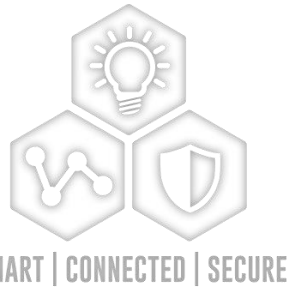
Microchip Automotive PCIe® Solutions – A PCIe Gen 3 Network Bridging and Fanout Family, and a 16-32 Lane PCIe Gen 4 Switch for Embedded Application

A Leading Provider of Smart, Connected and Secure Embedded Control Solutions



Brandon Kim, Senior Embedded Solutions Engineer

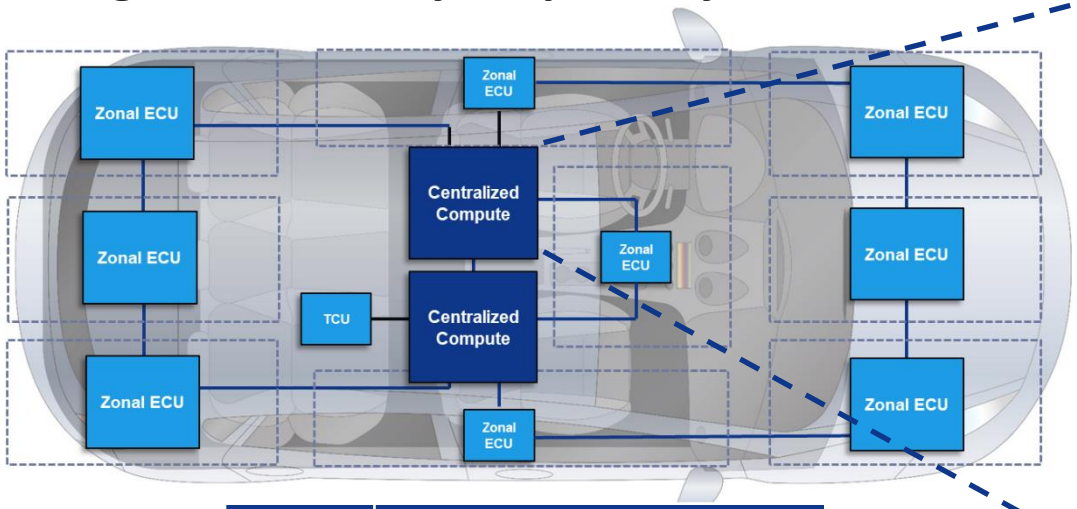
June 27, 2023

Agenda

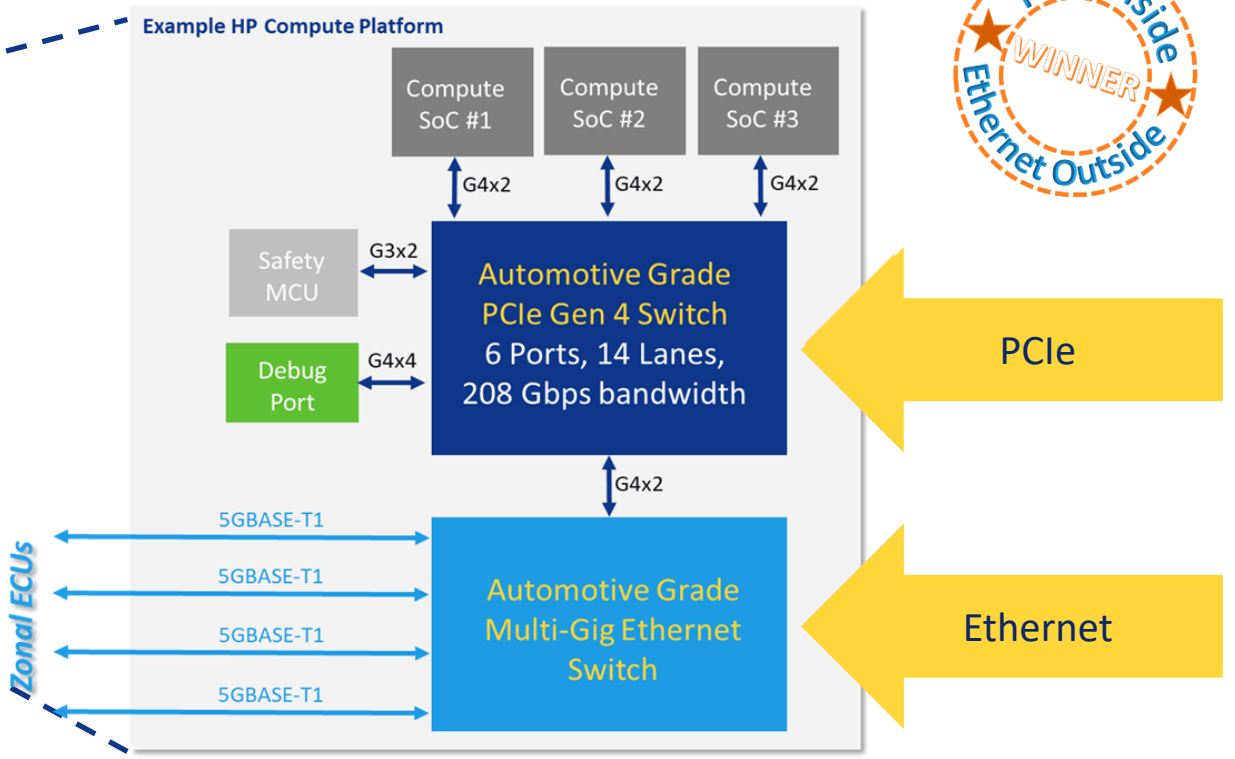
- PCIe® in Automotive
- Roadmap
- Advanced PCIe Switches
- Optimized PCIe Switching for ADAS
- PCIe Bridging
- Q&A

HPC & ADAS Drive need for PCIe switching

- **Zonal ECUs with Compute**
- **Big Data: Terabytes per day!**



BW	L3 Sensor / Camera
8Gbps	Front, Side, Rear, Blind
4Gbps	Surround
1-2Gbps	LiDAR, Driver CAM, eMirror, Radar



PCIe Inside WINNER Ethernet Outside

- **Zonal ECUs: 10Mbps to 10+Gbps Ethernet in-vehicle network**
- **Central Compute: >>100Gbps inter-processor PCIe switching**

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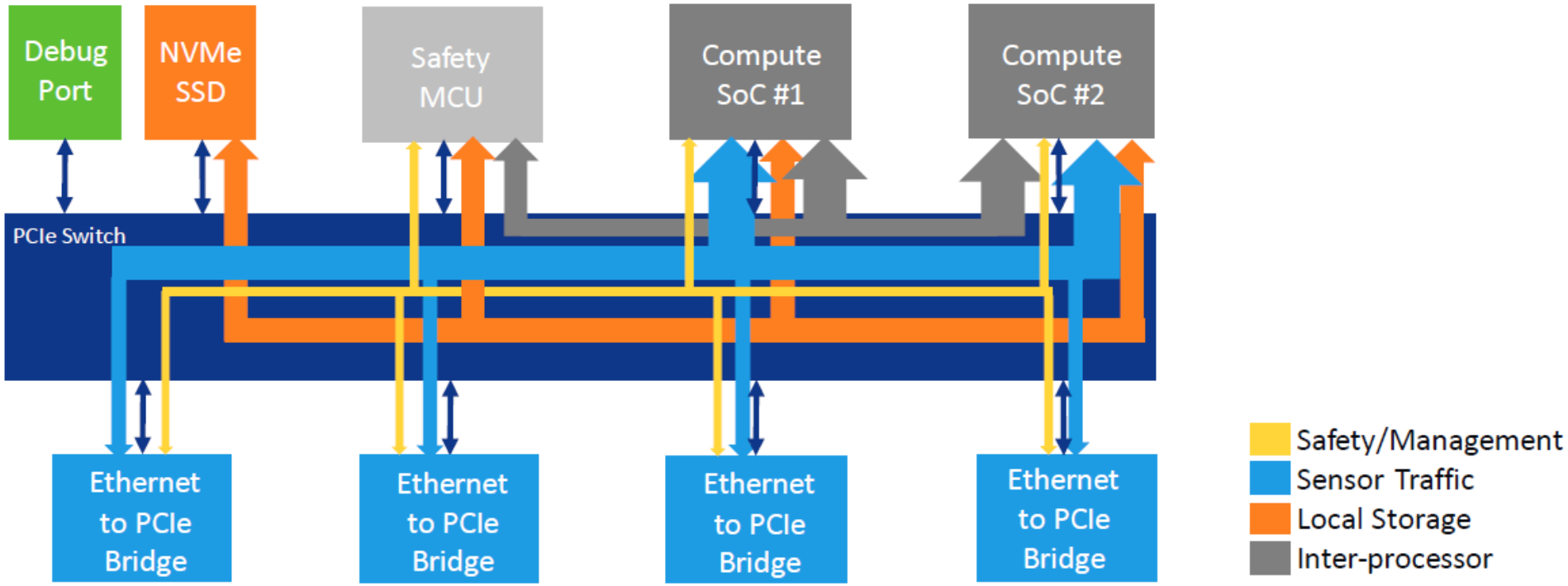
PCIe® for Inter-processor Connectivity

PCIe® features of VSP, NTB, MC enable a flexible, modular, secure communication interconnect within a centralized compute platform



Modern PCIe switches enable complex data path routing configurations

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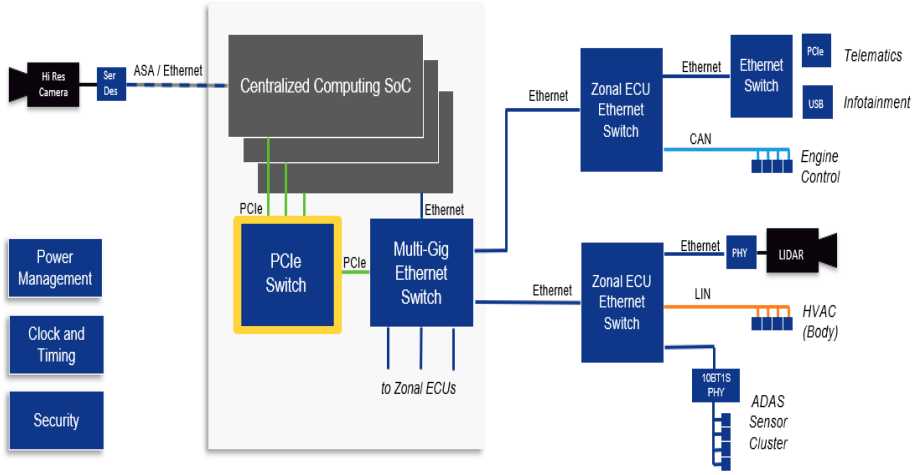
Innovation in scalable HPC PCIe® Solutions

Microchip Solutions

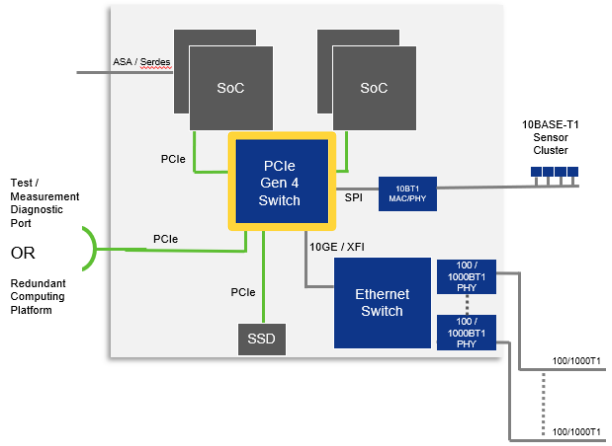
Advanced, Scalable L4-L5 ADAS



Trident/Harpoon: ***28 – 52 PCIe lanes Gen 4/5***

In Production

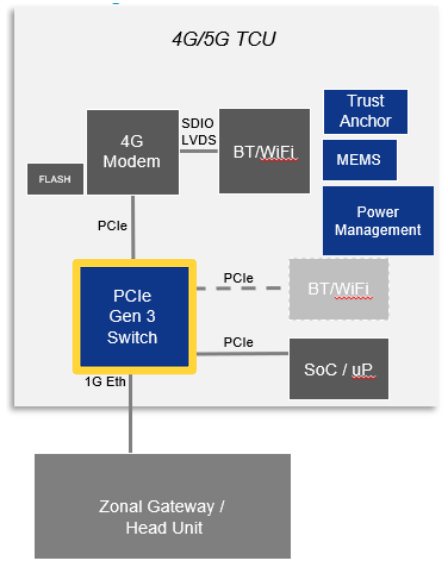
L2-L3 ADAS / Zonal Gateway



Stamford: ***16 PCIe lanes Gen 4***

Samples Q1'2024

Telematics / Zonal Gateway



Bridgeport: ***3-6 PCIe lanes Gen 3***

Samples now

Optimization for Automotive: size, power and cost reduction

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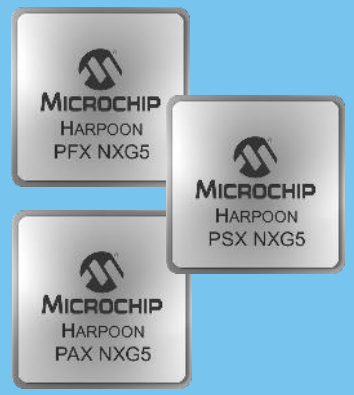
PCIe Roadmap – Switches & Expanders

Production	2022	2023	2024+

Switchtec™ Gen3 PCIe® Switches

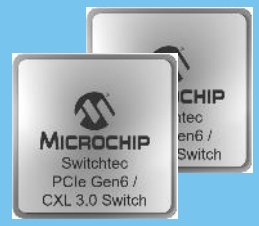
- 8 GT/s
- 24 to 96 lanes
- Up to 48 NTBs
- Fanout, Programmable and Industrial Temp PCIe switches

Switchtec Gen5 PCIe Switches



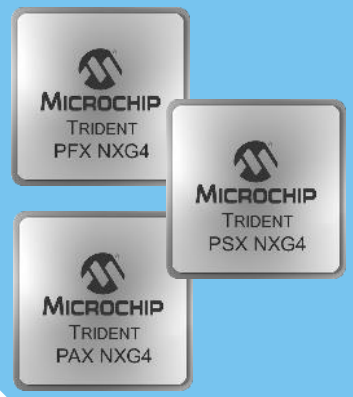
- 32 GT/s
- 28 to 100 lanes
- DMA
- Secure Boot
- Fanout, Programmable and Adv. Fabric PCIe switches

Switchtec PCIe Gen6 / CXL3.0 Switches



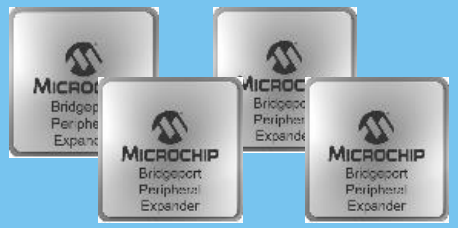
- PCIe Gen6 / CXL3.0 (Concept)

Switchtec Gen4 PCIe Switches



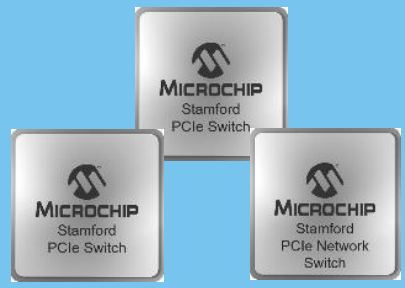
- 16 GT/s
- 28 to 100 lanes
- DMA
- Secure Boot
- Fanout, Programmable and Adv. Fabric PCIe switches
- Auto-qualified switches (3Q21)

Bridgeport PCIe Gen3 Peripheral Expanders



- USB2/USB3
- 2.5G Ethernet
- PCIe passthrough
- Auto-qualified

Stamford Gen4 PCIe Switches



- 16 GT/s
- 12 to 32 lanes
- NTB support
- Auto Functional Safety, ASIL-B

PCIe® Gen4 Switch Product Variants

PFX

PFX Gen4 Fanout PCIe Switch

- PCIe Gen4 Switch Scalable up to 52 ports, 48 NTBs, 26 virtual switches
- 110ns Pin-to-pin Latency
- Error Containment (Hot- and Surprise-Plug)
- Advanced Diagnostics and Debug
- End-to-end Data Integrity
- High-performance Cut-through DMA
- Secure boot

PSX

PSX Gen4 Programmable PCIe Switch

- Superset of Gen4 PFX
- SDK enables customization and differentiated solutions
- Enterprise- class, field-proven, enclosure management processor
- NVMe-MI support

PAX

PAX Gen4 Advanced Fabric PCIe Switch

- PCIe and GPGPU Fabric support
- Multi-host SR-IOV Sharing support
- High-performance Cut-through DMA and Fabric DMA
- PAX SDK enables customization and differentiated solutions

PCI

PCI Gen4 Fanout PCIe Switch

- Subset of Trident PFX Gen4 features
- PCIe Gen4 Switch Scalable up to 32 lanes, 15 ports, 15 NTBs
- Scalable to and from Trident PFX Gen4 family

Pin-compatible across 100-, 84-, 68-lane, across 52- 36-, and 28-lane switches, and across product families PFX, PSX and PAX

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Advanced PCIe® Switches

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PFX Gen4 Automotive PCIe® Switches

High-Reliability, Flexible PCIe Switches

Key Features

- **PCIe Gen4 Fanout Switches**
  - 52-lane/28-port, 36-lane/20-port, 28-lane/16-port
  - Flexible port bifurcation: x1*, x2, x4, x8, x16; Upstream/Downstream/NTB
- **Clocking**
  - SRIS support, up to 6 Host REFCLK inputs, 7 REFCLK outputs
  - SRNS, Common clocking with or without SSC, and SRIS clocking modes, SSC Clock Skewing
- **Error containment, DPC, CTS, Hot-Plug, Surprise-Plug Support**
- **PCIe Multicast, multiple overlays per port**
- **Diagnostics/Debug – physical to TLP layer**
- **Secure boot image authentication**
- **Peripheral Interfaces**
  - Up to 11 TWI, 2 SPI, 4 UARTs, 4 SGPIO, 103 GPIO
- **High Performance Cut-through DMA engines**
  - 175+ GB/s throughput, 64 DMA channels

- 52-, 36- and 28-lane Gen4 PCIe Switches
- Footprint compatible
- 29mm x 29mm

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PFX/PAX Gen5 Automotive PCIe® Switches

High-Reliability, Low Latency PCIe Switches

Key Features

- **PCIe Gen5 fanout switches**
  - 52-, 36-, and 28-lane PCIe switches
  - Flexible port bifurcation: x1*, x2, x4, x8, x16; Upstream/Downstream/NTB
- **Clocking**
  - SRIS, SRNS, Common clocking with SSC, SRIS clocking modes, SSC Clock Skewing
  - Up to 6 Host REFCLK inputs, 7 REFCLK outputs
- **Error containment, DPC, CTS, Hot-Plug, Surprise-Plug Support**
- **PCIe Multicast, multiple overlays per port**
- **Diagnostics/Debug – Physical to TLP layer**
- **Secure boot image authentication**
- **Peripheral Interfaces**
  - TWI, SPI, UARTs, 4 SGPIO, GPIO
- **High performance cut-through DMA engines**
  - 120GB/sec for 4KB transfer size and 175 GB/sec for 1MB transfer size, 100 DMA channels
- **Additional new feature for Gen5**
  - Flattening Portal Bridge (FPB) (Rev B)
  - Precision Time Measurement (PTM) (Rev B)
  - Automatic port bifurcation (Rev B)

PAX: advanced fabric PCIe switch

- Multi-host SR-IOV sharing
- PCIe Fabric Support
- Fabric DMA

* x1 natively on four lanes

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Stamford PCIe® Switch Gen4 Product Family

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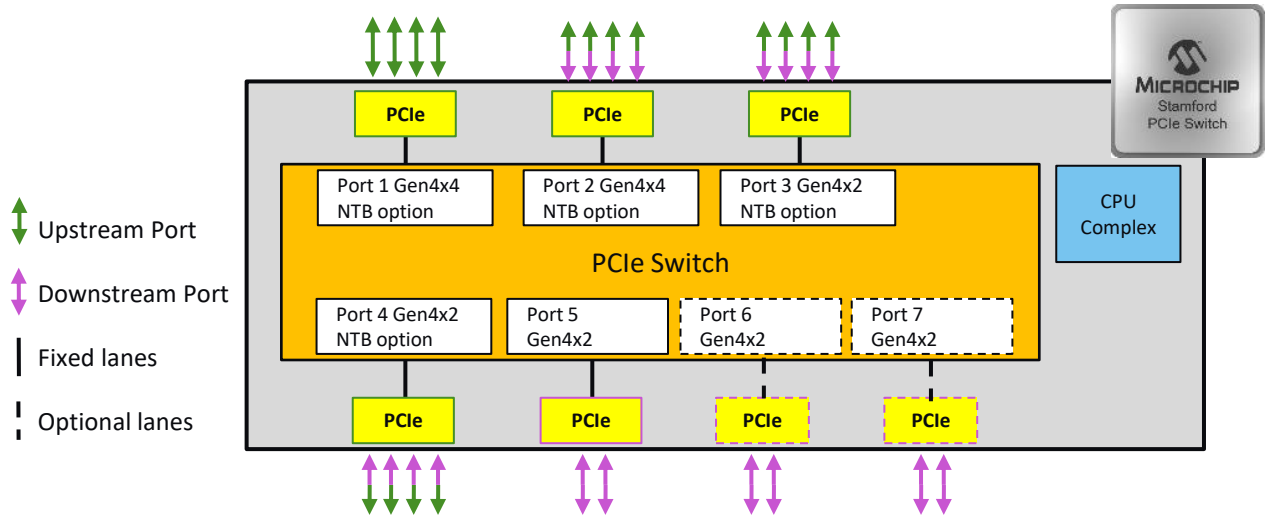
Stamford PCIe® Gen4 Switch

With non-transparent bridging

- **16-lane PCIe Gen4 Switch**
  - Bifurcation x2, x4
  - Up to 8 ports, pre-configured per table
- **NTB Functionality on UFPs**
- **Cross-link port for 2x switches**
- **Fast data transfers: Peer-Peer / DMA**
- **Secure boot & secure firmware update**
- **ChipLink diagnostic and debug tool suite**
- **Automotive grade 2 (-40°C to +105°C)**
- **Functional safety, ASIL-B Compliant**
- **Package 16 x 16 324-FCBGA**
- **Pre-silicon emulation using Trident Evaluation Kit**
  - Shared switch core, software
  - Reduced size, feature, cost
- **Status: Development. Samples April 2024**



Stamford configuration options

Part number	UFP Config	DFP Config	NTBs	Lanes	Ports
PCI1002 5-port 4-NTB PCIe Gen4x12 Switch	1x4 + 3x2	1x2	4	12	5
PCI1003 6-port 4-NTB PCIe Gen4x16 Switch	2x4 + 2x2	2x2	4	16	6
PCI1004 4-port 4-NTB PCIe Gen4x16 Switch	4x4	0	4	16	4
PCI1001 4-port PCIe Gen4x16 Fanout Switch	1x4	3x4	0	16	4
PCI1005 7-port PCIe Gen4x16 Fanout Switch	1x4	6x2	0	16	7

Proven IP, low risk, faster time-to-market

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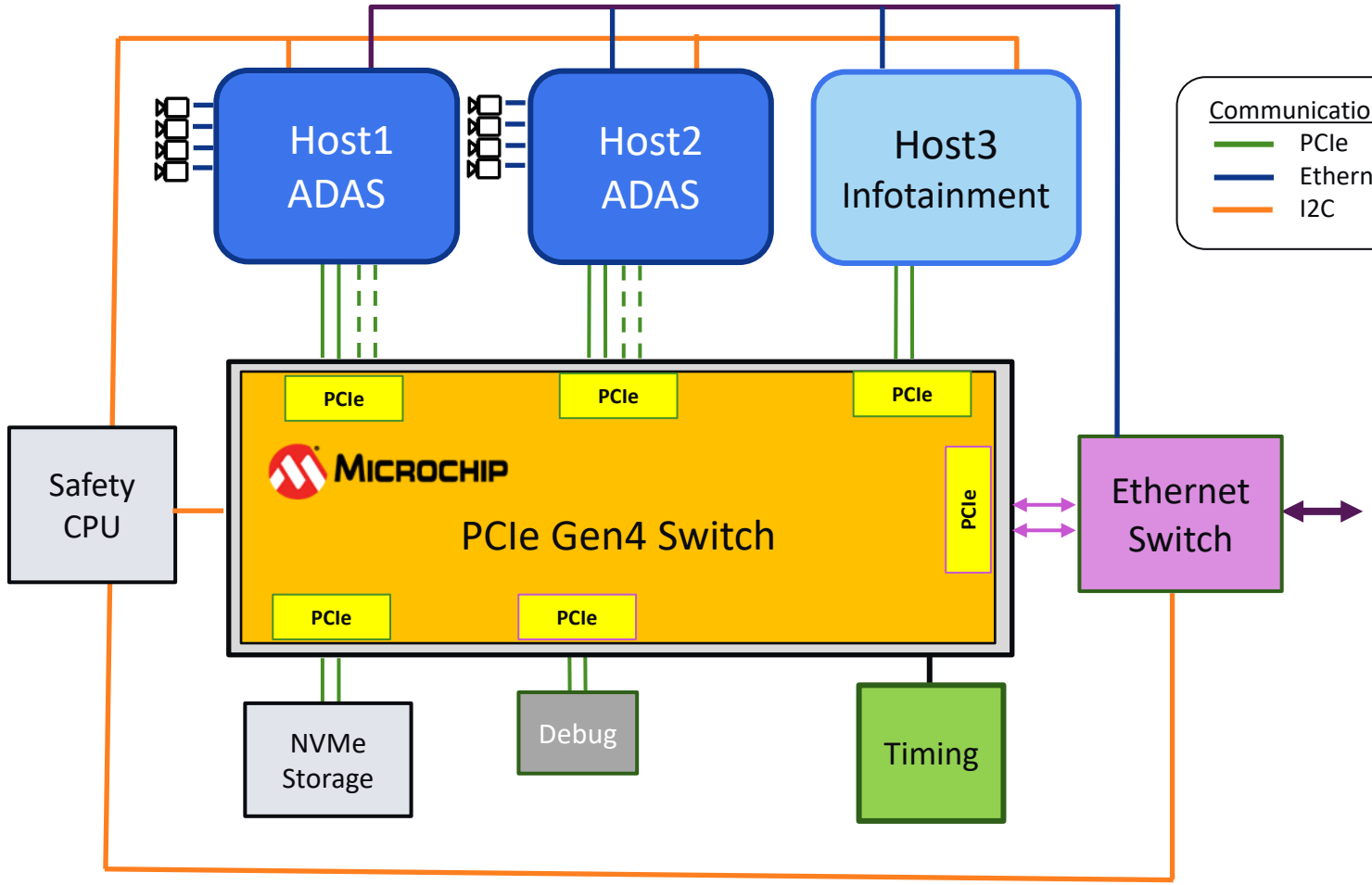
Example Automotive L2+ & L3 Driver Assist Platform

Key components

- **Image Processing SoCs**
  - Camera interface
  - Image recognition / heuristics
  - 360* stitching / perception
  - Localization
- **PCIe Gen4 communications**
  - High bandwidth, low latency
  - Host-host data sharing
  - Endpoint sharing
- **Ethernet communications**
  - Radar data interface
  - In-vehicle network connection
- **Safety monitoring MCU**
  - Component health interrogation
  - System health policy
  - Authentication

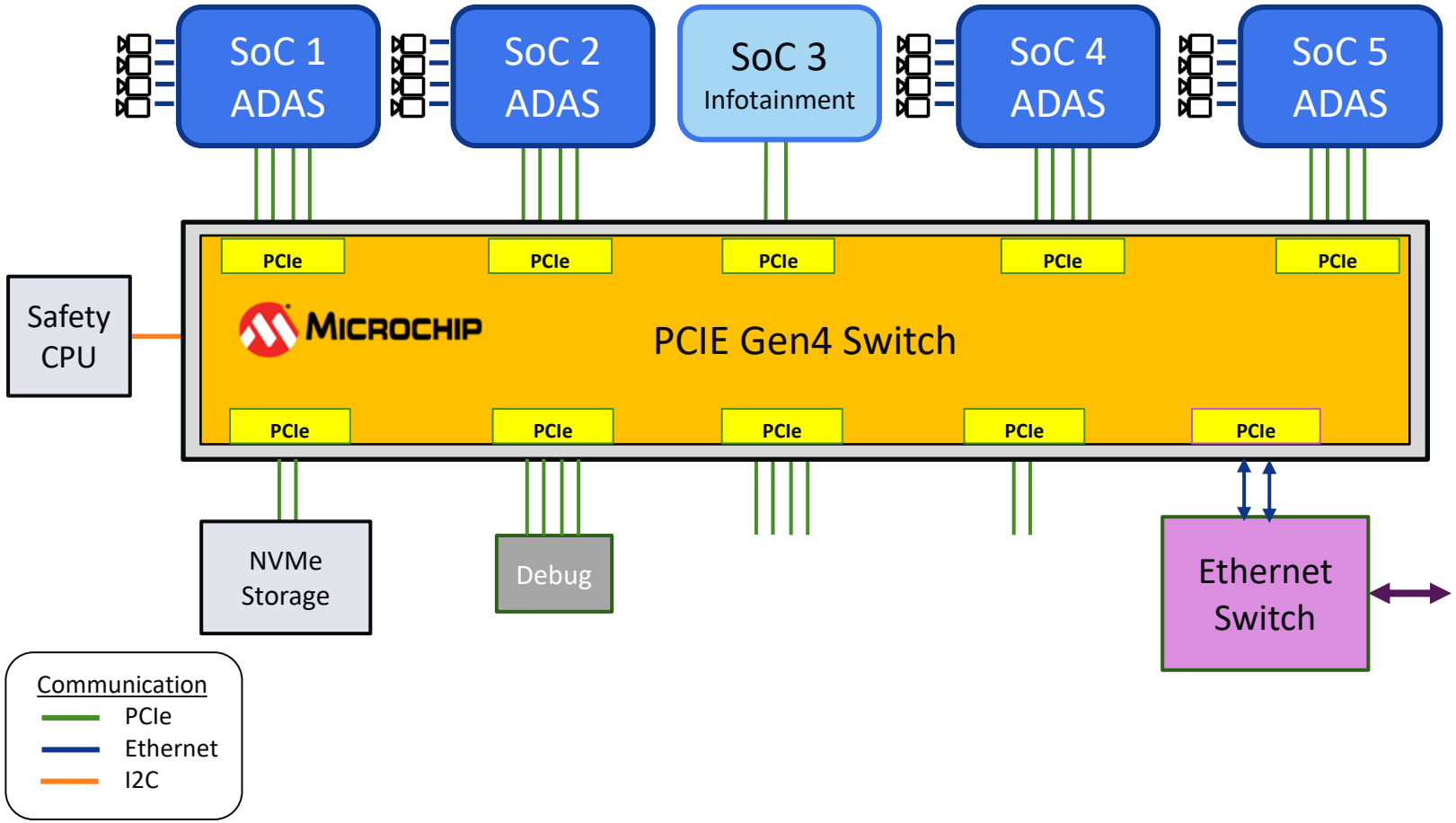


PCIe switching enables scalability and unified software

Example Automotive L2 through L4 Driver Assist Platform

Key components

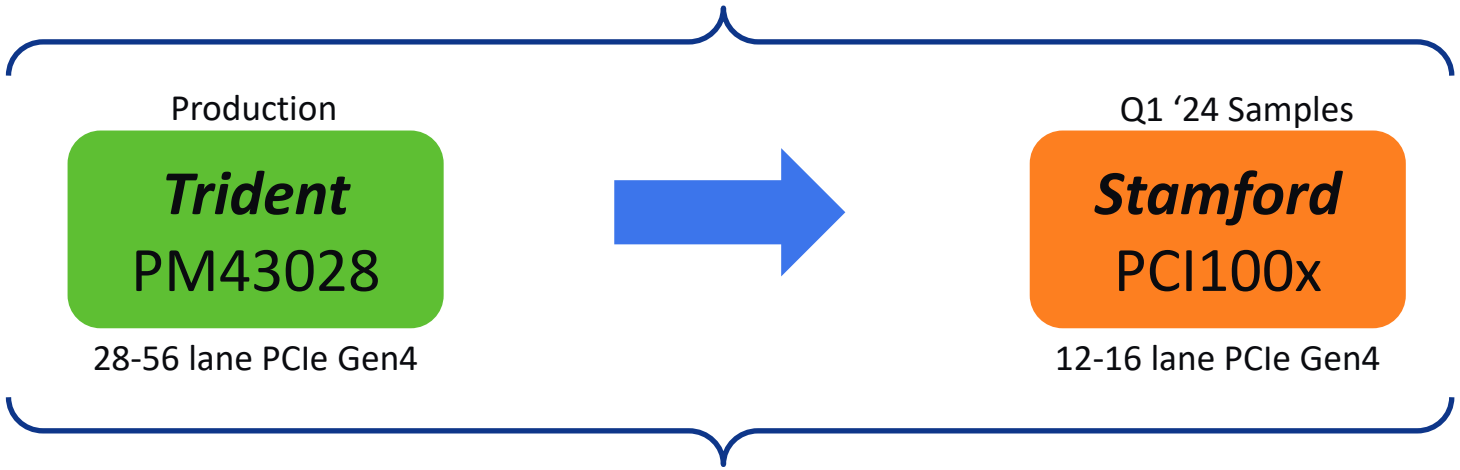
- **SoC count 3-6 units**
- **Image Processing SoCs**
  - Camera interface
  - Image recognition / Heuristics
  - 360* stitching / perception
  - Localization
- **PCIe Gen4 communications**
  - High bandwidth, low latency
  - Host-host data sharing
  - Endpoint sharing
- **Ethernet communications**
  - Radar data interface
  - In-Vehicle Network connection
- **Safety monitoring MCU**
  - Component health interrogation
  - System health policy
  - Authentication



PCIe switching enables scalability and unified software

Stamford PCIe® Switch Migration & Emulation

Common Software drivers and middleware: Dolphin
Common tool suite: Chiplink
Common API: MRPC (Memory Mapped Remote Procedure Calls)
Common operating firmware



Common Switch Core Hardware IP
Common CPU & control architecture
Broad range of switch sizes
Automotive ADAS support

Scalable, proven, low risk , optimized for ADAS

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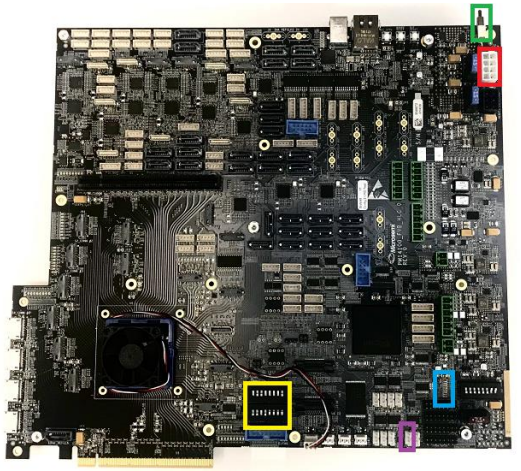
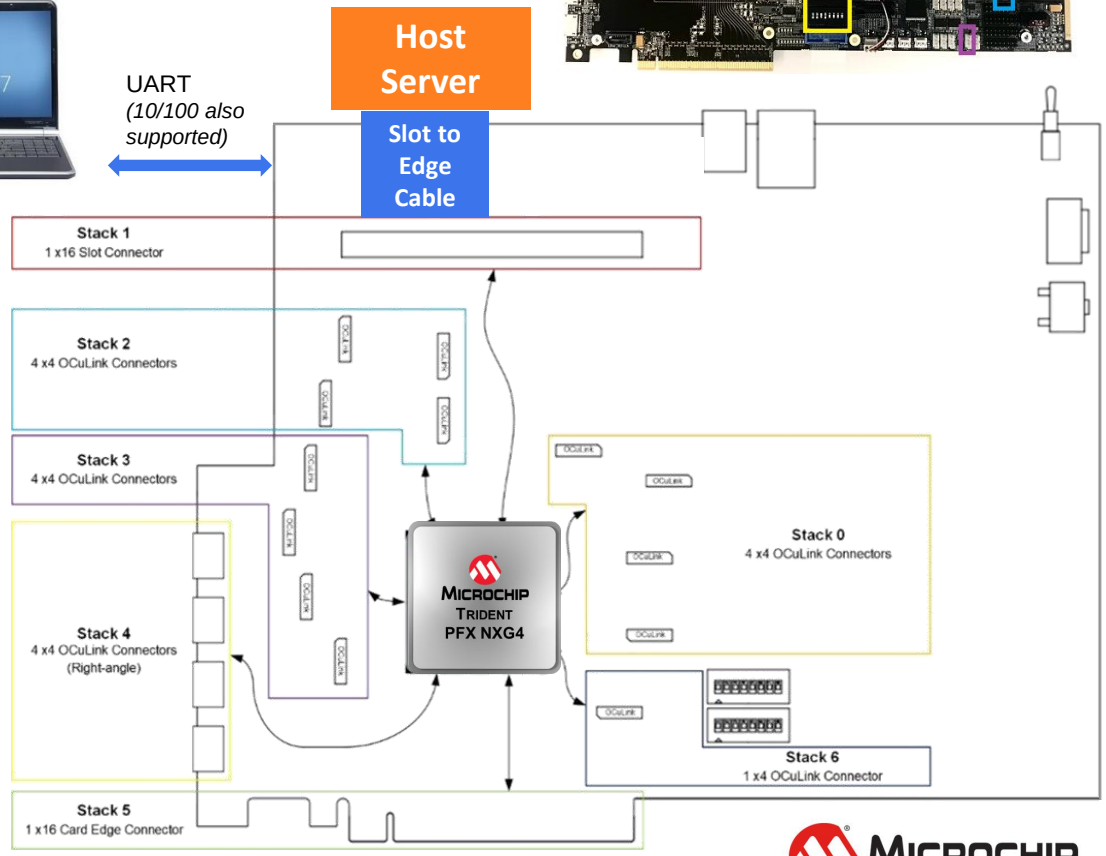
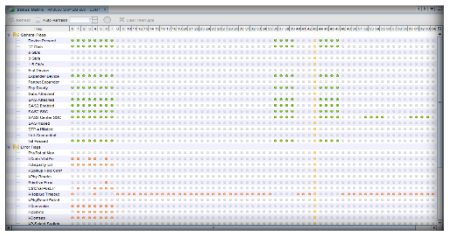
Trident Gen4 Customer Evaluation Kits

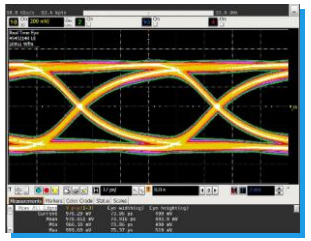
- **PCI, PFX, PSX, PAX, PCIe Switch and SERDES evaluation**
- **Software Development Environment: SDK (PSX, PAX)**
- **Supports SSD connectivity over PCIe Oculink cabling and adapters**
- **Supports Multi-Host connectivity**
- **ChipLink Diagnostic GUI Provides:**
  - Access to Link Rate and status information
  - Control of TLP, pattern generators and PCIe analyzer
  - Adjustment of analog settings
  - Read error counters
  - 1D and 2D eye, Signal Integrity analysis tools
  - Loopback modes
- **Ordering information:**
  - PM42100-KIT Gen4 PCIe Switch Evaluation Kit
  - ADP_EDGEG4 1x16 Edge to 4x4 HD Adapter board
  - ADP_SLOTG4 1x16 Slot to 4x4 HD Adapter board



UART
(10/100 also supported)







Bridgeport PCIe® Gen3 Product Family

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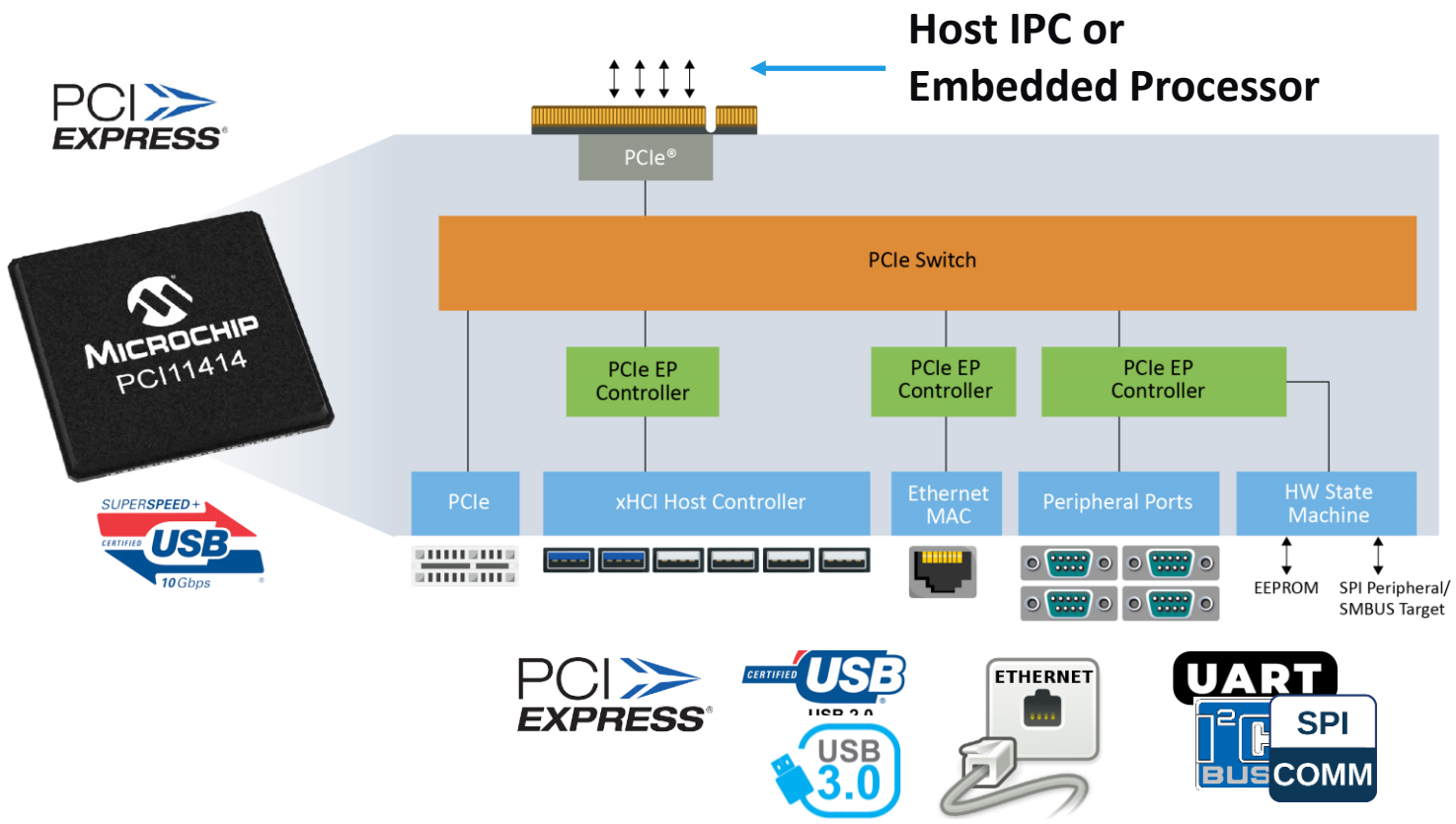
Bridgeport PCIe® Expander Device

Enables embedded connectivity and peripheral abstraction for PCIe-based SoC's

Features

- **PCIe link to common processor platforms**
- **Providing standard interfaces**
  - PCIe Fanout Switching
  - Ethernet networking – 2.5G, 1G
  - USB HOST supporting USB3.2Gen2 & USB2
  - UARTS, GPIO, SPI
  - SD Express



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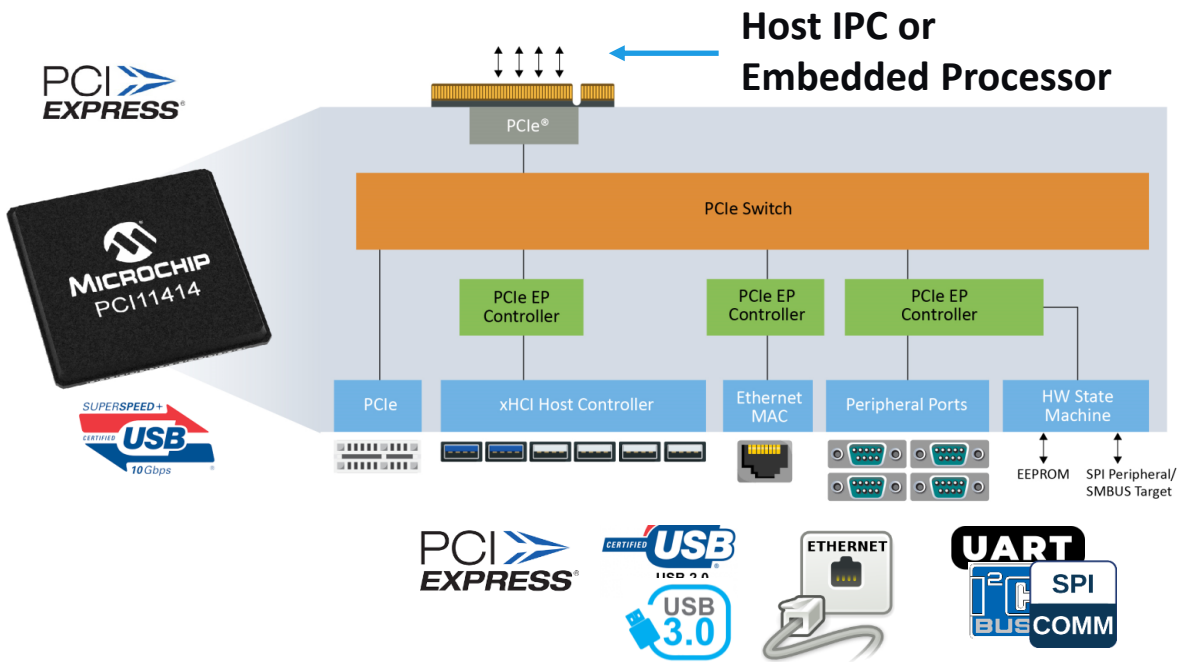
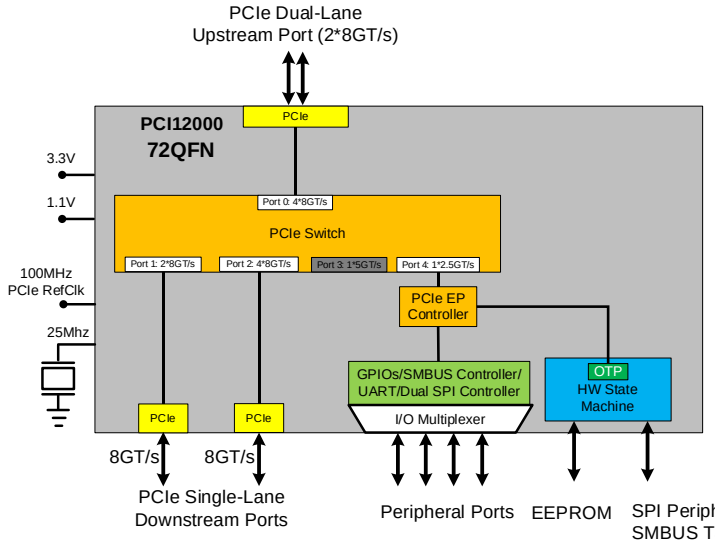
Bridgeport PCIe® Expander Device

Enables embedded connectivity and peripheral abstraction for PCIe-based SoC's

Features

- **Supports standard interfaces**
  - PCIe Fanout
  - Ethernet networking – 2.5G, 1G
  - USB HOST supporting USB3.2 Gen2 & USB2
  - UARTS, GPIO, SPI
- **Multiple SKU options**





PCIe 3.1 (8GT/s)

- Single/Dual lanes
- Low Power Sub States
- SD Express

Industry Standard Packaging

- AEC-Q100 & Automotive Grade 2 (+105°C)
- Commercial & Industrial (+85°C)
- 72QFN 0.5mm Pitch, 10mm x 10mm

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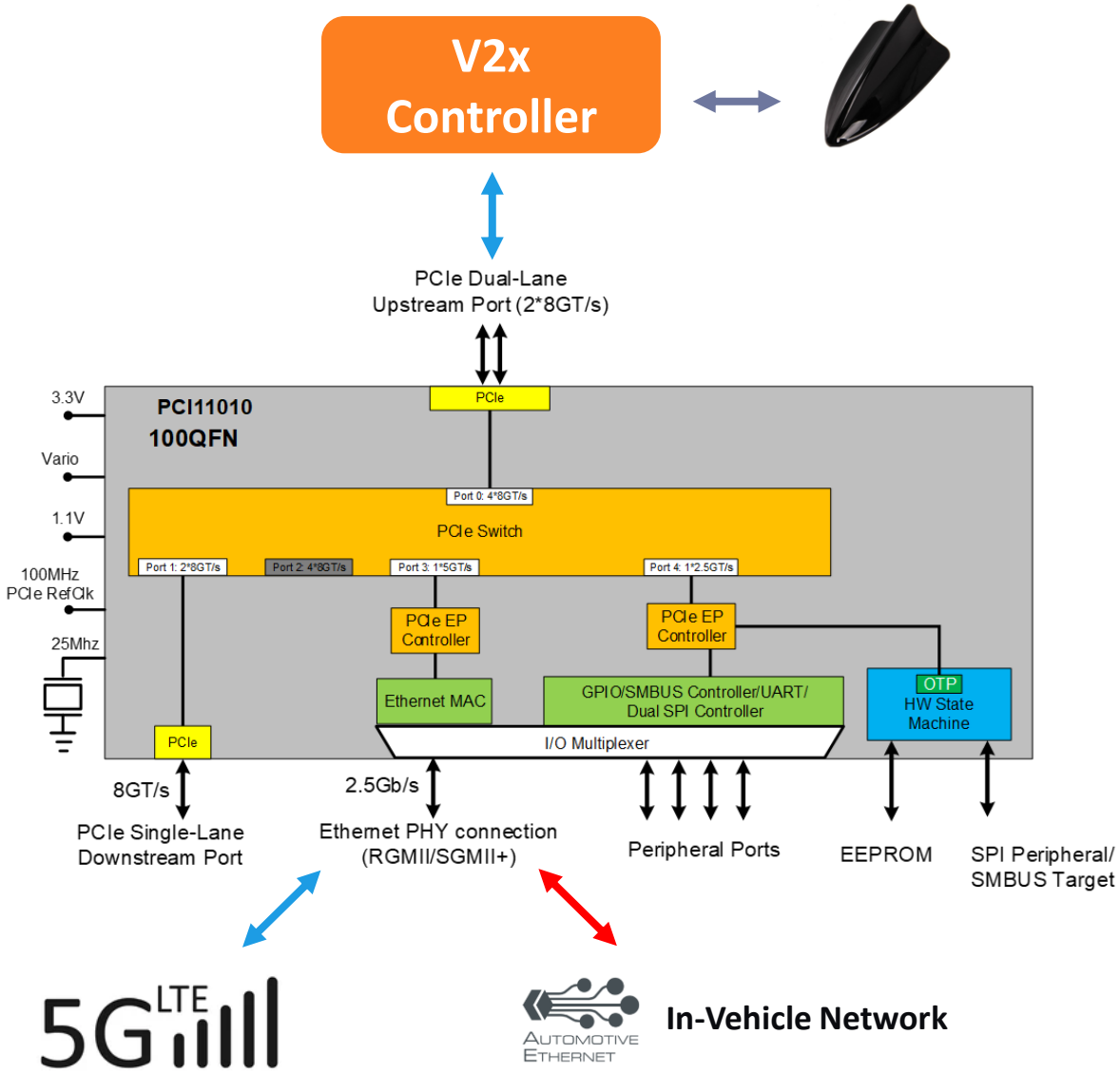
Where it fits

Automotive telematics

- **For systems which need Ethernet connectivity**
  - Gen3 speed 8GT/s aligned with 4G / 5G connections
  - Down facing PCIe port connects to 5G / LTE Modem modules
  - Simple fanout operation

Enables expanded connectivity for port limited V2X processors



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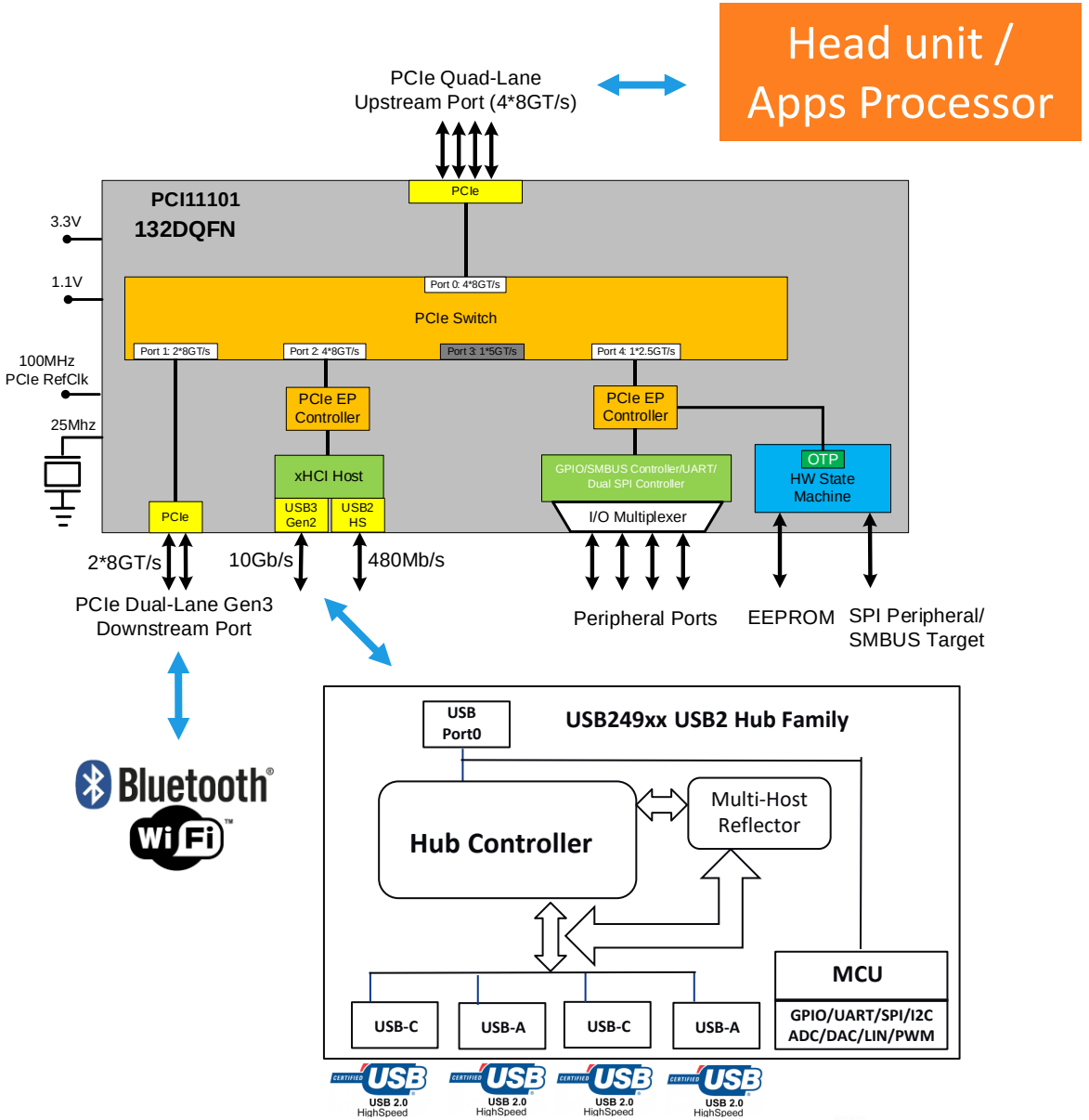
Where it fits

Automotive infotainment

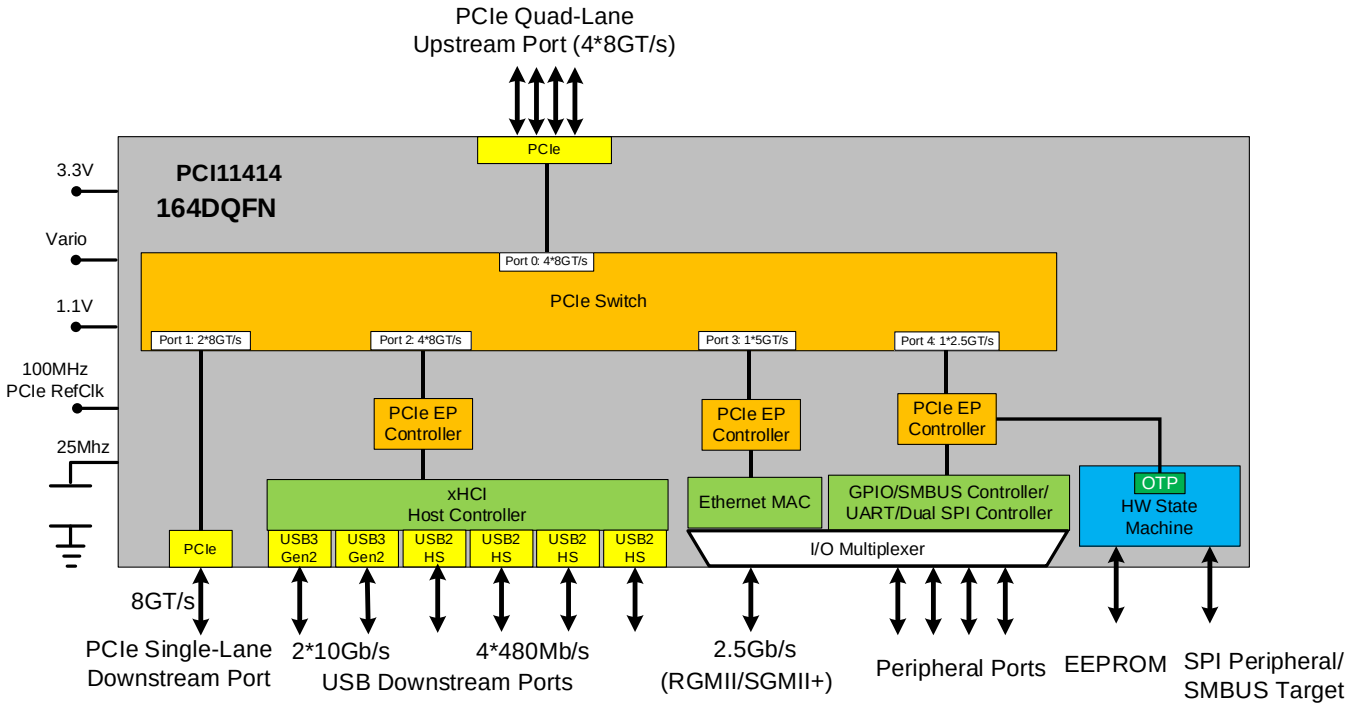
- **For systems requiring USB Host functionality**
  - PCIe Gen3 speed 8GT/s aligned with USB3 5G connections
  - USB Breakout box Architecture supported
  - Simple fanout operation

Enables Gen3 USB host capability without loss of PCIe port



Superset & Subset Products

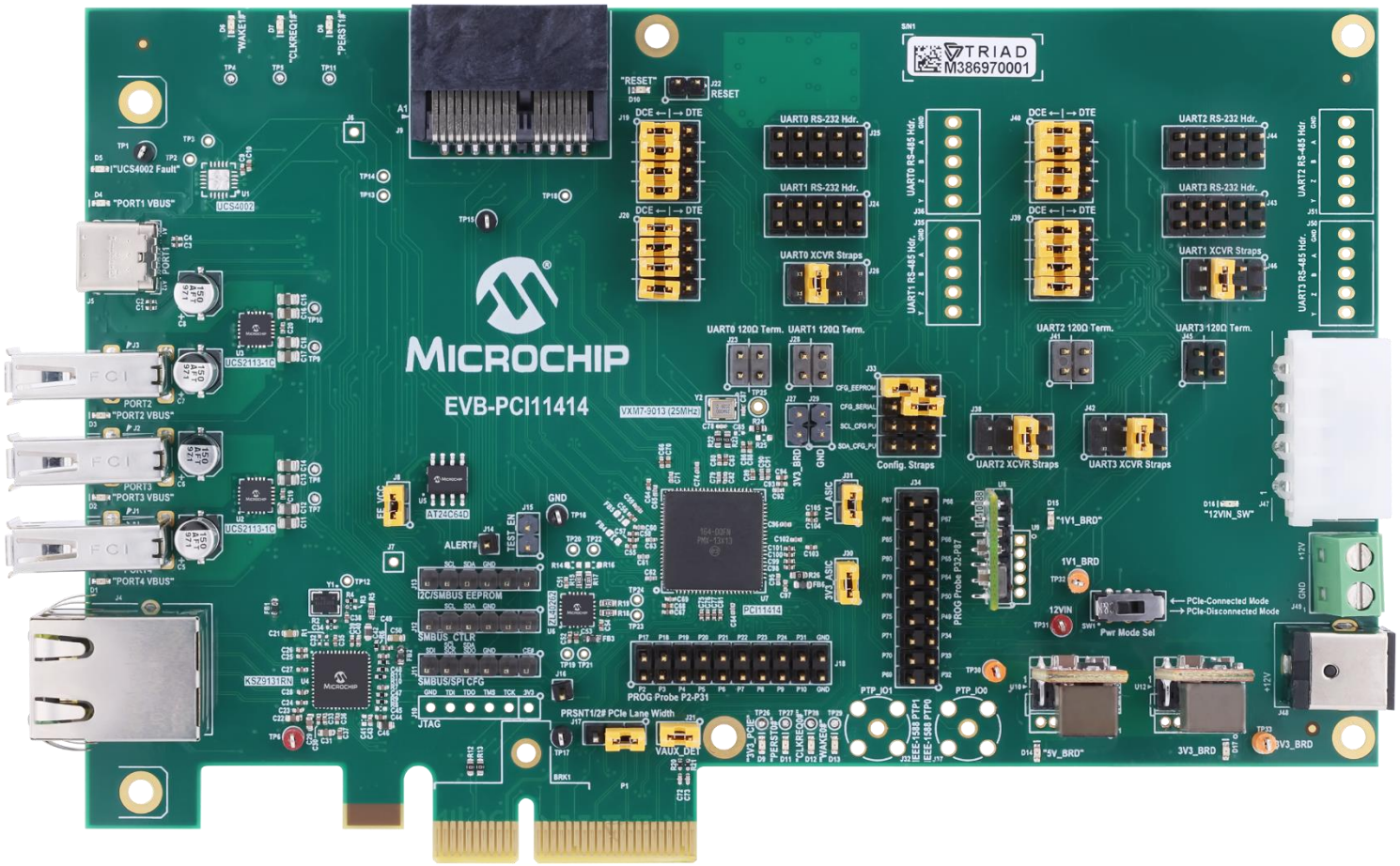
Bridgeport CPN Feature Table	Device	Feature							
		PCIe			USB Host		Networking MAC	UARTs	GPIO
		Upstream	Downstream		3.2Gen2 Port 0,1	LS/FS/HS Port 2,3			
		Port 0	Port 1	Port 2					
PCIe Switch – USB Host, Networking, Quad UART, GPIO	PCI11414	•	•		•	•	•	•	•
PCIe Switch – 1 downstream ports, USB Host	PCI11400	•	•		•	•			
PCIe Switch – 1 downstream port, Networking	PCI11010	•	•				•		
PCIe Switch – 1 downstream port, M.2 Buildout	PCI11101	•	•		•				
PCIe Switch – 2 downstream ports	PCI12000	•	•	•					



- **Industry Standard Packaging**
  AEC-Q100 & Automotive Grade 2 (+105°C)
  Commercial & Industrial (+85°C)
  72QFN / 100QFN / 132DRQFN / 164DRQFN
- **PCIe 3.1 (8GT/s)**
  Single/Dual/Quad lanes
  Low Power Sub States
  SD Express
- **Networking**
  2.5G / 1G / 100Mb / 10Mb
- **USB Host Controller**
  Type C support
  10Gb Single Lane XHCI Host
- **Serial interfaces & GPIO**
  RS232/RS485 (Auto direction), SPI, I2C
- **Design Pack**
  Symbol, schematic, design check services

Evaluation Platform

EVB-PCI11414



- **Industry Standard Packaging**
  - Commercial & Industrial (+85°C)
  - 164DRQFN 0.5mm Pitch , 13mm x 13mm
- **PCIe 3.1 (8GT/s)**
  - Single/Dual/Quad lanes upstream
  - Singe lane downstream
- **USB 3.2Gen2 10G XHCI Host Controller**
  - USB Type C & 3x USB type A
- **Ethernet 2.5G MAC**
  - Shown here with KSZ9131 GigE PHY
  - MAC PTP GPIO via SMA connectors
- **Serial interfaces & GPIO**
  - Quad RS232/RS485 (Auto direction)
  - Dual SPI, I2C, GPIO
  - 10bT1S /10SPE / IEEE802.3cg via SPI

Design support package

Reference design

Symbol for import

- ✓ Optimised flag layout structure
- ✓ Signal escapement
- ✓ Matched trace lengths to the die

Design check services

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Thank You

Why Microchip?

Provides Reliable, Cost-effective Integrated Solutions
The **One** Company to Offer All Wired Connectivity Technologies: 1) PCIe Switch, 2) Ethernet, 3) USB, 4) CAN, 5) SD, 6) INICnet, 7) Security
Only supplier offering scalable PCIe Switching solutions optimized for Automotive ADAS applications
Ease of Design, Lower Cost of BOM and Implementation with Highly Integrated Networking and Bridging Solutions
Microchip Obsolescence Policy for Long Term Automotive Support

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