ALPHA DATA

COTS in Space

NASA, AMD, TI, and SpaceVPX Enable an Industry

Embedded Tech Trends
23rd January 2024

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Alpha Data Inc.

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AGENDA

- AMD Radiation Tolerant Parts
- TI Powering Innovation
- NASA Constraining SpaceVPX
- Alpha Data Example ADM-VA601
- Q & A

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AMD Radiation Tolerant Devices for Space 2.0

Long Heritage in Space

- 20 Years ago! Virtex 4QV (90nm) XQRV4QVM

Recent Innovation: XQRKU060

- Shipping in 2020 with RT Kintex UltraScale (20nm)
- 32 transceivers at 12.5 Gbps
- DDR4 memory controllers
- Large DSP and CLB Flip-Flop Resources

Next Generation Performance: Versal

- Power reduction (7nm)
- System on Chip (SOC)
- AI Engines
- 44 transceivers at 26Gbps
- 2.5x more logic resources than KU060

Source: amd.com

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AMD Versal AI Core

Adaptive System-on-Chip

Application Processor

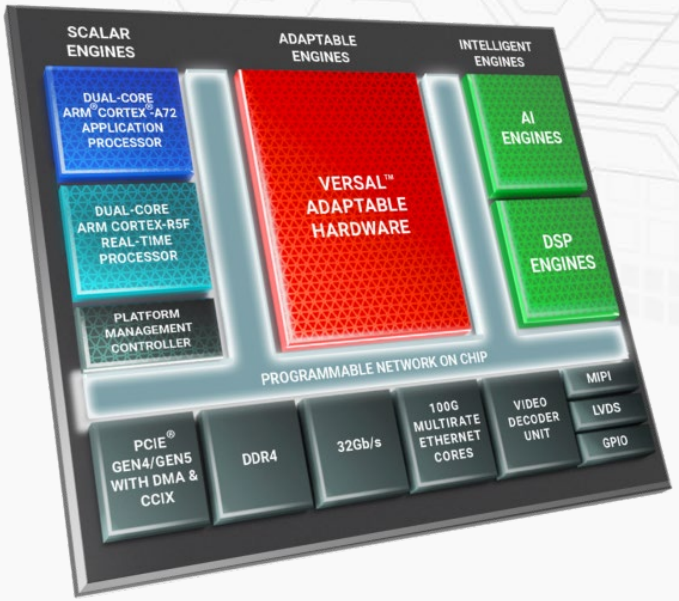
- Dual-core Cortex-A72
- L1 cache and TCM (tightly-coupled memory) include parity + ECC

Real-time Processor

- Dual-core Cortex-R5F with lock-step execution capability
- L1 and L2 cache include parity + ECC

Platform Manager Controller

- Manages configuration and health monitoring
- Runs on triple modular redundant Microblaze processors
- Runs Xilinx Soft Error Mitigation (XilSEM) library for soft error detection and correction



Versal AI Core

Source: amd.com

Adaptable Engines

The Field Programmable Gate Array (FPGA) within Versal

Network-on-Chip (NoC)

- AXI-4 based network of interconnect
- High-bandwidth memory-mapped access to all processing element types

Adaptable Intelligent (AI) Engines

- Array of VLIW SIMD processing tiles with dedicated program and data memory
- Optimized for real-time DSP and machine learning inference
- VC1902 has 400 AI Engine tiles
- VE2302 has 34 AI Engine-ML tiles with native support for INT4 and BFLOAT16

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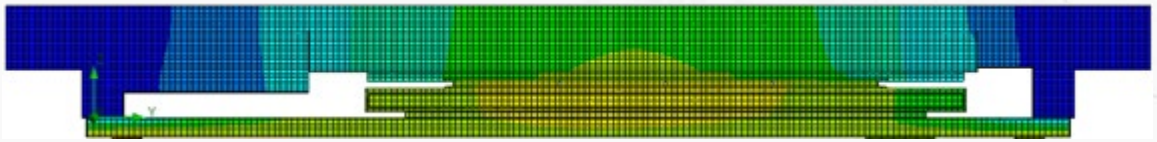
Versal Power

Versal has scalable compute, suitable for application to 100W+.

Versal AI Core 1902

- Applications in the range of 20 to 150W
- Total board power up to **200W!**



Minimum power:

- Static power @25C Junction 4.411W max; 2.363 W typical
- Static power @80C Junction 13.527W max; 7.865 W typical
- PMC dynamic power 0.247W

Estimates using AMD's PDM (Power Design Manager)

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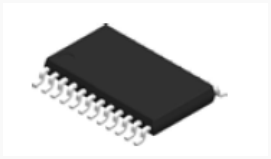
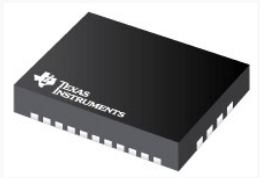
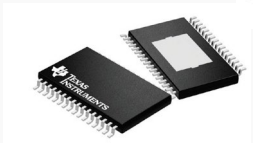
TI Space Power

How to achieve 200W from 12V with Radiation Tolerance?







Source: TI

TI Space Enhanced Plastic (SEP)!

- Smaller footprints, reduced weight, and lower cost than traditional ceramic package
- 30-50krad(Si) and 43Mev-cm^2/mg radiation tolerance
- Traceability and enhanced reliability compared to commercial parts
- Package and options familiar to COTS board vendors like:
  - QFN
  - SOIC/SOT/TSSOP
  - Monolithic DC-DC
- Core voltages at 0.8V requiring 160A!
- Footprint compatible with radiation hardened options (QML Class P)

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TI Parts of Note:

Part Number	Vin	Vout Min	Current	Note	Link
TPS73801-SEP	2.2-20V	1.2V	1A	Linear	https://www.ti.com/product/TPS73801-SEP
TPS7H1111-SEP	2.2-14V	0.4V	1.5A	RF Linear	https://www.ti.com/product/TPS7H1111-SEP
TPS7H3302-SEP	2.4-3.5V	0.8V	3A	DDR Termination Regulator	https://www.ti.com/product/TPS7H3302-SEP
TPS7H4003-SEP	3-7V	0.6V	18A	DC-DC Buck	https://www.ti.com/product/TPS7H4003-SEP
TPS7H4010-SEP	3.5-32V	1V	6A	Monolithic DC-DC Buck	https://www.ti.com/product/TPS7H4010-SEP
TPS7H5005-SEP	4-14V	0.7V	160A	PWM controller	https://www.ti.com/product/TPS7H5005-SEP
TPS7H6003-SP	10-14V	N/A	N/A	200V Half Bridge GaN Driver	https://www.ti.com/product/TPS7H6003-SP

Source: TI

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TI Space products grades

Same radiation levels, same qualification, different package

Rad Tolerant Plastic
TI Space EP
-SEP

Rad Hard Plastic
QML Class P
-SP

Rad Hard Hermetic
QML Class V
-SP

Pin-to-pin compatible, different radiation levels

Packaging	Plastic	Plastic	Ceramic / Metal Can
Mil. Spec	VID	SMD	SMD
Burn- in	No	Yes	Yes
TID Char	**30 – 50 krad(Si)**	**< - - - - - - - - - - 50krad(Si) – 300 krad(Si) - - - - - - - - - - >**	
TID RLAT	**20, 30, or 50 krad(Si)**	**< - - - - - - - - - - Non-RHA, 50, 100, or 300 krad(Si) - - - - - - - - - - >**	
SEL	**43 MeV·cm²/mg**	**< - - - - - - - - - - - - - - ≥ 60 MeV·cm²/mg - - - - - - - - - - - - - - - - - - >**	

Source: TI

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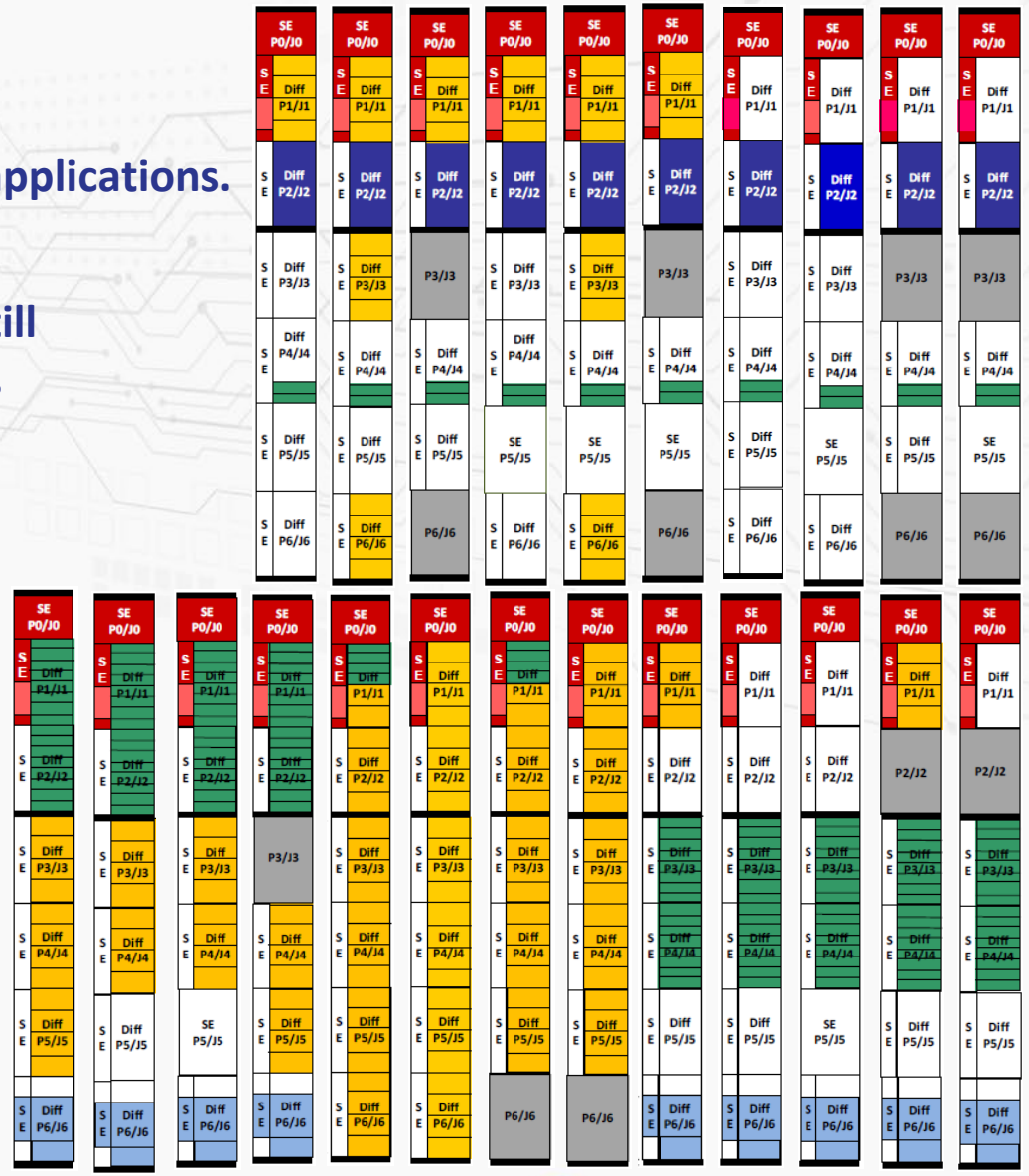
SpaceVPX

VITA 78.0 tailors OpenVPX (VITA 46.0) to Space applications.

SpaceVPX is not as expansive as OpenVPX, but still unmanageable from a board vendor perspective.



6U VPX permutations (>10,000):

Electrical

- 3 Power distribution architectures
- Data Plane: sRIO, SpaceFibre, or Ethernet
- Expansion Plane: sRIO, user defined, or Ethernet
- Control Plane: SpaceWire, SapceFibre, or Ethernet
- Lots of GPIO (no voltage level defined)!
- No PCIe (could be “user defined”)

Mechanical

- Pitch: 0.8”, 1.0”, 1.2”, 1.4”, 1.6”
- Length: 160, 220, 280, or 340mm
- Mixed pitches, lengths, and widths (3U) allowed

Source: Vita

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Consolidation

NASA is leading an effort to reduce the breadth to increase compatibility and re-usability.

Reduce: cost, development times

Increase: hardware ecosystem, re-use, interchangeability

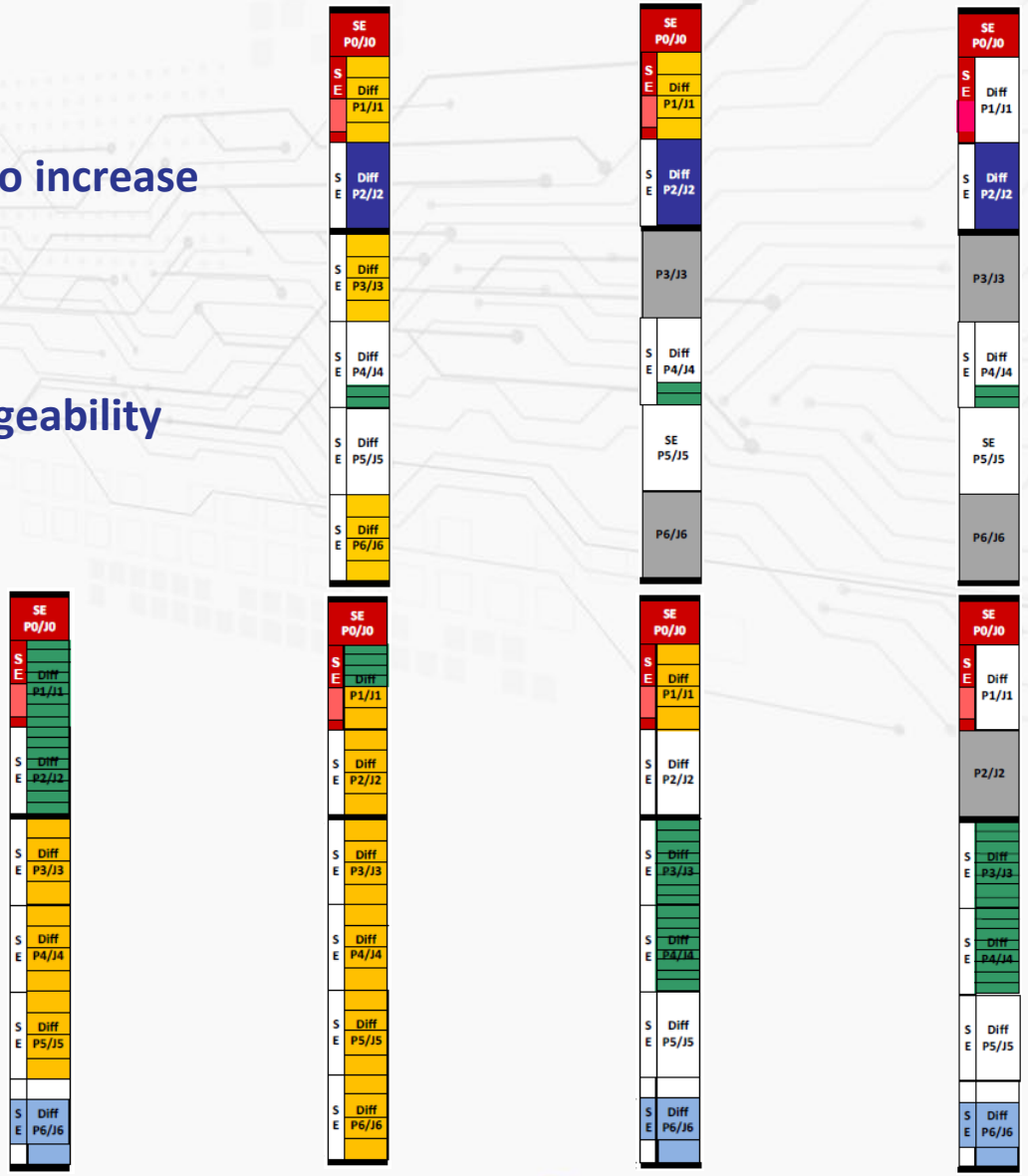
6U VPX permutations:

Electrical (Permutations reduced by **>200x**)

- 1 Power distribution architecture
- Data Plane: Ethernet
- Expansion Plane: PCIE or JESD204C (ADC/DAC)
- Control Plane: SpaceWire
- GPIO (2.5V LVCMOS or 1600mV SERDES)

Mechanical (Permutations reduced by **4x**)

- Pitch: 0.8”, 1.0”, 1.2”, 1.4”, 1.6”
- Length: 220mm
- Mixed 3U/6U allowed



Source: Vita

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Industry Example: ADM-VA601

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ADM-VA601 : Backplane Profile

SpaceVPX Slot Profile: SLT6-PAY-4F1Q2T-10.2.1

Module Length: 220mm

Pitch: 1.0”

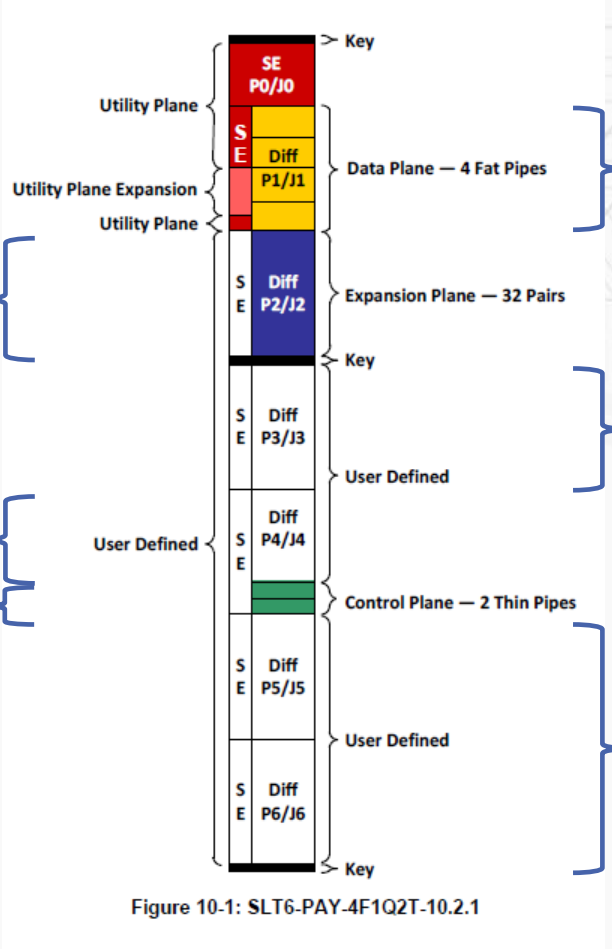

Figure 10-1: SLT6-PAY-4F1Q2T-10.2.1

P1

4x Fat Pipe connections

GTY 103 – 106

2x PCIE Endpoints

Ethernet with soft MAC

P2 PCIe or JESD204C

1x Fat Pipe connection (GTY 206)

other Fat Pipes unconnected

8x Single-Ended GPIO

P3

Ethernet (10/100/1000BASE-T)

1x UART, 2x CAN

32x GPIO (from PL)

3.3V GPIO accepts 2V in

P4

SelectMAP Interface to RTM

(usable as other PS interfaces)

2x SpaceWire

P5 & P6

Not used, not fitted

Potential NASA Optimizations:

- Data Plane re-aligned for MRMAC
- GPIO changed to 2.5V native

Source: ANSI/VITA 78.0.2022

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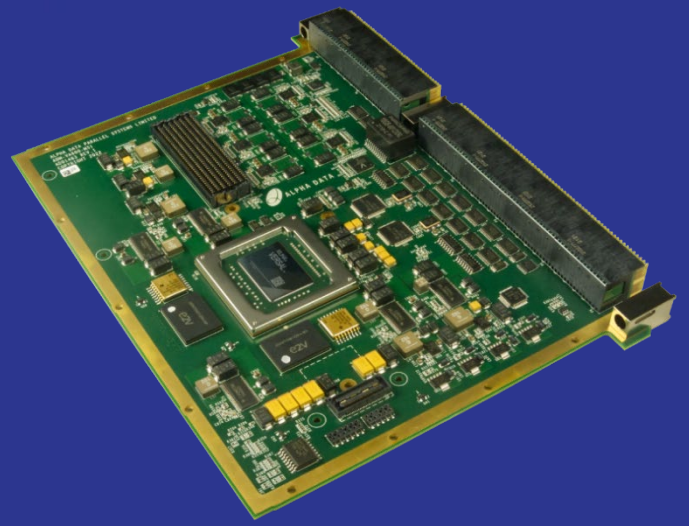
ADM-VA601

Versal AI Core Radiation Tolerant Reference Design & Development Kit for Space 2.0

SoC:	**AMD Versal AI Core XCVC1902-1MSI**
Front IO:	**FMC+** (GPIO + 24 GT lanes)
Rear IO:	(VPX) PCIE, 10GigE, SpW, CAN, SelectMAP
Power:	Fully Radiation-tolerant Power Solution from Texas Instruments
DRAM:	Rad-tolerant DDR4 memory 2x 8GB (1G x 72) from Teledyne e2v 34GB/s peak B/W
Config:	2Gb QSPI on daughtercard Config options available
SWaP:	Size: 233 x 220mm (6U) Mass: 600g (PCB) / 1,500g (w/AC heatsink) Power: ~25W to 200W (design dependent)
Radiation:	TID: xxx Krads, SEL: xxx MeV-cm^2/mg



Developed in Partnership with

AMD

Texas Instruments

TELEDYNE e2v
Everywhereyoulook™

Availability: Q1'2024

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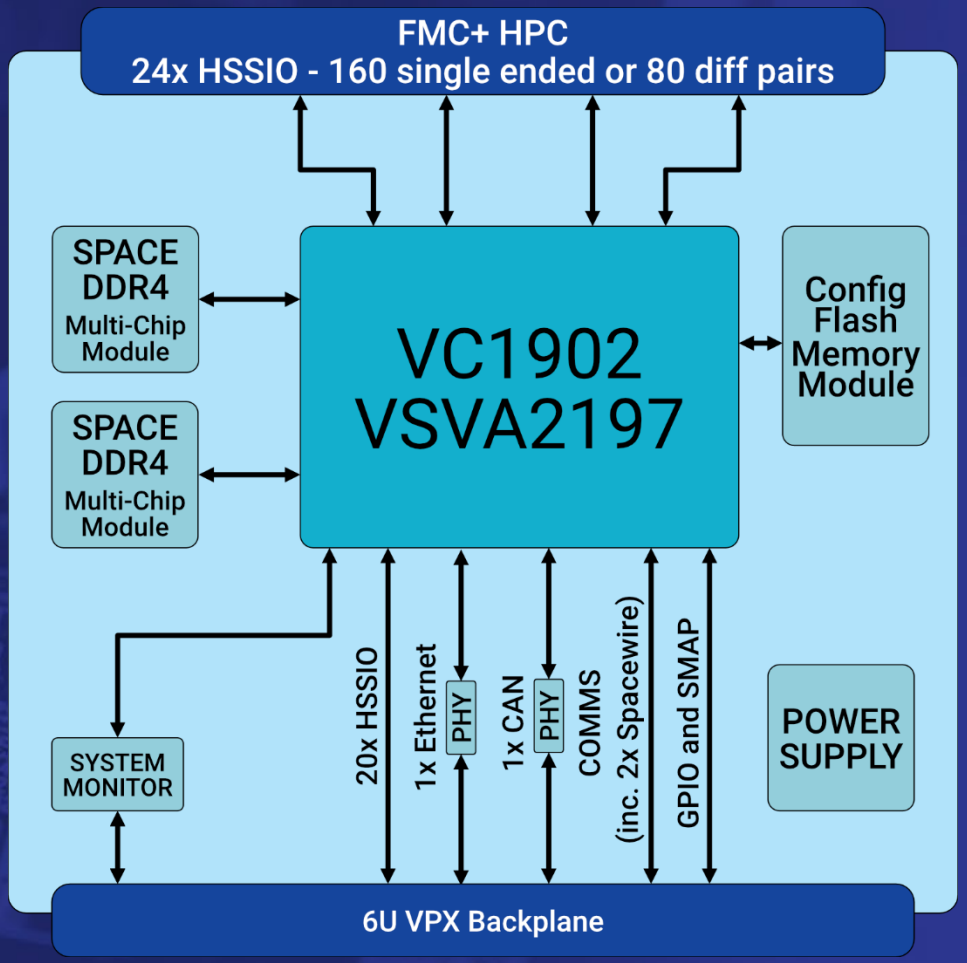
ADM-VA601



SOC:	**AMD Versal AI Core XCVC1902-1MSI**
Front IO:	**FMC+** (GPIO + 24 GT lanes)
Rear IO:	(VPX) PCIE, 10GigE, SpW, CAN, SMAP
Power:	Rad-tolerant Power Solution from Texas Instruments
DRAM:	Rad-tolerant DDR4 memory 2x 8GB (1G x 72) from Teledyne e2v
Config:	2Gb QSPI on daughtercard Config options available
Other:	Space SysMon from Texas Instruments RTM for IO Breakout & custom scrubbing Ref Designs & Schematic

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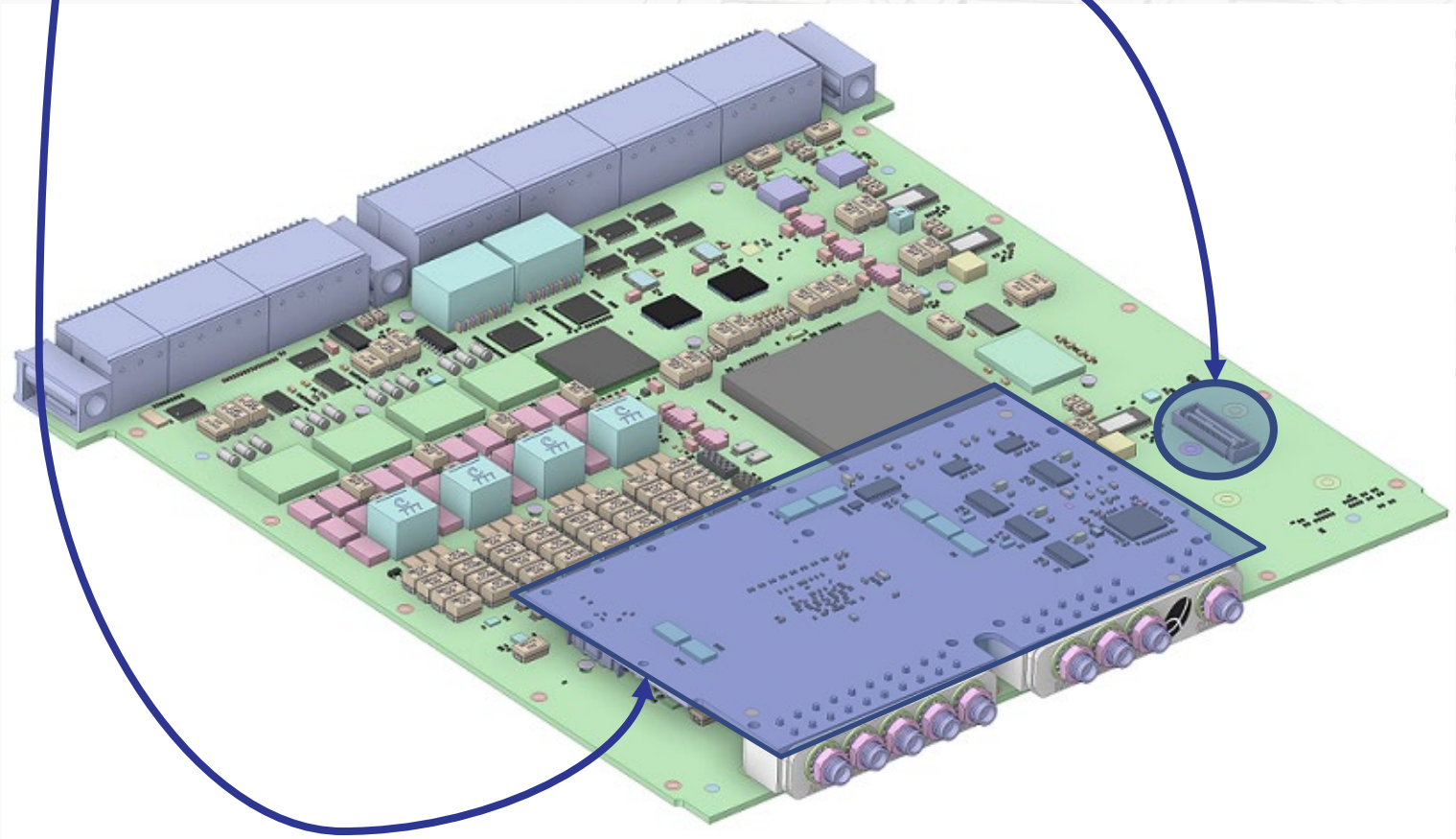
ADM-VA601 : Daughtercard Example

Standard Baseboard with dual width FMC

Customizable Boot PROM expansion



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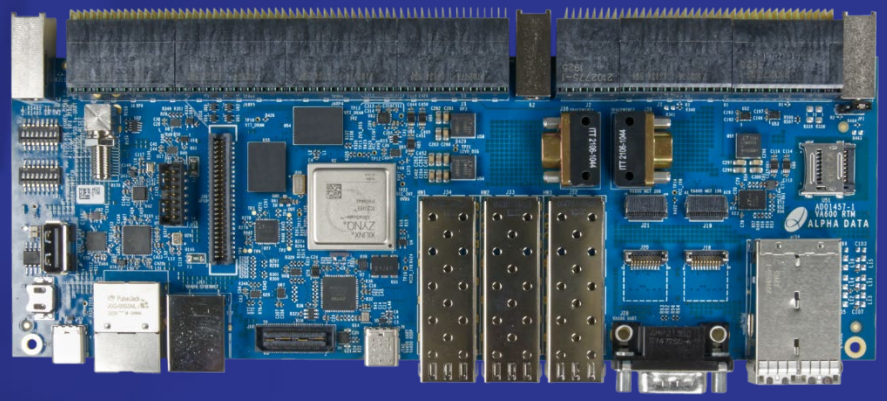
ADM-VA601-RTM



6U VPX Development Rear Transition Module

Provides IO connections and debug connectivity for lab development and other ground-based testing

High Speed Serial Breakout connections

Low Speed IO connectors

Commercial Grade Debug Controller (ZU4EG MPSoC)

SelectMap control of VA600 Versal configuration, can emulate CPU, FPGA configuration solution or provide pass through access from external connector

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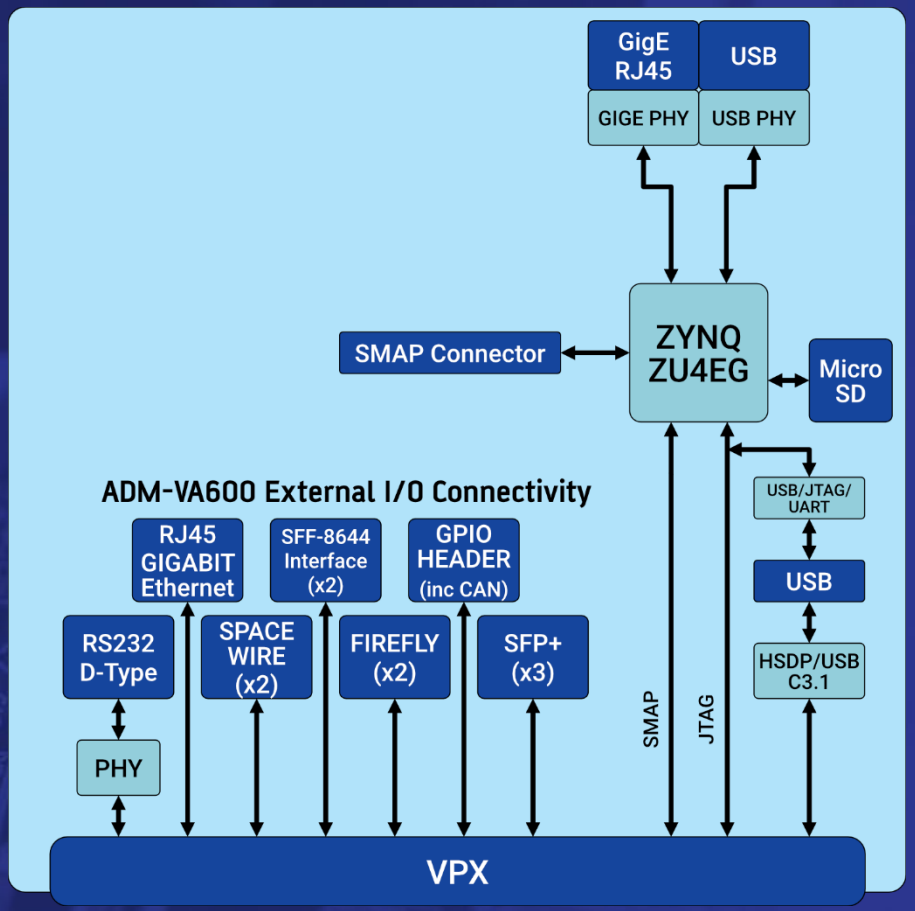
ADM-VA601-RTM



Breaks out ADM-VA601 VPX connections

8 GTY lanes on SFF-8644
can connect to PCIe or 10/25G Ethernet

8 GTY lanes on Firefly

3 GTY lanes on SFP+

1 GTY lane for Debug on USBC / HSDP

RJ45 for VA600 Ethernet PHY

D-Type RS232 for Versal UART Comms

Space Wire, CAN bus and GPIO connections

JTAG debug access

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Next Steps

Standards Adoptions

- Simplify and narrow SpaceVPX specs

ADM-VA601/FLIGHT

- Reliability analysis
- Radiation tests and qualification

Small Form Factor (SFF)

- Versal AI Edge XQRVE2302 (4W to 25W)
- SpaceVPX Light (ANSI VITA 78.1) and SpaceVNX+?

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DESIGN • DEVELOP • DEPLOY

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30 Years of Innovation

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