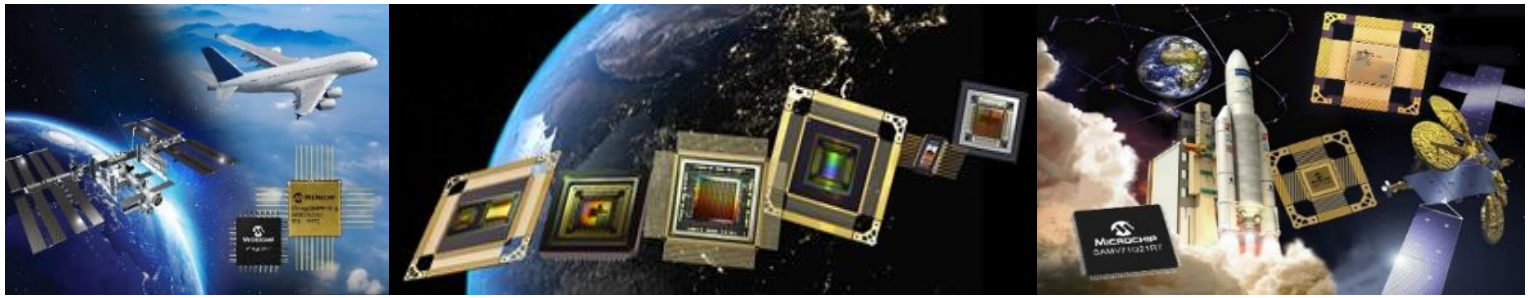
TTTech

Solution Provider for Deterministic Networks and Modular Avionics

Space Qualified European Ethernet PHY 100Mb/1Gb

MICROCHIP
Aerospace & Defense

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



SMART | CONNECTED | SECURE

AMICSA

June 2022

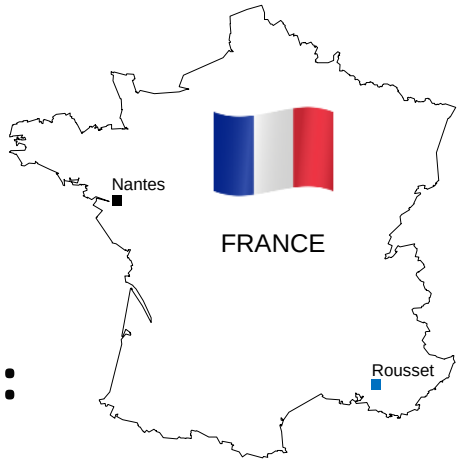
Microchip ADG France

Aerospace and Defense Product Line

Microchip Nantes - France

- **Committed to High Reliability and Long-Term Supply**
  - Delivering aerospace ICs for more than 30 years
  - Strong flight heritage in space and avionics applications
  - Leverage from automotive solutions for “new space” challenges: volume, cost and time to market
- **Major Product Focus**
  - **ASICs**
  - **Processors and microcontrollers**
  - **Communication interfaces and memories**
- **Long-term Cooperation with European Agencies:**
  - ESA, CNES, DGA, DLR …
- **Internal Qualified Supply Chain**
  - DLA/ESCC: Wafer lot to qualified parts (France)
  - DLA: Assembly line (Thailand)

Microchip Rousset - France



Microchip MMT - Thailand

Design

Foundry

Probe

Assembly

Test

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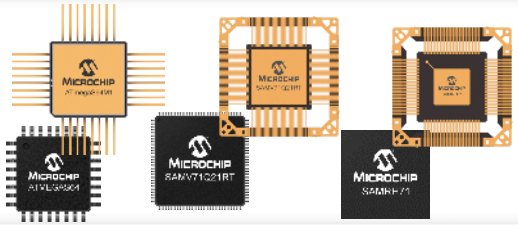
Microchip Space Portfolio

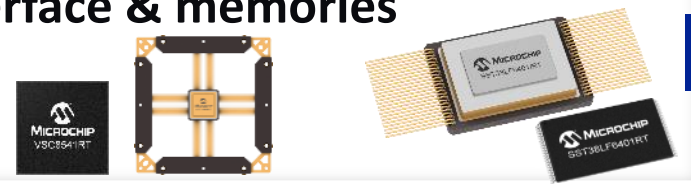
MPUs and MCUs

8-bit AVR
32-bit SPARC V8 and arm M3 & M7
GNSS SoC



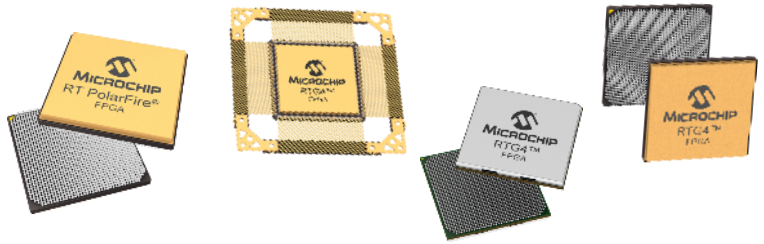
Communication Interface & memories

SpaceWire, Ethernet, CAN
SRAM
NVM memories



FPGAs

RT PolarFire
RTG4
RT ProASIC3
RTAX, RTSX-SU

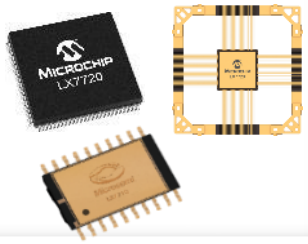


Power Solutions

Rad-hard JANS Diodes, Bi-Polar Small Signal Transistors
Rad-hard Isolated DC-DC Converter Modules
Custom Power Supplies 2 W to > 5 KW
Point of Load Hybrid Solutions
Electromechanical Relays

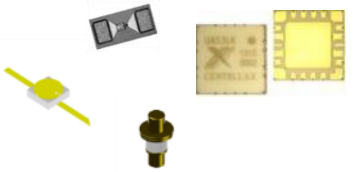
Mixed Signal Integrated Circuits

Telemetry and Motor Control Space System Managers
Power Supply protection



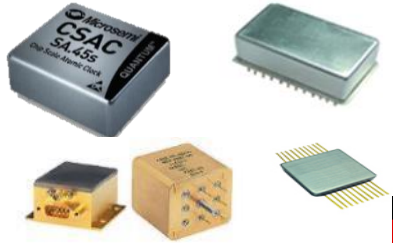
RF Products

Packaged and Chip Si and GaAs RF Diodes,
SAW filters,
Packaged and bare die GaN and GaAs MMICs
GaN on SiC HEMT transistors.



Timing solutions & Oscillators

Ovenized Quartz Oscillators
Hybrid Voltage Controlled &
Temperature Compensated Crystal Oscillators
Cesium Clocks
Chip Scale Atomic Clock (CSAC)



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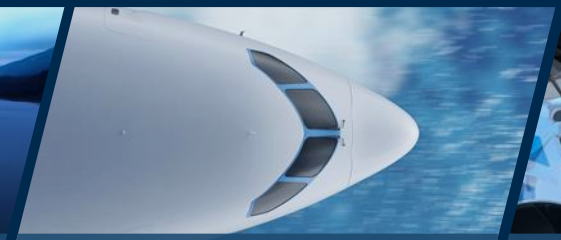
TTTech Group - Truly Global

TTTech

Automotive



Aerospace & Space

Off-Highway

Industrial & IoT

Android & Services

Global Reach:
2300+ employees
20 locations/sites
in 14 countries
headquartered in Austria

RENESAS · intel · AMMANN · MOFFETT · rosenbauer · NORTHROP GRUMMAN

QNX · NXP · Honeywell · KION GROUP · BOMBARDIER · esa European Space Agency

WIND · CISCO · CATERPILLAR · PALFINGER · eASIC · arianeGROUP

SAMSUNG · MOXA · KUKA · JOHN DEERE · CRRC · STMicroelectronics

hp · EPAUS · Schneider Electric · katek · Keestrack · RUAG

Rockwell Automation · LIEBHERR · EMBRAER · GE Aviation

HIRSCHMANN · VECTOR · Continental · TADANO · Collins Aerospace · AIRBUS

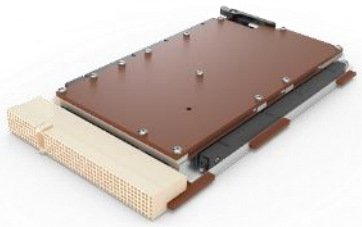
SAIC · PORSCHE · HYDAC · TEREX · CLAAS · BOEING

MAGNA · APTIV · ABB · HYUNDAI · LOCKHEED MARTIN

TTEthernet Products

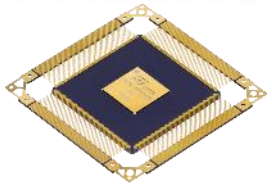
TTE Equipment

- TTEEnd System Space 3U cPCI (EDU, PROTO, FLIGHT)
- TTESwitch Space 3U cPCI (EDU, PROTO, FLIGHT)



TTE Components

- TTEController HiRel (PBGA400, AEC-Q100)
- TTEController Space (CQFP352, QML-V)



TTE Software (tools & embedded) - Building Blocks

- TTETools Development Suite
- TTEVerify and TTEAnalyze Verification Tools

TTEPlan TTEBuild TTEVerify TTEAnalyze

TTE Development, Testing & Integration - Building Blocks

- TTEDevelopment Systems Linux / VxWorks 653
- TTETesting Systems
- TTETestbed

TTEDevelopment Systems

TTETesting Systems

TTETestbed

Ethernet for Avionics Networks

Ethernet is becoming a more common standard in modern spacecrafts

- Most used technology for local networks
- Used in automotive, industrial control and aircraft avionics
- Flexible, plug & play
- High data rates
- Open cross-industry standard (IEEE 802.3) with multiple providers
- Connectivity: works with any commercial laptop

Enabler of more Ethernet in Space – component qualification

"TTTech - Internal"

TTEthernet for Spacecraft Network Systems

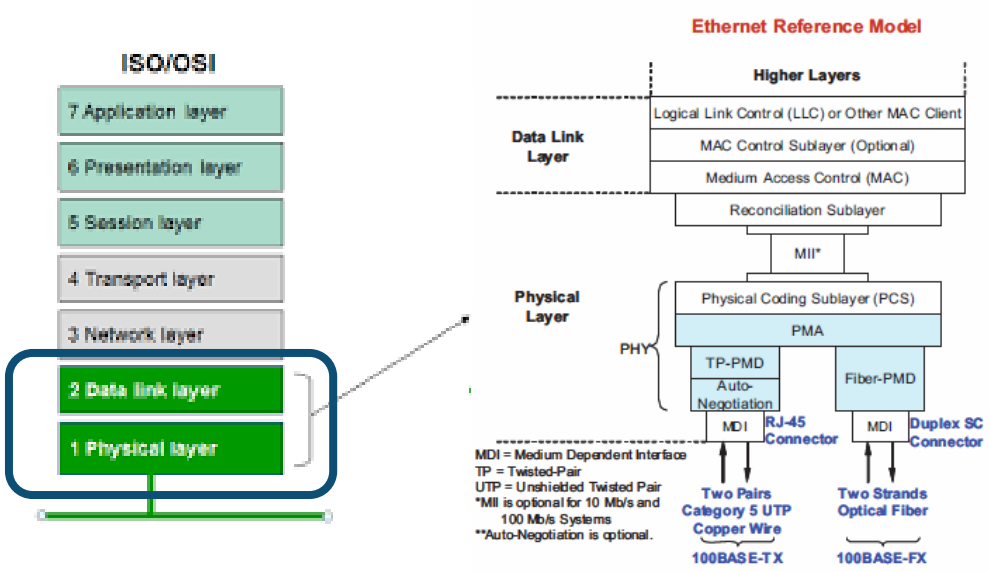
TTEthernet for high-reliable deterministic Ethernet for safety-critical systems

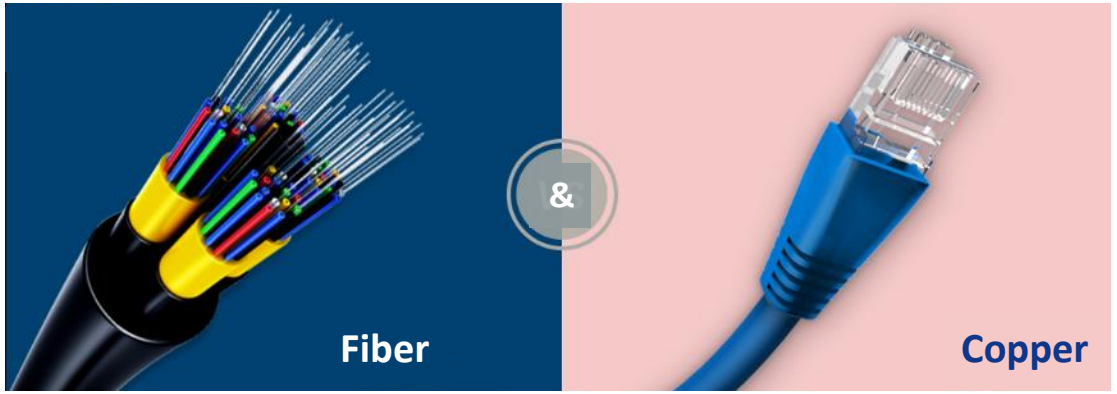
- Protocol on top of standard Ethernet
- Network devices synchronized autonomously via dedicated sync frames
- Redundancy, network fault management, diagnostics data reporting - abstracted fully by the network

Used on Ariane 6 and as Gateway backbone

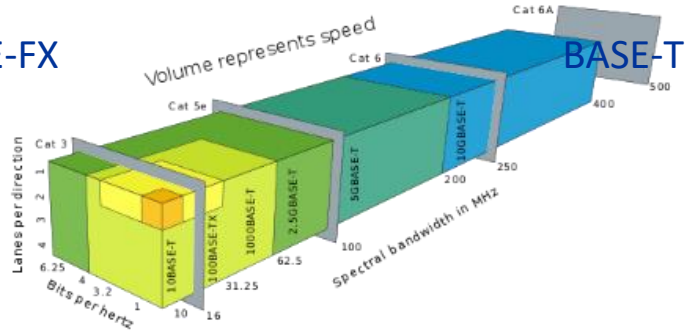
June 1, 2022

What is Ethernet PHY ?

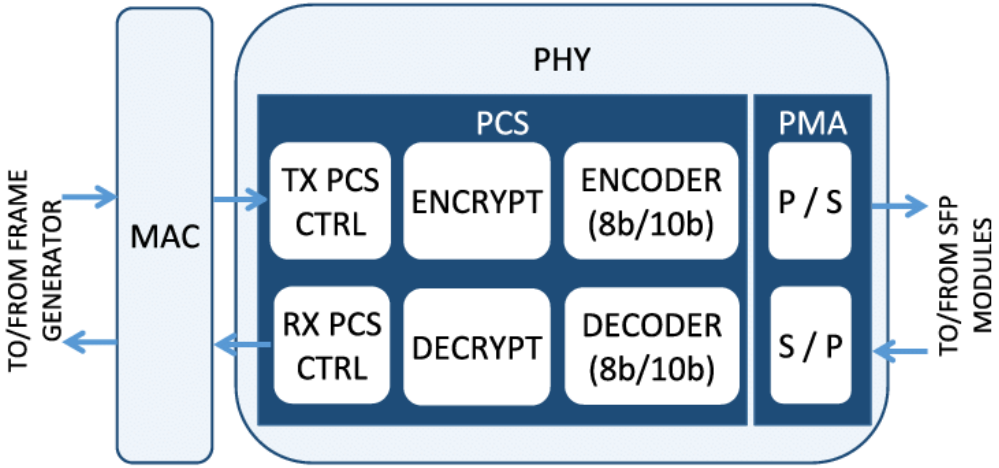




BASE-X / BASE-FX



BASE-T / BASE-TX



- **MAC layer** builds the Ethernet packets transmitted to the PHY.
- **PHY** includes the PCS and PMA (Physical Medium Attachment) sublayers.
  - **ENCRYPT and DECRYPT** modules perform the format preserving encryption/decryption of 8b/10b symbols at the PCS sublayer.
  - **P/S and S/P modules** are Parallel to Serial and Serial to Parallel modules, that transmit and receive the bitstream from the optical link.

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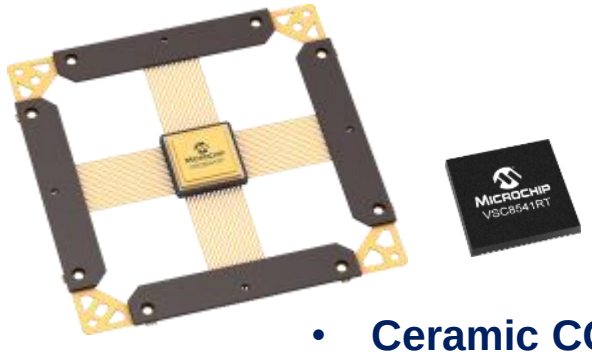
VSC8541RT

Rad Tolerant Fast/Gigabit Ethernet PHY

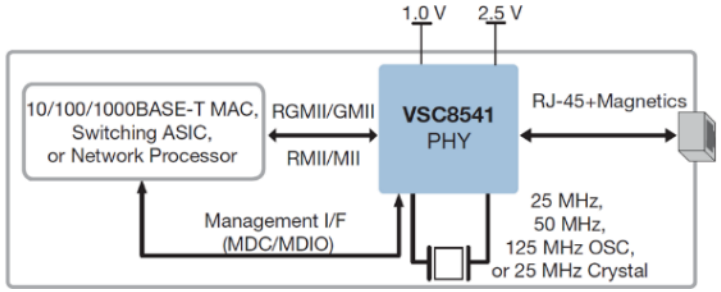


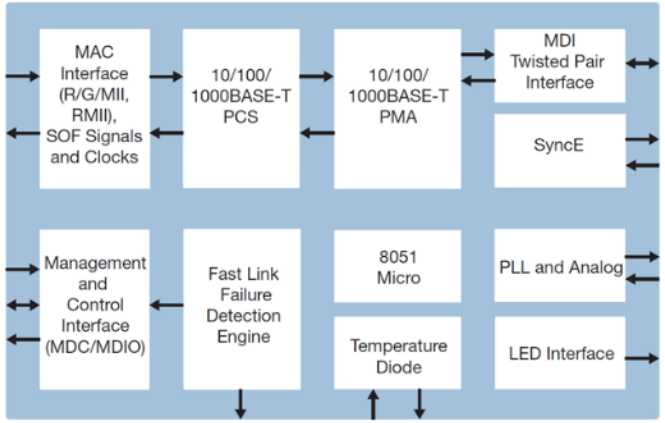
- Ceramic CQFP68
- Plastic QFN68

Samples & Flight Models available

ESCC Detail Specification No. 9405/020

- 10/100/1000BASE-T Ethernet copper transceiver (IEEE 802.3ab compliant)
- RGMII/GMII/MII/RMII MAC interface
- Synchronous Ethernet and IEEE 1588 Start of Frame identification
- Patented line driver with low EMI voltage mode
- Wake-on-LAN
- Supports clocking from 25 MHz crystal or 25/50/125 MHz oscillator
- Host-free configurability through hardware strapping
- Best-in-Class power consumption
- Extended temperature range -55°C to 125°C
- CQFP68 and VQFN68 packages





Radiation
TID 100krad(Si) SEL immune up to 78MeV.cm2/mg

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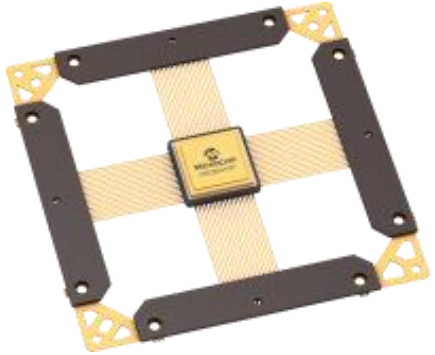
COTS to Radiation Tolerant devices

- **Start from industrial/automotive products**
  - Same mask set
  - Same functionality
  - Same development tools
  - Easy access via commercial eval kit
  - Free tool chain & libraries
  - Same pin out as commercial device

- **Hardening of critical parameters**
  - Process tuning for **no Single Event Latch-up at least up to 62 MeV.cm²/mg** @ Tmax
  - Total Ionizing Dose **– Specific screening & Lot selection** (>50Krad)
  - Radiation report including SEU full characterization
- **Scalable solutions**
  - Space Grade Ceramic:
    - QML qualification & screening equivalent
    - Minimum Ordering Quantity of 5 units
  - Hirel Plastic (HP):
    - 3-Temp screening + Ext. Visual Inspection
    - Minimum Ordering Quantity > 200 units



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VSC8541RT Radiation Results

- **Tests supported by CNES (Centre National d'Etudes Spatiales)**
- **Single Event Latchup – SEL**
  - Performed under worst case conditions (Vcc_{max} & 125°C)
  - In accordance with ESCC25100 and MIL STD 883/Mil PRF 38535 standards
  - Single Event Latch-Up LET threshold is **higher than 78 MeV.cm²/mg**
- **Single Event Upset – SEU**
  - SEFI conditions as well as Hard and Soft reset occurrence characterized
  - Weibull curves and MTBF tables available for the different SEFI conditions
  - **No Power Off/On sequence was needed to restart the device after a link loss**
- **Total Ionizing Dose – TID**
  - Performed according to MIL STD 883 TM1019 & ESCC22900 standards
  - 27 parts remained **inside the specification limits after test read-out at 100krad(Si)** on parametrical parameters and **no functional deviation** was observed
- **Radiation report available upon request**

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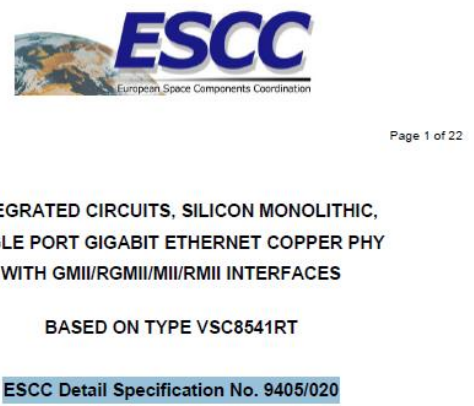
VSC8541RT Qualification Results

- **Goal is to demonstrate high reliability and ability to withstand user environmental constraints**
- **Qualification is based on:**
  - Technology Qualification
  - Product Qualification for space applications
- **Technology Qualification**
  - Qualified with projected lifetime at 110°C higher than 15 years
- **Product Qualification for Space applications**
  - Successfully qualified on 3 successive assembly lots
  - All tests passed successfully : HBM & CDM ESD, Electrical latch Up, Life test, Assembly/Packaging reliability tests, Construction analysis and Irradiation tests
- **VSC8541RT fully qualified and Qualification Package available upon request**
- **Part of European Preferred Part List => ESCC Detail Specification No. 9405/020**


ESCC
European Space Components Coordination

Page 1 of 22

INTEGRATED CIRCUITS, SILICON MONOLITHIC,
SINGLE PORT GIGABIT ETHERNET COPPER PHY
WITH GMII/RGMII/MII/RMII INTERFACES

BASED ON TYPE VSC8541RT

ESCC Detail Specification No. 9405/020

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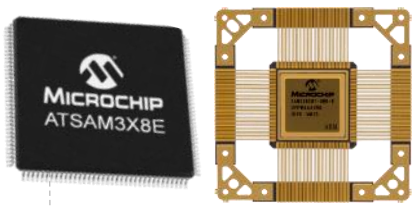
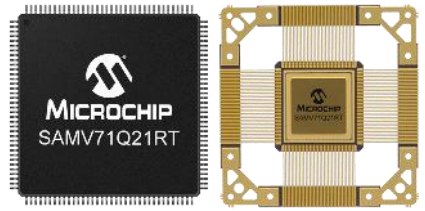
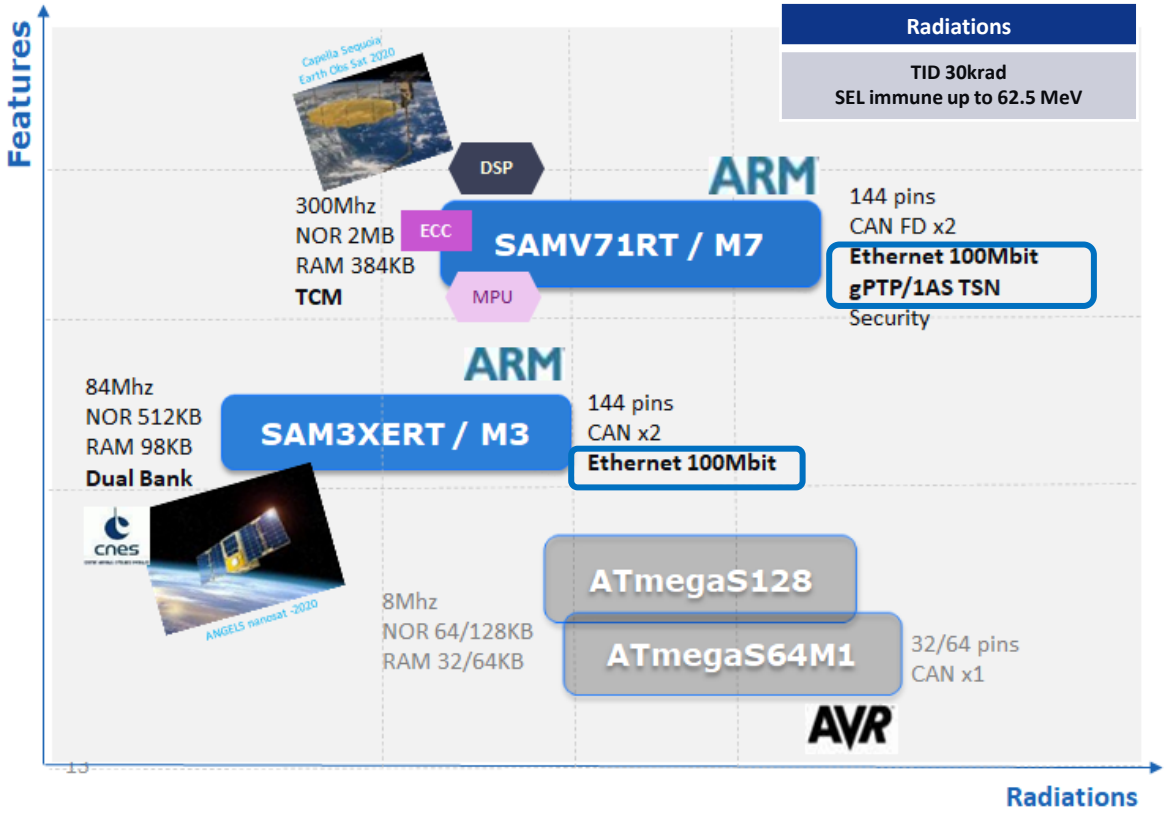
SoC w Embedded Ethernet for Space

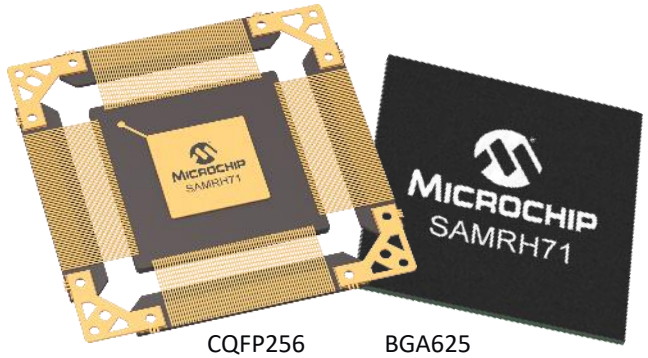
- **Rad Tolerant µC**







- **Rad Hardened processor**



CQFP256 BGA625

Radiations

TID 150krad (Flash limited to 20krad)
SEL immune up to 62 MeV
SEU LET >20Mev.cm2/mg (Xsection <10-9 cm2/word)

- **ARM Cortex M7 SoC w TCM/MPU & DSP capabilities**
- **>200DMIPS, 1MB SRAM w ECC, 128KB Flash w ECC**
- **Spw, 1553, CAN FD, 100Mbit Ethernet gPTP/1AS TSN**

- **Ready for Spacewire to Ethernet Gateway**

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Ethernet for Space - Looking forward

- **Supporting European space industry & agencies towards more Ethernet solutions**

- **Targeting new RT/RHBD Ethernet devices for Space**
  - Ethernet PHY
    - SGMII, FX & 10Gbit
  - Ethernet Switch
    - 1 to 10Gbit (w/wo TSN)
  - Ethernet SoC
    - Gbit ARM MCU & MPU
    - Gbit embedded IP for FPGA

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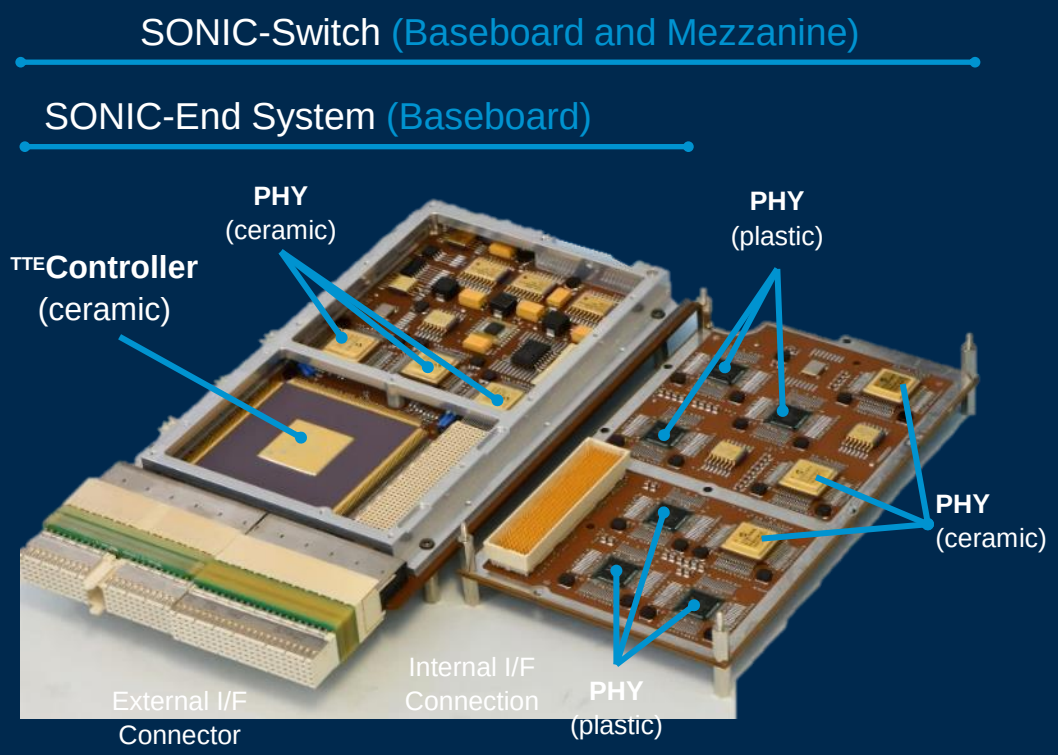
TTEthernet® Equipment for Gateway as Reference Design with VSC8541RT

Switch or network interface card (SONIC)

- **TTESwitch:** interconnection of several nodes
- **TTEEnd System:** ability for host computer to connect to TTEthernet

Main components

- **TTEController:** Main functional block for TTEthernet, contributing to all high-level functions
- **VSC8541RT PHY:** Translation of MII to MDI signals (100/1000 BASE-T) to provide connectivity to the function of the TTEController



SONIC Elegant Bread Board (EBB) used for development tests

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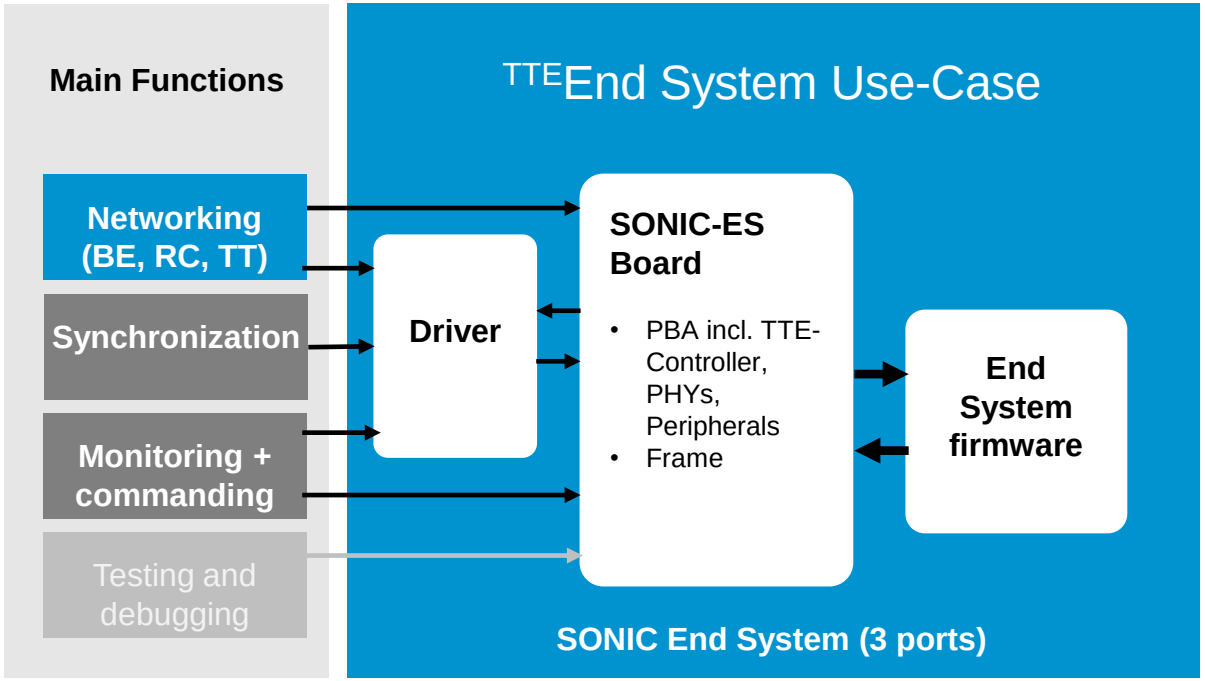
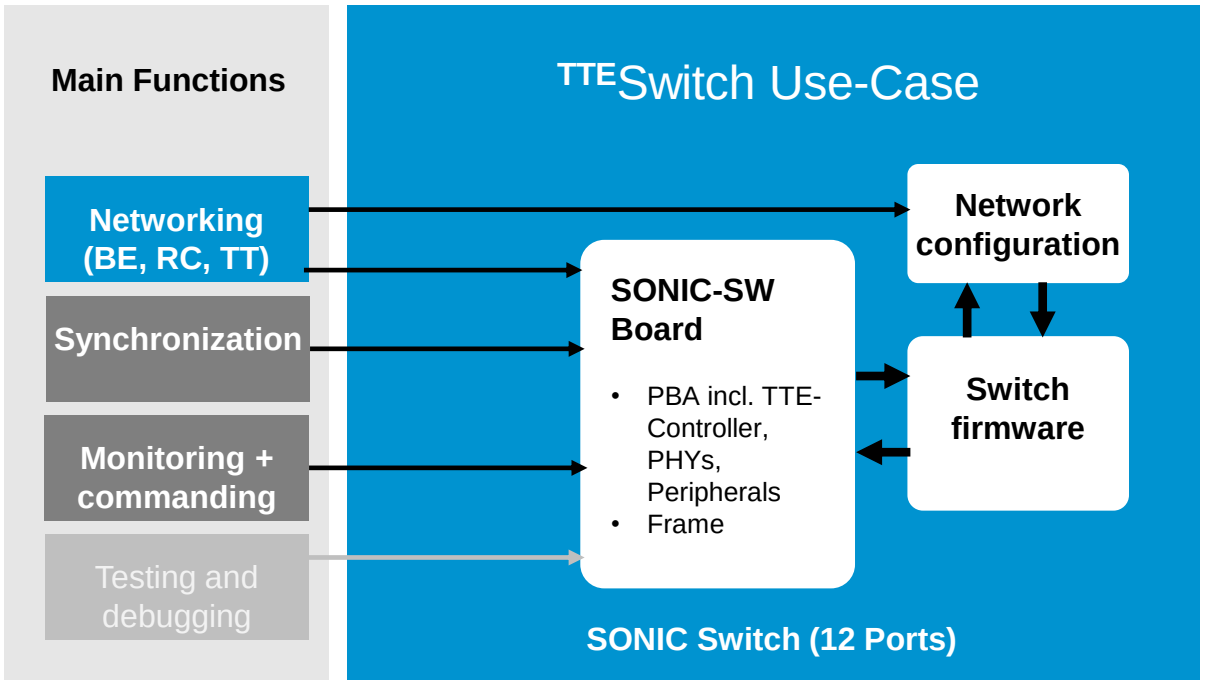
SONIC Architecture and Main Functions

- Modular design concept to provide flexibility, easy integration and maintenance for different use cases
- SONIC supports multiple network lanes for fault-tolerant computer architectures





"TTTech - Internal"

VSC8541RT Performance Validation

Objective

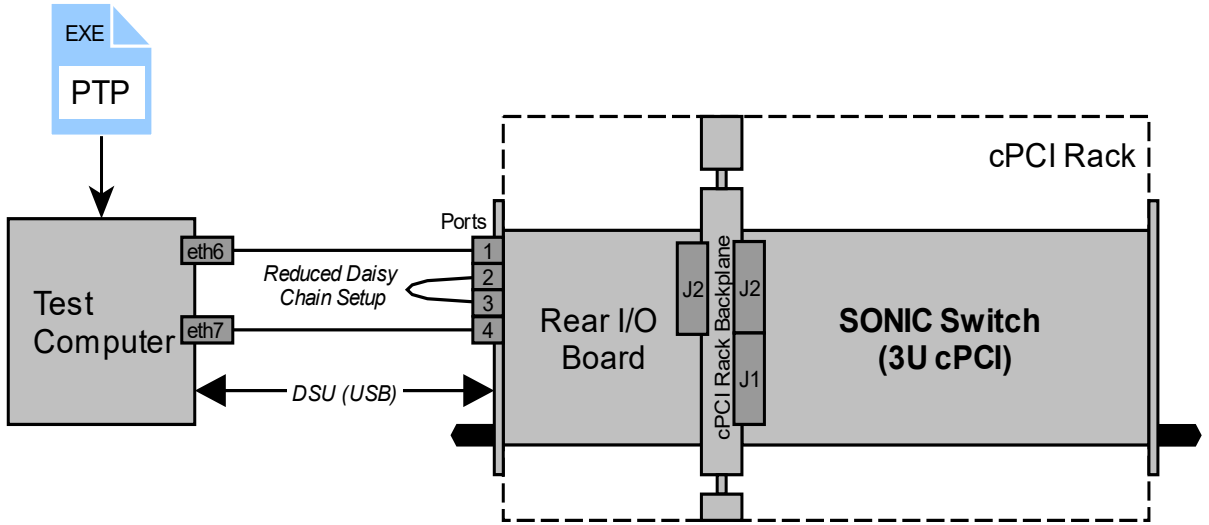
- Functional validation and performance measurements as a part of component qualification
- Link speed: 1Gbit/s
- Tests performed on Development Model (DM) and Elegant Bread Board (EBB)

Test Setup

- Ports 2-3 daisy chained
- Performance test script (PTP) running on Host CPU
- Throughput measured via Wireshark and recorded via the test script (log-file)
- Dropped frames counted and recorded (log-file)

Switch ID	SONIC Switch Model	TTE-Controller	PHYs (Baseboard)	PHYs (Mezzanine)
SW1	DM	plastic	plastic	plastic
SW2	EBB	ceramic	plastic	plastic
SW3	EBB	ceramic	ceramic	plastic

Overview of SONIC Switch models used for performance tests



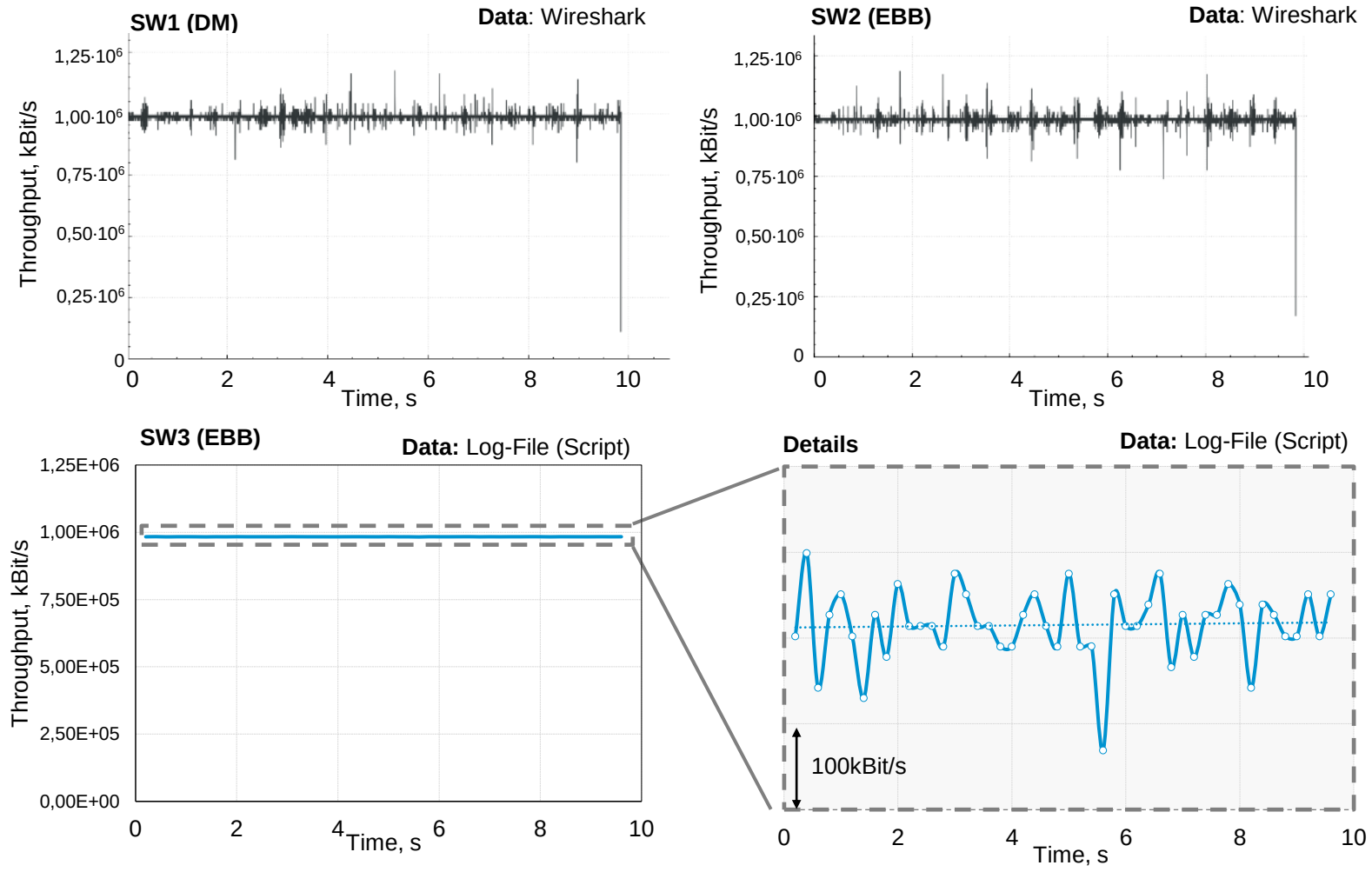
SONIC Switch performance test setup with reduced daisy chain

"TTTech - Internal"

VSC8541RT Performance Validation

Test Results

- Successful tests for
  - Different SONIC Models (DM/EBB)
  - TTE-Controller and PHY configurations (plastic/ceramic)
- 1Gbit/s throughput successfully demonstrated
- No dropped frames



Throughput results for different SONIC Switch configurations

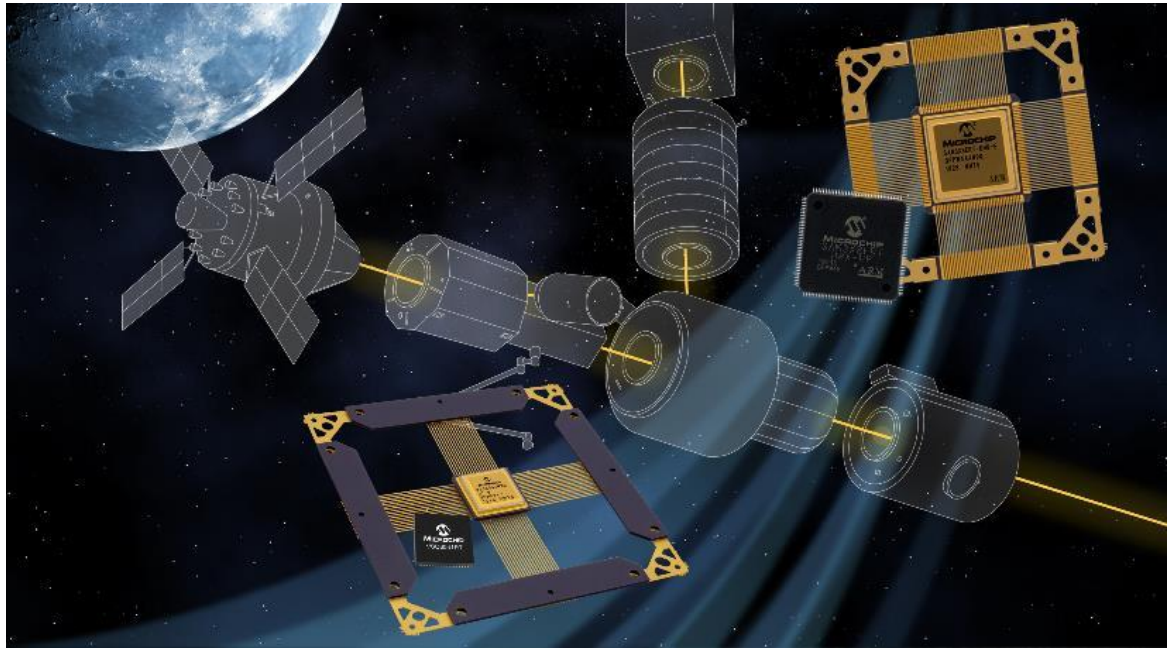
"TTTech - Internal"

Conclusion

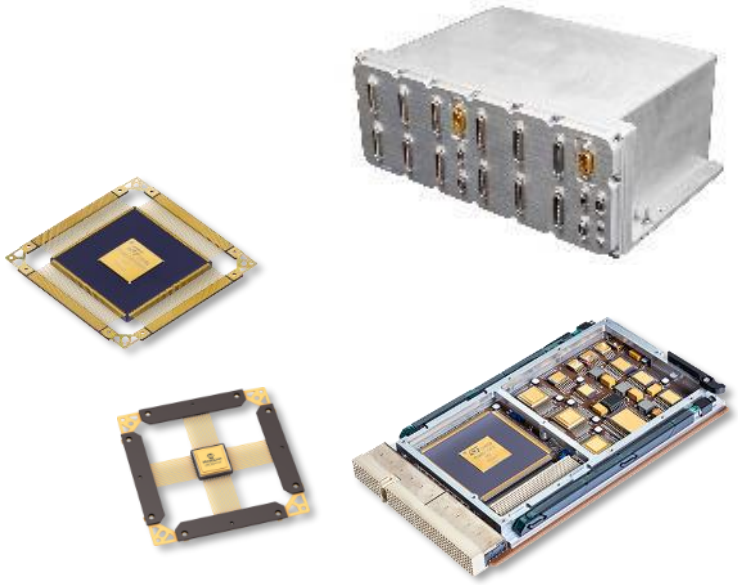
- Ethernet PHY successfully qualified
- TTE-Controller (TTTech) and VSC8541RT (Microchip) – key components for high-speed deterministic Ethernet avionics networks for future spacecrafts
- Reference design based on high-profile human space flight Gateway equipment

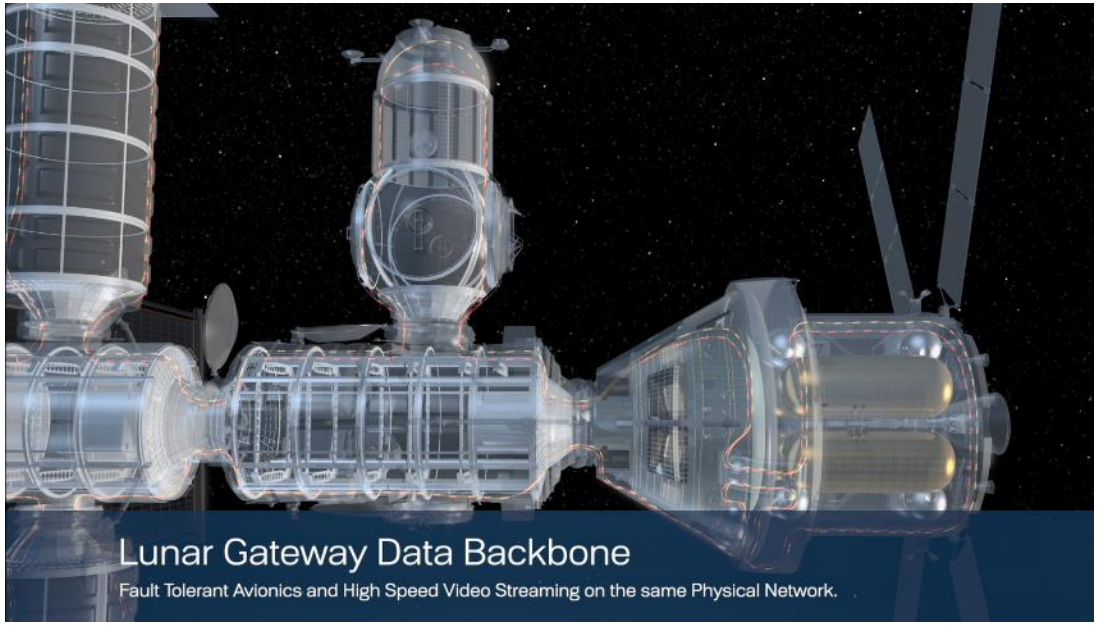
Thank you & please visit us at our exhibition booths to learn more about chip and board-level solutions for dependable avionics

"TTTech - Internal"



Thank You





TTTech

MICROCHIP

VSC8541RT ordering codes

VSC8541 Evaluation Kit

Tool	Part Number
VSC8541 Evaluation Board	VSC8541EV

VSC8541RT Part Numbering

Part Number	Package	Interface	Ethernet Bandwidth	Quality Flow
VSC8541WZBRT-E	CQFP68	GMII / RGMII / MII / RMII	10/100/1000Mbps	Engineering Sample
VSC8541WZBRT-MQ				QML-Q Equivalent
VSC8541WZBRT-SV				QML-V Equivalent
VSC8541XMVRT-HP	VQFN68	GMII / RGMII / MII / RMII	10/100/1000Mbps	Hirel Plastic (HP)

TID wafer lot data available for QML-V eq. under specific request

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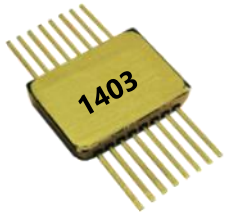
VSC8541RT Reference Clocks

App Note AN3503: Reference Clocks from Vectron for VSC8541RT Radiation Tolerant Ethernet Transceiver



Microchip Part Number	Quality Level	REF Clock Frequency (MHz)	Oscillator Specification	Oscillator Model Number	Oscillator Supply Voltage(V)	TID (krad)
VSC8541WZBRT-E	Prototype (-E)	25	OS-68338/PX-709	PX-709-0025-25M0000000	3.3	100
VSC8541WZBRT-MQ	QML_Q	25	OS-68338/PX-709	PX-709-0026-25M0000000	3.3	100
VSC8541WZBRT-SV	QML_V	25	OS-68338/PX-709	PX-709-0027-25M0000000	3.3	100
VSC8541XMVRT-HP	Hirel Plastic (-HP)	25	OS-68338/PX-709	PX-709-0028-25M0000000	3.3	100
VSC8541WZBRT-E	Prototype (-E)	50	OS-68338/PX-709	PX-709-0029-50M0000000	3.3	100
VSC8541WZBRT-MQ	QML_Q	50	OS-68338/PX-709	PX-709-0309-50M0000000	3.3	100
VSC8541WZBRT-SV	QML_V	50	OS-68338/PX-709	PX-709-0031-50M0000000	3.3	100
VSC8541XMVRT-HP	Hirel Plastic (-HP)	50	OS-68338/PX-709	PX-709-0032-50M0000000	3.3	100
VSC8541WZBRT-E	Prototype (-E)	125	DOC204900	1403D125M0000CX	2.5	100
VSC8541WZBRT-MQ	QML_Q	125	DOC204900	1403B125M0000CE	2.5	100
VSC8541WZBRT-SV	QML_V	125	DOC204900	1403R125M0000CS	2.5	100
VSC8541XMVRT-HP	Hirel Plastic (-HP)	125	DOC204900	1403C125M0000CB	2.5	100

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