Components for CAN-based systems
Texas Instruments

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HiRel Products
Texas Instruments

Overview

- TI Space Overview
- TI Interface Products
  - CAN Transceiver: SN55HVD233-SP
- Distributed Telemetry
  - RTU & Microcontroller
  - Sensors
- Summary

TI in Space

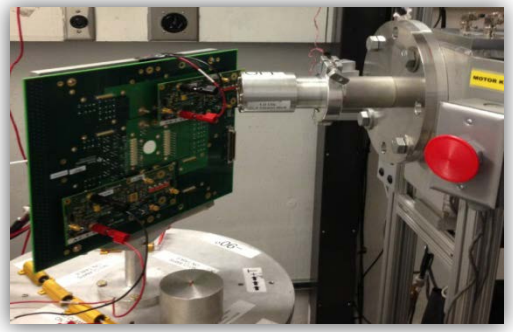
Texas Instruments

- Product **life cycles** that last 25 years+
  - No obsolescence for convenience
- A Global Company
  - **8** QMLV-certified Wafer Fabs and growing
  - Dozens of Design Centers around the Globe
  - Industry's largest Sales / Applications team in the Field
- TI investing to grow Space business
  - Space team size has doubled over the past three years
  - Re-investing in the entire space portfolio to bring more of the Space signal chain to market

50+ years experience in the Space Market

TI's Radiation Test Capability

- **Single Event Effects Testing (SEE)**
  - Quad-site motherboard connected to PXI system allows testing both destructive and non-destructive events:
    - Destructive - SEL, SEB, SEGR
    - Non-Destructive - SEU, SET, SEFI
  - In house capability and expertise ensures that future space products "-SP" will have the necessary data to fly in space
- **TID Testing (HDR and LDR)**
  - Production automated test setup is used for pre and post electrical testing for evaluating HDR and LDR TID degradation
    - Production test setup ensures coverage and reliability
  - TI's Co-60 source is leveraged to accelerate RHA releases for CMOS devices
- **Radiation Data and Support**
  - Radiation reports can be found at www.ti.com/radiation and under the individual product under technical documents

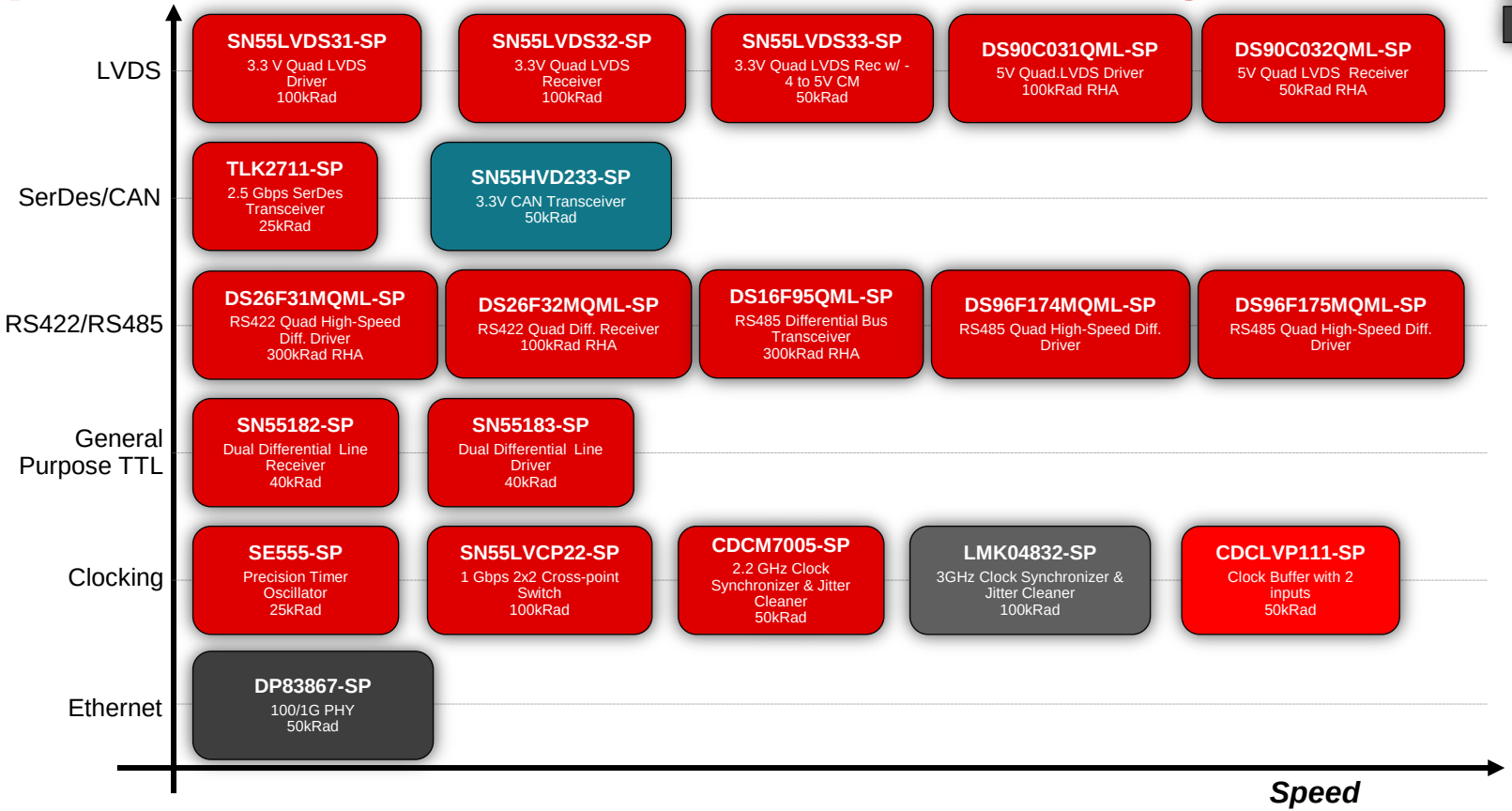


PXI System at TAMU

Co-60 HDR Gamma Cell

TI CAN Transceiver: SN65HVD233-SP

Space Qualified Interface and Clocking



SN55HVD233-SP

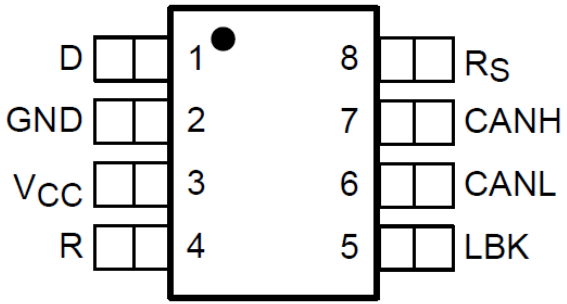
+3.3V CAN Transceiver

Features

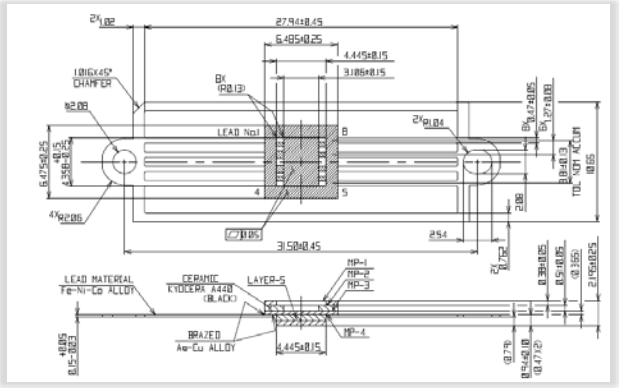
- Compatible with **ISO 11898-2**
- 5V tolerant I/O with 3.3V Supply
- Bus pin short-circuit protection to **±36V**
- ESD protection exceeds **16kV**
- Designed for signaling rates up to 1 Mbps
- Glitch free power up & power down protection
- Lowest standby current (600uA max)
- Low **Propagation delay**: 85 ns (LH), 120 ns (HL)
- Analog Slew Rate Control via RS pin
- -7V to 12V Common Mode Range
- 8 Pin CFP
- **ECCN: EAR99**
- Release to market: **December 2017**

Performance

- TID = 50kRad(Si) RHA (L-level)
- SEL Immune: LET 86 MeV.cm2/mg @ 125C
- QMLV certified

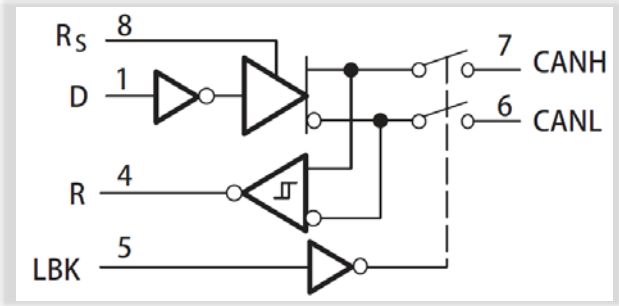


3.3-V CAN Bus Transceiver



Package

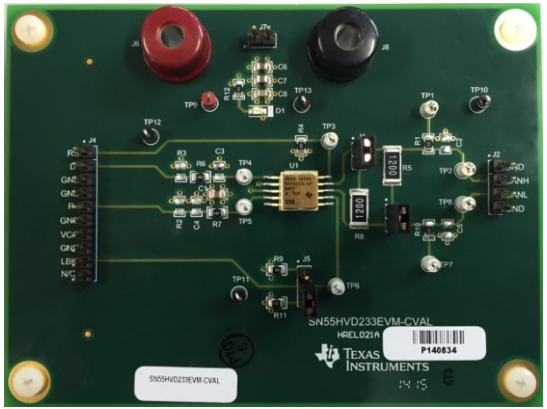
- 8-pin Ceramic HKX CQFP package
- 6.48 mm x 6.48 mm



Functional Block Diagram

- Compatible with the ISO-11898 specification
- **Diagnostic loopback:** redirects (D) → (R)
- **Harsh environments:** bus-pin fault protection > ±36 V

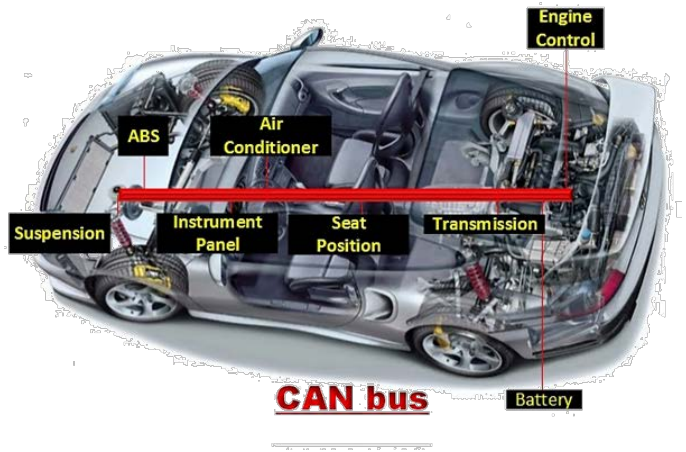
SN55HVD233-SP EVM



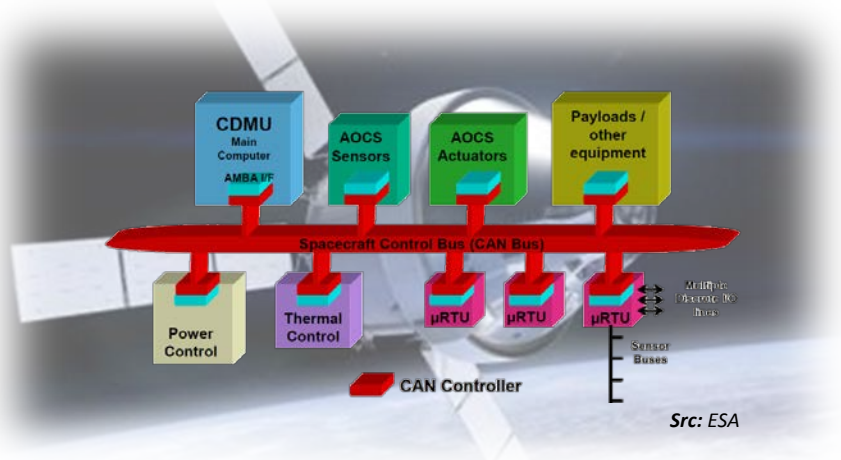
- EVM available at product release
  - SN55HVD233/EM installed by factory
  - Release to market: December 2017
- Benefits
  - Lab verification of CAN interface compatibility with FPGA, ASIC, or uC
  - Thermal testing
  - Debugging
  - Layout and Schematic reference for designing with TI Space CAN transceiver
  - EAR99 for easy shipment to Europe

Distributed Telemetry

System Architecture: Cars to Spacecraft



Src: *http://resources.infosecinstitute.com/future-now-car-hacking/#gref*

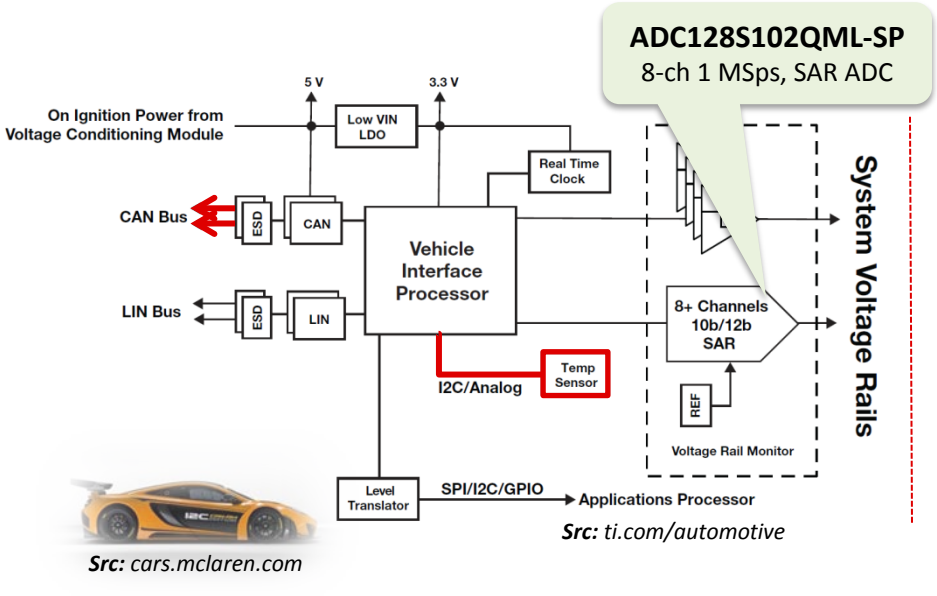


Src: *F.T. Lopez and P.Roos, A VHDL implementation of CANopen Protocol for CAN Bus On Board Spacecraft*

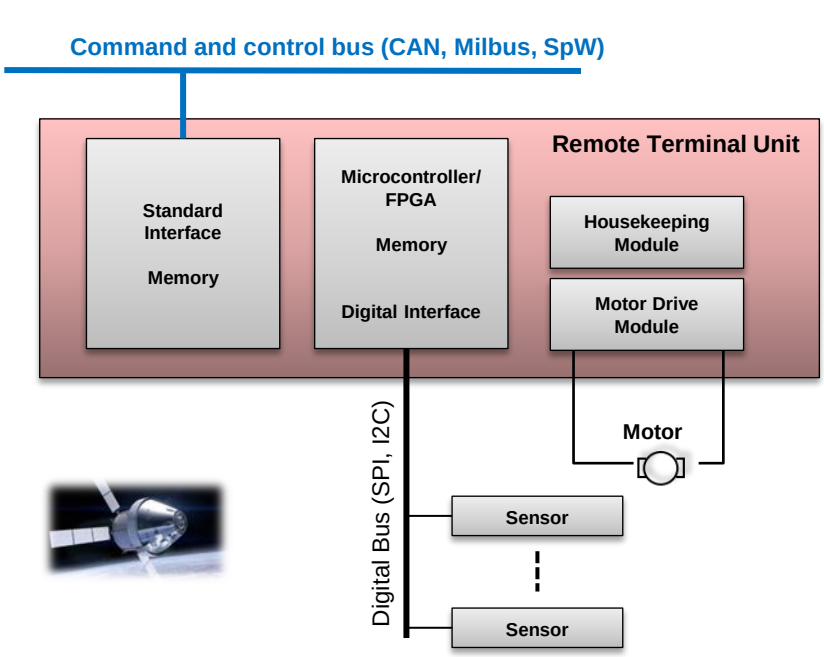
- **Car**: Engine control, Brakes, A/C, Transmission, Seat position, Instrument panel
- **Satellite**: AOCS Sensors & Actuators, Payload, Thermal control, Command & Data, …
- **CAN Bus**: Reliable bus standard with latency constraints

AOCS: Attitude, orbit control system

Automotive Interface Coexistence: CAN + I2C

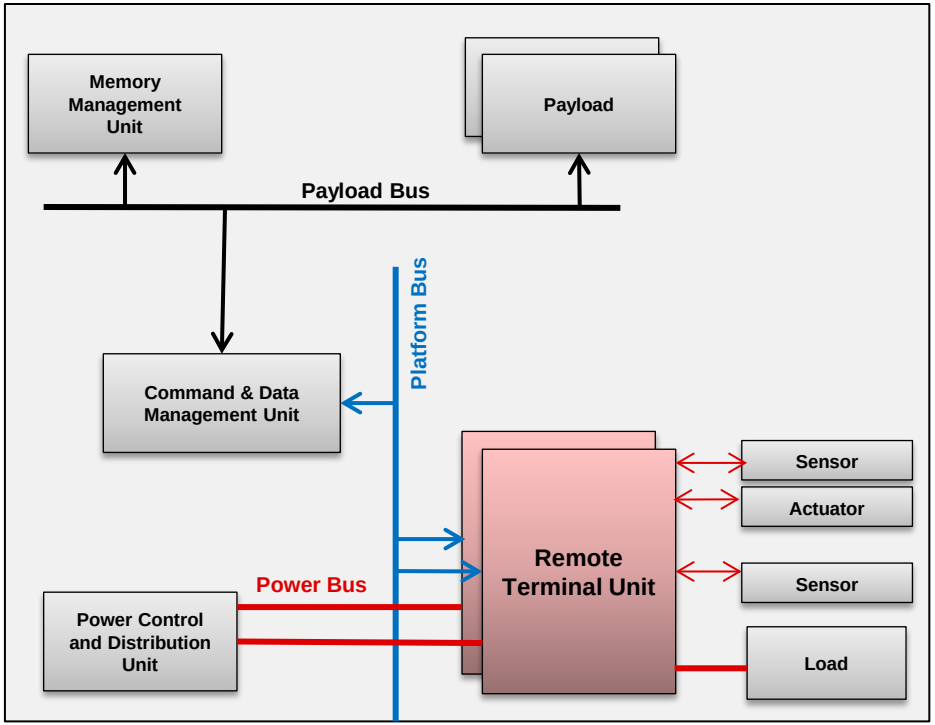


Src: cars.mclaren.com



- Vehicle interface processor (VIP):
  - Enable support power devices, system health monitoring – **temperature, voltage, and currents**
  - May be analogous to remote terminal units is spacecraft
- CAN bus and other interfaces (I2C/LIN) coexist in automotive designs

Microcontroller: Remote Terminal/Telemetry Unit



RTU interfacing to sensors and actuators, and controlling a load

- **RTU Functions:**
  - Gather from sensors (temp, pressure, digital status)
  - Signal conditioning for sensor data
  - Control AOCS actuators and sensors
  - Distribute power to heaters
- **Example: AOCS subsystem**
  - Acquires sensor data, control actuators
  - Distribute power to a load
- **MCU's enable "smart" RTU**
  - Reusable architecture across subsystems

MSP430FR5969-SEP

Radiation Tolerant MSP430 with FRAM

Features

- Ruggedized for space and radiation environments
- **16 MHz, 16-bit RISC CPU**
- Wide Supply Voltage Range 1.8V to 3.6V
- Ultra low power consumption: Shutdown Mode (LPM4.5): 0.32 uA
- Wake up from Standby Mode in 7µs
- **64KB FRAM** with free program code / data memory partitioning
  - Nearly infinite (10^{15}) write cycles
  - 160x faster than Flash (>2MB/s)
  - 250x less power in writes
- 2 KB SRAM
- **Signal conditioning**
  - ADC 12 bit, 16 channel: 200 ksps and 150uA consumption
  - PWM output
  - Analog comparator 15 channels, voltage hysteresis, reference generator
- **Package: 52 (48) TQFP AND QFN**

Applications

- Spacecraft distributed sensing & control

Radiation Performance

- TID = 50kRad(Si)
- SEL Immune to LET = 72 MeV.cm2/mg at 125 C

Benefits

- Key component of distributed sensing & control
- Unique capabilities in small form factor design
- Integrated signal conditioning & nonvolatile memory
- Guaranteed TID and SEL performance

Real Time JTAG ,
Embedded emulation, BSL

32x32 Multiplier
DMA (3 Ch), CRC16

Up to 3 1x8 + 1 1x3 I/O Ports
w/ Interrupt / wake up

Comp_D / Vref
ADC12(up to 16 ch)

64KB FRAM

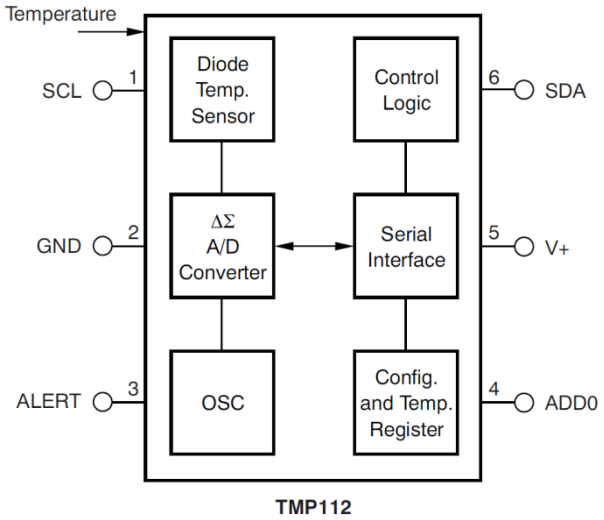
Watch Dog Timer, Timer 0_A3,
Timer1_B3, Timer2_A3,
Timer 3_B3, Timer 4_B3

2 UARTs or SPI
1 I2C or SPI

Power on Reset
Brownout Reset
Low Power Vreg (1.5V)
XT1, VLO
DCO (±2%), Real Time Clock

TMP112-SP*
I2C PCB Monitor Temp Sensor

Development

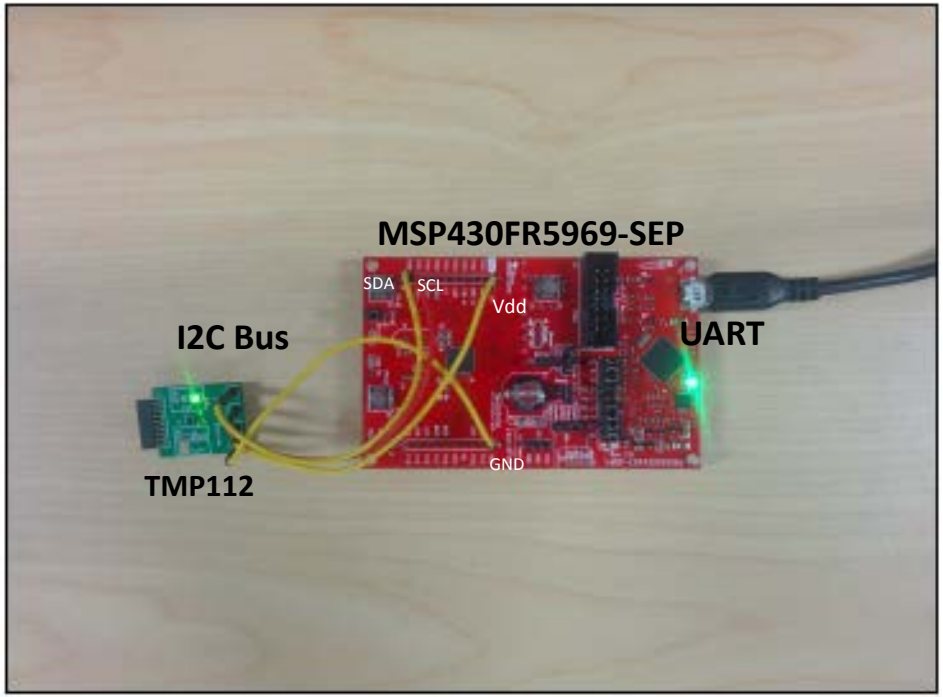


TMP112

- **High Accuracy**
  - 1.0°C (max) Accuracy From –40°C to+125°C
  - 0.5°C (max) Accuracy From -25°C to 85°C
  - True 12 Bit Resolution Measures Temp changes to 0.0625ºC
  - Highly accurate PSR through supply range: 0.0625ºC/V (typ)
- **Low Voltage & Low Power**
  - Vs=1.4V to 3.6V
  - 10µA Active, 1µA Shutdown
- **Ceramic LCCC package**
- **Radiation: SEL (85 MeV.cm2/mg at 125 C)**

* Part numbers and release dates are subject to change

Evaluation Boards in Action

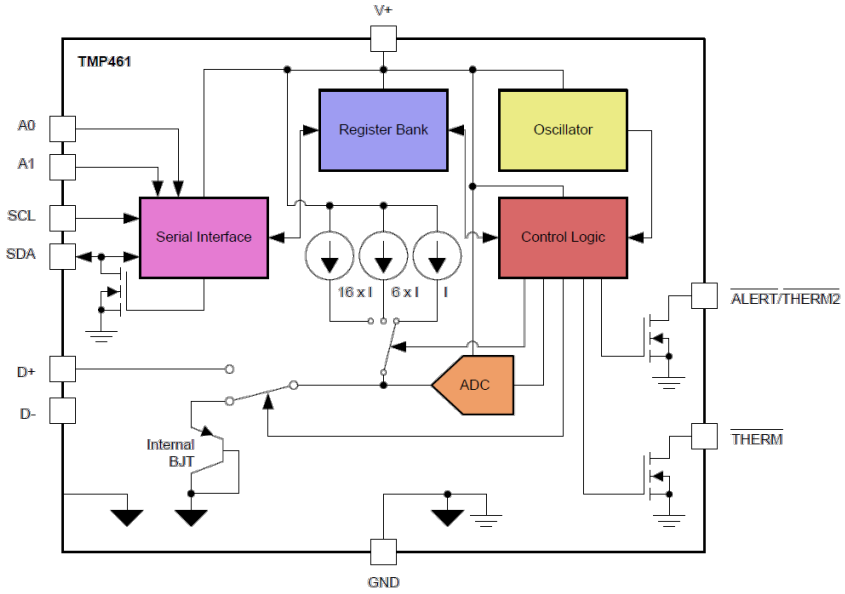


- **Radiation tolerant MCU**
  - MSP430FR5969-SEP
  - Nonvolatile memory
  - I2C interface
- **Digital temp sensor**
  - Space qualified (2018)
  - 12-bit ADC: 0.0625 C resolution
  - 1.4 V to 3.6 V Supply
  - 3 mm x 3 mm form factor

Development

TMP461-SP*

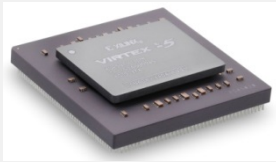
1.8V, High-Accuracy, Low-Power Remote Temp Sensor



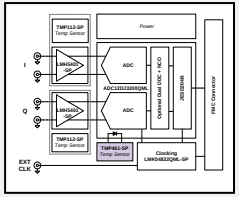
- Eliminates offset error due to series resistance
- Programmable non-ideality factor
- Programmable digital filtering
- Remote diode accuracy: +/- 0.75 C
- Local temp accuracy: +/- 1 C
- Resolution: Temp changes to 0.0625ºC
- 0.0625ºC/V (typ)
- Vs=1.7 V to 3.6V, 35 uA operating current
- Ceramic HKU package
- SEL (60 MeV.cm2/mg at 125 C), 50 kRad

* Part numbers and release dates are subject to change

TMP461-SP*: Remote Diode Temp Sensor

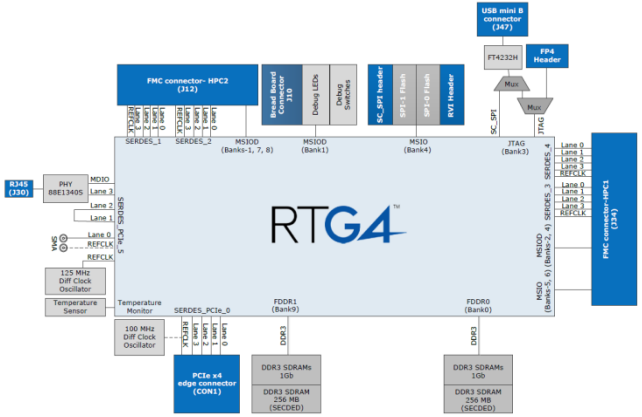


Rad-hard Xilinx Virtex 5QV



TI ADC12DJ3200QML:
Space Grade ADC

Texas Instruments



CubeSat Onboard Processing Validation Experiment using JPL Payload

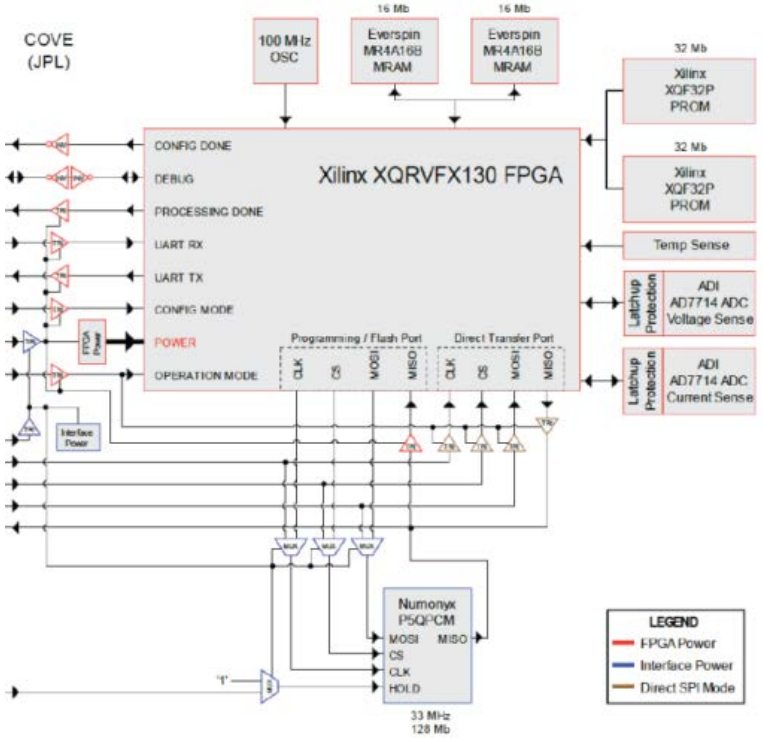


Figure 2. COVE Payload Block Diagram

* Part numbers and release dates are subject to change

Summary

- **CAN physical layer transceiver**
  - SN65HVD233-SP
  - 50 kRad TID, 86 MeV-cm2/mg
  - Available under EAR99
  - Pin-2-pin compatible with other transceivers in market

- **Distributed Telemetry**
  - Analogous to automotive system architecture
  - MSP430FR5969-SEP: Radiation tolerant microcontroller
  - Digital temperature sensors using I2C
  - Decentralized sensing for voltages, currents