWARDS WINNER

Four star Best in Show Award at the 55th Annual AOC International Symposium

QUARTZ

Thank You!! – Questions??



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