TI Space Products
Innovating your space solution with leading-edge Rad Hard (RHA) and QMLV products

MIL-PRF-38535 QML
Class V Qualified

Radiation Hardness
Assured per MIL-STD-883 Method 1019

Single Event Effects
Characterized
**TI Space Products**
Texas Instruments offers the most comprehensive selection of leading-edge radiation hardness assured (RHA) and QMLV products for space flight. With a proven legacy of 60+ years in the space market and supporting countless space programs both domestically and internationally, TI is a trusted partner. We focus on radiation performance and best-in-class SWaP (Size, Weight, and Power) to enable leading-edge designs. The breadth of TI's space portfolio provides a full signal-chain solution. The portfolio includes the smallest RHA point-of-load power solutions, fast discrete SerDes and some of the world's highest performance data converters.

TI's Space products include MIL-PRF-38535 QML Class V and RHA components. These devices are typically supported with Total Ionizing Dose (TID) and Single Event Effects (SEE) test reports to address potential product degradation in a space environment. The test results for these devices are available in the product folder under the Technical documents tab.

**Satellite Applications**
- Satellite bus/platform
- General payload
- Communications payload
- Imaging payload
- Data processing and storage
- Telemetry sensors
- Inertial navigation (IMU/INS)
- Manned vehicles
- Launch vehicles
- Power generation and distribution
- Health monitoring

**TI Space Products Portfolio**
TI offers RHA and radiation-tolerant, hermetically packaged components highlighted in each of the red blocks to the right. TI also offers many of these space grade products in die form (known good die or tested die).

For a complete list of TI's Space Products, see [www.ti.com/space](http://www.ti.com/space).
To view this guide online, visit [www.ti.com/spaceguide](http://www.ti.com/spaceguide).
For detailed radiation training and information, please visit [training.ti.com/aerospace-defense-training-series](http://training.ti.com/aerospace-defense-training-series) or download our Radiation handbook for electronics.
Space Enhanced Plastics
Overview

In addition to the large QMLV selection, TI has begun to offer a leading-edge portfolio of plastic devices for Low Earth Orbit (LEO) missions with short mission life, and requirements for small size. This encompasses the emerging term, “New Space”, loosely defined as covering some of the trends in the space community, including the emerging private spaceflight industry and programs that have reduced reliability, lifetime and radiation requirements. There are unique challenges with the space environment such as radiation requirements, thermal cycling and outgassing. TI has addressed this with a new line of rigorously developed products, Space-Enhanced Plastics (SEP).

Space-EP devices offer the following advantages over standard catalog products:

- Controlled baseline with one wafer fab, one assembly site, one material set.
- Optimized material set with die attach, mold compound, leadframe and bond wire all selected to maximize reliability.
- No high tin (>97% Sn) construction including terminations (SnAgCu solderballs and Matte-Sn plating) or internal package components (die bumps or substrate plating).
- No copper bond wire. Product is either flipchip mounted (no bond wire) or uses gold bond wire.
- Additional assembly processing including 100% temperature cycle or 100% single-pass reflow simulation in lieu of temperature cycle.
- Characterization over target temperature range (–55°C to +125°C).
- Parametric testing is standard at both room and high temperatures with guardbands to assure datasheet limits at cold temperature.
- Assembly lot acceptance including x-ray sampling and CSAM sampling.
- Wafer lot acceptance using MIL-PRF-38535 QML Class V as baseline.
- Radiation Lot Acceptance Testing (Group E) to 20krad TID for each wafer lot per MIL-STD-883.
- One time characterization testing to 30krad TID per MIL-STD-883.
- SEL characterization to 43 MeV-cm²/mg.
- Outgassing qualification for each product per ASTM E-595.
- Qualification to SMC-SO-11.

Space applications require known radiation performance. Not only are TI Space-EP products characterized for total dose and single event radiation performance, but in many cases different wafer fabrication processes or alternate die designs are used to achieve specified levels of radiation tolerance. This is further ensured with a radiation lot acceptance test (RLAT or Group E) performed on each Space-EP wafer lot. An OEM may be tempted to characterize one lot of product and then assume that subsequent material will perform the same. This is not always true. Depending on the process technology, some devices exhibit a significant wafer lot to wafer lot variation and, in some cases, a wafer to wafer variation. Since traceability of Commercial Off The Shelf (COTS) material is only to the wafer lot level, it creates a substantial risk to the OEM.

Texas Instruments Space-EP provides a very cost effective means of mitigating the risks associated with using commercial off-the-shelf plastic encapsulated microcircuits. TI's approach, combining the best of the Enhanced Product methodology and Class V-like wafer processing, ensures a product that meets published specifications in critical space and launch vehicle applications, while providing small size and reduced system cost.

TI is currently offering five SEP devices, and is planning to offer many more in a variety of functions.

- **TLV1704-SEP** — 2.2-V to 36-V, radiation hardened microPower quad comparator in space-enhanced plastic
- **IN240-SEP** — 80-V, low-/high-side, zero-drift, current sense amp with enhanced PWM rejection in space-enhanced plastic
- **TL7700-SEP** — Voltage supervisor in space-enhanced plastic
- **TPS73801-SEP** — Radiation-hardened 1-A low-noise fast-transient-response LDO in space-enhanced plastic
- **SN55HVD233-SEP** — Radiation-hardened 3.3-V CAN transceiver in space-enhanced plastic package with standby mode

For more information on the device roadmap and offerings, please contact your TI representative, or reach out to TI through the E2E™ community or ti.com/sep.
Radiation-Hardened Power Management
Featured Products

1.5–7 VIN, 6 A, 35 mΩ On-Resistance Load Switch with Reverse Current Protection and Current Limiting
TPS7H2201-SP

Key Features
• VIN = 1.5 to 7 V, 6-A maximum current
• On Resistance (RON) of 35 mΩ max at VIN = 5 V at 25°C
• Reverse current protection
• Configurable rise time
• Low control input threshold enables use of 1.8-, 2.5- and 3.3-V logic
• Thermally enhanced 16-pin CDFP, 9.88 × 11.26 mm

Benefits
• RHA qualified and orderable as SMD: 5962R1722001VXC
• Highly integrated solution eliminating the need for discrete FETs for power management
• Controlled inrush current during system power-up
• Reverse current protection for cold-sparing applications
• Able to parallel for current sharing and reduced RON
• Low threshold enable compatible with multiple IO standards
• Over-current system protection with programmable fault timer

Radiation Performance
• TID = 100 krad RHA
• SEL, SEB and SEGR immune to LET = 75 MeV-cm²/mg

Applications
• Satellite power management and distribution
• Radiation-hardened and tolerant power-tree applications

More information at www.ti.com/product/TPS7H2201-SP

3–7 VIN, 12-A or Dual 6-A Output QMLV POL DC-DC Converter
TPS50602-SP

Key Features
• 2× TPS50601A-SP dice into single package
• Adjustable output voltage down to 0.8 V
• Precision reference accuracy (±1.5% over temp, line/load and TID)
• >90% overall efficiency at 6 A (VIN = 5 V, VOUT = 2.5 and 1.8 V)
• Current mode control and pre-bias startup capability
• 500-kHz fixed frequency
• Selectable softstart, external compensation, power good, enable, integrated tracking
• Thermally enhanced 64-pin CQFP, 16 × 14 mm

Radiation Performance
• TID = 100 krad RHA
• SEL, SEB and SEGR immune to LET = 75 MeV-cm²/mg

Applications
• Space satellite power management and distribution
• Radiation-hardened and tolerant power-tree applications

More information at www.ti.com/product/TPS50602-SP
Radiation-Hardened Power Management

Featured Products

3-A, Sink/Source DDR Termination Regulator with Built-In VTTREF Buffer

**TPS7H3301-SP**

**Key Features**
- Control input voltage: 2.5 and 3.3 V
- VLDO input down to 0.9 V
- Enable input and power good output
- 10-mA buffered VTTREF
- Source/sink VTT voltage output with droop compensation
- Thermally enhanced 16-pin CFP (HKR) package

**Radiation Performance**
- TID = 100 krad RHA
- SEL, SEB and SEGR immune to LET = 65 MeV-cm²/mg
- SET immune up to LET = 52.5 MeV-cm²/mg while supporting JEDEC DDR specifications

**Applications**
- Space payload processing and data storage
- DDR, DDR2, DDR3, LPDDR3 and DDR4 VTT memory termination and VREF buffer

**Benefits**
- RHA qualified and orderable as SMD: 5962R1422801VXC
- Meets DDR, DDR2, DDR3, LPDDR3 and DDR4 JEDEC specifications
- Smaller size than competing discrete solutions enabling very small form factor designs
- Outstanding SEE performance, VTT-VTTREF < ±5 mV (JESD8-9B standard is VTT-VTTREF < ±40 mV)
- Very low \( R_{\theta JC} = 0.6°C/W \)

More information at [www.ti.com/product/TPS7H3301-SP](http://www.ti.com/product/TPS7H3301-SP)

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3- to 7-\( V_{IN} \), 6-A, Monolithic Point-of-Load DC/DC Converter

**TPS50601A-SP**

**Key Features**
- \( PVIN = VIN = 3.0 \) V to 7 V
- 6-A maximum output current
- Min output voltage to 0.8 V
- Integrated 58-mΩ high-side and 50-mΩ low-side power FETs
- Adjustable frequency from 100 kHz to 1.0 MHz
- Parallel operation 180° out of phase with Sync pin
- Integrated tracking function
- \( R_{\theta JC} = 0.6°C/W \)
- Packaged in thermally enhanced 20-pin ceramic flatpack (HKH) and known good die (KGD)

**Radiation Performance**
- TID = 100 krad RHA
- SEL, SEB and SEGR immune to LET = 75 MeV-cm²/mg
- SET/SEFI onset 65 MeV-cm²/mg

**Applications**
- Satellite point-of-load (POL) power supplies

**Benefits**
- RHA qualified and orderable as SMD: 5962R1022102VSC (RHA) 5962R1022102V9A (KGD)
- 96.6% peak efficiency (\( V_{OUT} = 3.3 \) V) and low \( V_{OUT} \) optimized
- Excellent for driving 12-A current through current share
- Ease of implementing power sequencing schemes
- Best-in-class thermal performance
- WEBENCH® and PSpice models available

Radiation-Hardened Power Management

Featured Products

1.5- to 7-V_{IN}, 3-A Low-Drop-Out Regulator

**TPS7H1101A-SP**

**Key Features**
- \( V_{IN} = 1.5 \text{ V to } 7 \text{ V} \)
- Ultra-low dropout, PMOS pass device
  - 62 mV (typ) @ 1 A, 335 mV (Max) at 3 A
- Very-high accuracy = ±2%
  - Internal VREF = ±1.8%
- Ultra-low noise: 20.33 μVRMS
- PSRR: >45 dB at 1 kHz
- Programmable softstart and OCP (with current reading)
- Enable across all input voltages and Power Good output (for sequencing)
- Temperature range: –55°C to 125°C
- Packaged in thermally enhanced 16-pin ceramic flatpack

**Radiation Performance**
- TID = 100 krad RHA
- SEL immune to LET = 85 MeV-cm²/mg
- SET immune to LET = 52 MeV-cm²/mg

**Applications**
- Power management – LDO
- RF components VCOs, receiver, ADC's amplifiers
- High PSRR and low noise for clean analog-supply requirement applications

**Benefits**
- RHA Qualified: 5962R1320202VXC
- ELDRS Free
- High power savings with lowest \( V_{IN} \) on the market for LDO


Wide \( V_{IN} \) (2.3 to 20 V), 1.5-A Low-Drop-Out Regulator

**TPS7A4501-SP**

**Key Features**
- \( V_{IN} = 2.3 \text{ V to } 20 \text{ V} \)
- Adjustable output from 1.21 V to 20 V
- Optimized for fast transient response
- Low noise: 35 μVRMS (10 Hz to 100 kHz)
- High ripple rejection: 68 dB at 1 kHz
- No protection diodes needed
- Less than 1-μA quiescent current in shutdown
- Reverse battery and reverse current protection
- Thermally enhanced 10-pin CFP (HKU) package

**Radiation Performance**
- Total Dose (TID) = 100 krad RHA
- SEL immune to LET = 85 MeV-cm²/mg
- SET immune to LET = 75 MeV-cm²/mg for VOUT < 5%

**Applications**
- Power management — LDO
- Satellite point-of-load (POL) power supplies
- Satellite bus and payload

**Benefits**
- RHA qualified and orderable as SMD: 5962R1222403VXC
- Outstanding low-noise performance
- Widest input voltage range for a RHA LDO

### 3.3-V CAN Transceiver
**SN55HVD233-SP**

**Key Features**
- Compatible with ISO 11898-2
- Data rates up to 1 Mbps
- Extended –7-V to 12-V common mode range
- High input impedance allows for 120 nodes
- LVTTL I/Os are 5-V tolerant
- Unpowered node does not disturb the bus
- Temperature range: –55°C to 125°C
- Available in 8-pin 6.48 × 6.48-mm ceramic flat pack (HKX)
- Bus pins ESD protection exceeds ±16 kV HBM

**Radiation Performance**
- TID = 50 krad RHA
- SEL immune to LET = 86 MeV-cm²/mg

**Applications**
- Spacecraft backplane data bus communication and control
- Telemetry/Sensor data transmission
- CAN bus standards such as CANopen, DeviceNet, CAN Kingdom, ISO 11783, NMEA 2000, SAE J1939

**Benefits**
- RHA qualified and orderable as SMD: 5962L1420901VXC
- Thermal shutdown protection
- Adjustable driver transition times for improved signal quality


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### RS-485 Differential Bus Transceiver
**DS16F95QML-SP**

**Key Features**
- Designed for multipoint transmission
- Wide positive and negative input/output bus voltage ranges
- Thermal shutdown protection
- Driver positive and negative current-limiting
- High-impedance receiver input
- Receiver input hysteresis of 50 mV typical
- Operates from single 5.0 V supply
- Available in 10-pin ceramic flatpack

**Radiation Performance**
- TID = 300 krad RHA

**Applications**
- Satellite communication
- Defense electronics
- Radar and guidance systems

**Benefits**
- Orderable as SMD RHA: 5962F8961501VHA
- Meets EIA-485 and EIA-422A specifications
- Meets SCSI-1 (5 MHz) specifications
- RHA and QMLV qualified

**Other Drivers/Receivers in RS-485 Family (Tx, Rx, 3.3 V, 5 V)**
- **DS96F174MQML-SP** Quad high-speed differential driver
- **DS96F175MQML-SP** Quad high-speed differential receiver

More information at [www.ti.com/product/DS16F95QML-SP](http://www.ti.com/product/DS16F95QML-SP)
Octal, 128-kSPS, Simultaneous Sampling 24-Bit Delta-Sigma ADC

**Key Features**
- Simultaneous sampling of 8 inputs via independent 24-bit Delta-Sigma ADCs capable of converting up to 128 kSPS
- Bandwidth: 70 kHz
- Signal-to-Noise Ratio (SNR): 111 dB
- Total Harmonic Distortion (THD): –96 dB (Max.)
- Operating temperature –55 to 125°C
- 84-lead ceramic HFQ 10 mm × 10 mm

**Radiation Performance**
- TID = 75 krad, 50 krad RLAT
- SEL immune to LET = 69 MeV-cm²/mg (125°C)
- Follows RHA flow without SMD number

**Applications**
- Orbital observation systems
  - Satellite, shuttles, space stations, launchers
- Satellite sensing
- Space scientific instrumentation

**Benefits**
- Offers easy implementation of simultaneous analog-to-digital conversion for multiple inputs sourced from a wide range of transducers without the need of using an external multiplexer
- Allows accurate measurement of AC signals in the presence of noise; its highly linear transfer function provides high-fidelity and undistorted conversions
- Allows user to better resolve low-level signals found especially in the fields of satellite sensors

More information at [www.ti.com/product/ADS1278-SP](http://www.ti.com/product/ADS1278-SP)

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High-Resolution Delta-Sigma ADC

**Key Features**
- Very high resolution:
  - 130-dB SNR (250 SPS, G = 1)
  - 125-dB SNR (250 SPS, G = 16)
- Ultra linear
  - THD = –122 dB, INL = 0.5 ppm
- Two-channel input MUX
- Low power consumption: 25 mW (high-res); 10 µW (standby)
- Flexible digital filter (sync, FIR or IIR)
- Packaged in thermally enhanced CFP package

**Radiation Performance**
- TID = 50 krad RHA
- SEL immune to LET = 40 MeV-cm²/mg

**Applications**
- Orbital observation systems (e.g., satellite, shuttles, space stations, launchers)
- Satellite sensing
- Space scientific instrumentation

**Benefits**
- RHA qualified and orderable as SMD: 5962L1423101VXC
- Allows user to acquire wide dynamic-range signals in satellite-telemetry sensors
- Minimal distortion to convert signals for frequency-domain analysis and post processing
- Selectable digital filter assures a flexible design that will meet the requirements of the most demanding applications

Radiation-Hardened Data Converters

Featured Products

Dual-Channel, 14-Bit, 40-MSPS Analog Front End (AFE)  
**LM98640QML-SP**

**Key Features**
- Fully integrated signal-processing solution for imaging systems
- Correlated double sampling (CDS) or sample/hold (S/H) processing for CCD or CIS sensors
- Serialized LVDS outputs
- Dual lane at 16× sample rate or quad lane at 8× sample rate
- Programmable sampling edge up to 1/64th pixel period
- Programmable analog gain for each channel
- Programmable analog offset correction

**Radiation Performance**
- TID = 100 krad RHA
- SEL and SEFI immune to LET > 120 MeV-cm²/mg

**Applications**
- CCD arrays
- CMOS image sensors
- Earth observation
- Star tracker

**Benefits**
- RHA qualified and orderable as SMD: 5962R1820301VXC
- Enables digitization on the focal plane
- No cabling
- Reduced weight
- Low power consumption
- Meets space reliability requirements
- TID and SEU characterization data available for faster design in


12-Bit, Dual 3.2-GSPS or Single 6.4-GSPS, RF-Sampling Analog-to-Digital Converter (ADC)  
**ADC12DJ3200QML-SP**

**Key Features**
- JESD204B interface: Up to 12.8 Gbps and 16 lanes
- Digital down-converters: 2×–16× decimation
- Analog input bandwidth (–3 dB): 7 GHz
- Full-scale input voltage: 0.8 VPP
- Noise floor: –152.4 dBFS/Hz
- Noiseless aperture delay adjustment: 19-fs step size
- Easy-to-use synchronization features: SYSREF and timestamp
- Small LGA package: 15 mm × 15 mm
- Power consumption: 3.0 W

**Radiation Performance**
- TID: 300 krad RHA
- SEL immune to LET = 120 MeV-cm²/mg
- Single Event Upset (SEU) immune registers

**Applications**
- Wideband satellite communications
- RADAR/LIDAR
- Software-defined radio

**Benefits**
- The ADC12DJ3200QML provides direct RF-sampling up to at least 7 GHz and beyond
- All of the dual 3.2-GSPS or single 6.4-GSPS 12-bit data can be offloaded over 8 lanes of 12.8-Gbps JESD204B SERDES
- The data rate can be decimated and the signal down-converted on-chip using the optional DDC (digital down-converters)

More information at [www.ti.com/product/ADC12DJ3200QML-SP](http://www.ti.com/product/ADC12DJ3200QML-SP)
Radiation-Hardened Data Converters

Featured Products

8-Channel, 12-Bit, 50-kSPS to 1-MSPS ADC

**ADC128S102QML-SP**

**Key Features**
- Eight input channels
- $V_A$: 2.7 V to 5.25 V
- $V_D$: 2.7 V to $V_A$
- Only 2.3 mW of power at 3 V
- Power down 0.06 µW
- DNL: –0.5 to +0.9 LSB typical
- INL: ±0.9 LSB typical
- SPI digital output
- ADC addressing through CS decoder
- SPI/QSPI/MICROWIRE/DSP compatible
- Available in 16-pin ceramic SOIC, CFP and die

**Radiation Performance**
- TID = 100 krad RHA
- SEL and SEFI immune to LET > 120 MeV-cm²/mg

**Applications**
- Sensors
- Thermistors
- Motor control

**Benefits**
- Orderable as SMD: 5962R0722701VZA, 5962R0722701VFA and KGD 5962R0722701V9A
- Eight sensors can be monitored with one ADC
- All ADC serialized data shares the same input bus to onboard FPGA/ASIC
- Ultra-low power consumption
- RHA qualified for space applications
- TID and SEU characterization data available for faster design in


12-Bit Micro-Power DAC with Rail-to-Rail Output

**DAC121S101QML-SP**

**Key Features**
- Supply range: +2.7 V to +5.5 V
- Only 0.64 mW of power
- Power down < 1 µW
- Rail-to-rail voltage output
- Power-on reset to zero volts output
- SYNC interrupt facility
- Guaranteed monotonic
- DNL: +0.25/-0.15 LSB
- 3-wire 20-MHz SPI digital interface
- SPI/QSPI/MICROWIRE/DSP compatible
- Full-scale step settling time
- Available in a 10-pin ceramic SOIC

**Radiation Performance**
- TID = 100 krad RHA
- SEL and SEFI immune > 120 MeV-cm²/mg

**Applications**
- Sensors
- Thermistors
- Motor control

**Benefits**
- Orderable as SMD: 5962R0722601VZA
- Wide operating range
- Ultra-low power consumption
- RHA and QMLV qualified

More information at [www.ti.com/product/DAC121S101QML-SP](http://www.ti.com/product/DAC121S101QML-SP)
Radiation-Hardened Amplifiers
Featured Products

6.5-GHz, Low-Noise, Low-Power, Gain-Configurable Fully Differential Amplifier
LMH5401-SP

Key Features
• Gain bandwidth (GBW) of ~6 GHz
• 17,500 V/µs slew rate
• Gain >3 dB (externally set)
• Low harmonic distortion (SE-DE, 200Ω, G = 17 dB)
  • ~80/–80 DBC HD2/3 @ 500 MHz, 1 Vpp
• Low intermodulation distortion (SE-DE, 200Ω, G = 17 dB)
  • ~88 DBC IMD3 @ 500 MHz, 1 Vpp
• Output: 5.8 Vpp on 5-V supply
• Supply operation from 3.3 to 5.0 V @ 55 mA
• Power down
• Package: Flipchip Ceramic Leadless Chip Carrier, 5.5 mm × 6.0 mm

Benefits
• RHA orderable as SMD: 5962R1721401VXC
• Unprecedented usable bandwidth and application flexibility
  DC to 2 GHz
• Excellent linearity performance through 1 GHz
• Supports DC coupled operation, with either single or split supply operation
• Easy single-ended in to differential out conversion without external baluns
• Low power (280 mW on 5-V supply) makes it attractive for a variety of wide-band, high-dynamic-range applications
  where power and board space savings are desirable

Radiation Performance
• TID = 100 krad RHA
• SEL immune to LET = 85 MeV·cm²/mg at 125°C

Applications
• Balun replacement DC to 2 GHz
• GSPS ADC drivers
• Baseband, IF and RF gain blocks
• Level shifters

More information at www.ti.com/product/LMH5401-SP

Dual, High-Precision, Rail-to-Rail Output, Operational Amplifier
LMP2012QML-SP

Key Features
• Low guaranteed VIO over temperature: 60 µV
• No popcorn noise
• Low quiescent current: 1.2 mA/Ch
• Wide supply range: 2.7 V–5 V
• Low bias current: –3 pA
• Gain-bandwidth product: 3 MHz
• High slew rate: 4 V/µs
• Rail-to-rail output
• No external capacitors required
• Available in 10-pin ceramic SOIC

Benefits
• Orderable as SMD: 5962L0620602VZA
• Very stable – temp coefficient
• RHA and QMLV qualified

Radiation Performance
• TID = 50 krad RHA

Applications
• Satellites
• Gyroscopes
• Star trackers
• Reaction wheels

More information at www.ti.com/product/LMP2012QML-SP
Radiation-Hardened Amplifiers
Featured Products

Quad, High-Precision Op Amp

**OPA4277-SP**

**Key Features**
- Low offset voltage: 20 µV
- Low offset drift: ±0.15 µV/°C
- Voltage noise: 8 nV/√Hz @ 1 kHz
- Gain Band Width (GBW): 1 MHz
- Low quiescent current: 790 µA/Ch
- Wide supply range: ±2 V to ±18 V
- Low bias current: 17.5 nA (max)
- Available in KGD and CFP packages

**Radiation Performance**
- TID = 50 krad RHA
- SEL immune to LET = 85 MeV-cm²/mg

**Applications**
- Orbital observation systems (e.g., satellite, shuttles, space stations, launchers)
- Satellite sensing
- Space scientific instrumentation

**Benefits**
- RHA qualified and orderable as SMD: 5962L1620901VYC (CFP) and 5962L1620901V9A (KGD)
- High accuracy and stability for use in bridge-amplifier or transducer-amplifier applications
- Unity gain stable while providing excellent dynamic behavior over a wide range of load conditions
- Various packaging options provide design flexibility
- Excellent replacement for RH1013 or RH1014

More information at [www.ti.com/product/OPA4277-SP](http://www.ti.com/product/OPA4277-SP)

Radiation-Hardened Clock and Timing
Featured Products

3.3-V, 2.2-GHz, Low Phase Noise, Clock Synchronizer and Jitter Cleaner

**CDCM7005-SP**

**Key Features**
- VCXO_IN clock synchronized to primary or secondary reference clock inputs redundancy support with manual/auto selection
- Accepts LVCMOS input frequencies up to 200 MHz
- VCXO_IN frequencies up to 2.2 GHz (LVPECL)
- LVPECL and/or LVCMOS output combinations
- Output frequency is selectable by ×1, /2, /3, /4, /6, /8, /16 on each output individually
- SPI controllable device setting
- 3.3-V power supply
- Temperature range: −55°C to +125°C
- Available in 52-pin ceramic QFP (HFG) package

**Radiation Performance**
- TID = 50 krad
- SEL immune to LET = 80 MeV-cm²/mg

**Applications**
- Satellites
- Radar and guidance systems
- Defense electronics

**Benefits**
- Orderable as SMD: 5962-0723001VXC
- Wide input/output frequency range supports high/low end of frequency standards
- Flexible single and differential outputs
- Selectable input/output standards

More information at [www.ti.com/product/CDCM7005-SP](http://www.ti.com/product/CDCM7005-SP)
Radiation-Hardened Clock and Timing
Featured Products

1:10 LVPECL Buffer/Clock Distribution with Selectable Input
CDCLVP111-SP

Key Features
- 1:10 differential LVPECL clock outputs with frequency range from DC to 3.5 GHz
- Supply voltage range: 2.375 V to 3.8 V
- Low output skew: 15 ps (Typ)
- Input MUX
- Flexible input capability: LVDS, CML, SSTL, LVCMOS/TTL input compatible
- VBB reference voltage output for single-ended clocking
- Low additive jitter

Radiation Performance
- TID = 50 krad RHA
- SEL Immune LET = 69.2 MeV-cm²/mg

Applications
- Orbital observation systems (e.g., satellite, shuttles, space stations, launchers)
- Clock distribution

Benefits
- Orderable as SMD: 5962-1620701VXC
- Wide range supports various applications and use one single device across multiple designs
- Wide supply voltage saves additional cost on LDO
- Low skew ensures high-quality clock distribution
- Selectable input allows flexibility
- QMLV/RHA qualified to full mil temp (–55 to 125°C)

More information at www.ti.com/product/CDCLVP111-SP

Radiation-Hardened MCU
Featured Product

16-MHz Ultra-Low-Power Microcontroller with FRAM and 40 IO
MSP430FR5969-SP

Key Features
- Extremely low power consumption 16-bit RISC architecture:
  - 100 µA/MHz active
  - 0.02 µA shutdown, 0.4 µA standby
- 64 KB of non-volatile, Ferroelectric RAM (FRAM)
- Integrated peripherals for system housekeeping, telemetry
  - Real-time clock (RTC)
  - Five 16-bit timers
  - 16-channel analog comparator
  - 12-bit analog-to-digital converter (ADC)
  - Serial interfaces supporting UART, SPI, I²C
  - Multi-function I/O ports
- Support for 32-kHz crystals or internal clock sources
- 48-pin VQFN and TQFP plastic package for reduced size and weight

Radiation Performance
- TID = 50 krad (RLAT performed)
- SEL immune to LET = 72 MeV·cm²/mg

Applications
- Spacecraft distributed telemetry and housekeeping
- Sensor management and data logging
- Satellite remote terminal units

Benefits
- Reduced SWaP needed for system housekeeping functions
- Housekeeping/telemetry can be offloaded from FPGA
- Reusable RTU architecture across subsystems

More information at www.ti.com/product/MSP430FR5969-SP

Texas Instruments
TI Space Products Guide 2019 | 13
## Radiation-Hardened Sensor Products

### Featured Product

#### Very Wide Common Voltage Current Sense Amplifier with Split Stage for Filtering

**INA901-SP**

**Key Features**
- –15-V to 80-V common-mode range independent of supply
- 2.7-V to 16-V supply
- Split stages for filtering
- Bandwidth up to 130 kHz
- Gain: 20 V/V
- Package: Ceramic 8-lead HKX 6.5 mm × 6.5 mm

**Radiation Performance**
- TID = 100 krads RHA
- SEL immune to LET = 85 MeV-cm²/mg

**Applications**
- Current monitor for current-mode control DC-DC converter
- Current measurement in an H-Bridge for motor control
- Latching current limiters on high common-mode bus
- Current sensing on GaN modules for increased efficiency

**Benefits**
- Eliminates need for additional protective components in the event of CMR reversals
- Preserves buffered voltage output and saves using an additional op amp
- Simplifies design of current control loops
- Enables a flexible circuit design
- Will be orderable as SMD: 5962R1821001VXC

More information at [www.ti.com/product/INA901-SP](http://www.ti.com/product/INA901-SP)

#### Remote and Local Digital Temperature Sensor

**TMP461-SP**

**Key Features**
- Enables measurement of remote diode temperatures in the range of –64°C to +191°C
- Programmable calibration registers
- Remote diode temperature sensor accuracy: ±1.5°C
  - Local temperature sensor accuracy: ±2°C (across extended temperature range of –55°C to +125°C)
- Accuracy post calibration: ±0.1°C
- Supply and logic voltage range: 1.7 V to 3.6 V
- 35-μA operating current (1 SPS), 3-μA shutdown current

**Radiation Performance**
- TID = 100 krads RHA
- SEL immune to LET = 76 MeV-cm²/mg

**Applications**
- Spacecraft FPGA, ADCs, DACs and ASIC diode temperature monitoring
- Board temperature monitoring
- Spacecraft housekeeping and telemetry

**Benefits**
- RHA orderable as SMD: 5962R1721801VXC
- Thermal pad on bottom of package for low thermal resistance for board temperature monitoring
- Two-wire and SMBus™ serial interface compatible with pin-programmable address

More information at [www.ti.com/product/TMP461-SP](http://www.ti.com/product/TMP461-SP)
## Space-Grade Parts List

### Amplifiers + Comparators

<table>
<thead>
<tr>
<th>Generic Part Number</th>
<th>Description</th>
<th>RHA Version Available</th>
<th>Max TID (krad)¹</th>
<th>MAX SEL (MeV-cm²/mg)¹</th>
<th>Orderable Material</th>
<th>Subfamily</th>
<th>Pin</th>
<th>PKG</th>
<th>PKG Group</th>
<th>ECCN²</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF411QML-SP</td>
<td>Low offset, low drift JFET input operational amplifier</td>
<td>Yes</td>
<td>100</td>
<td></td>
<td>LF411MWGRMLLV</td>
<td>Operational amplifiers</td>
<td>10</td>
<td>NAC</td>
<td>CLGA</td>
<td>EAR99</td>
</tr>
<tr>
<td>LM111QML-SP</td>
<td>Voltage comparator</td>
<td>Yes</td>
<td>100</td>
<td></td>
<td>LM111WGRMLLV, LM111WLRMLLV, LM111HLRMILV, LM111J-8LRLMILV</td>
<td>Comparator</td>
<td>10</td>
<td>NAC</td>
<td>CLGA</td>
<td>EAR99</td>
</tr>
<tr>
<td>LM124AQML-SP</td>
<td>Low-power quad</td>
<td>Yes</td>
<td>100</td>
<td></td>
<td>LM124 MDE, LM124 MDR, LM124AWGRMLLV, LM124AWRQMLLV</td>
<td>Operational amplifiers</td>
<td>0</td>
<td>Y</td>
<td>DIESEL</td>
<td>EAR99</td>
</tr>
<tr>
<td>LM139QML-SP</td>
<td>Quad differential comparator</td>
<td>No</td>
<td>40</td>
<td></td>
<td>LM139 MDE, LM139 MDR, LM139AWGRMLLV, LM139AWRQMLLV</td>
<td>Comparator</td>
<td>0</td>
<td>Y</td>
<td>DIESEL</td>
<td>EAR99</td>
</tr>
<tr>
<td>LM158QML-SP</td>
<td>Low power, dual operational amplifier</td>
<td>Yes</td>
<td>100</td>
<td></td>
<td>LM158 MDE, LM158 MDR, LM158AWGRMLLV, LM158AWRQMLLV</td>
<td>Operational amplifiers</td>
<td>0</td>
<td>Y</td>
<td>DIESEL</td>
<td>EAR99</td>
</tr>
</tbody>
</table>

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## Space-Grade Parts List

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<thead>
<tr>
<th>Generic Part Number</th>
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<th>RHA Version Available</th>
<th>Max TID (krad)</th>
<th>Max SEL (MeV·cm²/mg)</th>
<th>Orderable Material</th>
<th>Subfamily</th>
<th>Pin</th>
<th>PKG</th>
<th>PKG Group</th>
<th>ECCN²</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM193QML-SP</td>
<td>Low power low offset voltage dual comparator</td>
<td>Yes</td>
<td>100</td>
<td>Bipolar</td>
<td>LM193 MDE&lt;br&gt;LM193 MDR&lt;br&gt;LM1933HRQMLV&lt;br&gt;LM1939HRQMLV&lt;br&gt;LM193AJ-QMLV&lt;br&gt;LM193AJRQMLV&lt;br&gt;LM193ARQMLV</td>
<td>Comparator</td>
<td>0</td>
<td>Y</td>
<td>DIESEL</td>
<td>EAR99</td>
</tr>
<tr>
<td>LM3170QML-SP</td>
<td>Dual high-speed, low power, low distortion voltage feedback amplifiers</td>
<td>Yes</td>
<td>100</td>
<td>Bipolar</td>
<td>LM6172 MDR&lt;br&gt;LM6172 MDE&lt;br&gt;LM6172AMGWQMLV&lt;br&gt;LM6172AMGWQMLV&lt;br&gt;LM6172JMFDQMLV</td>
<td>Operational amplifiers</td>
<td>0</td>
<td>Y</td>
<td>DIESEL</td>
<td>EAR99</td>
</tr>
<tr>
<td>LM7171QML-SP</td>
<td>Very high speed, high output current, voltage feedback amplifier</td>
<td>Yes</td>
<td>300</td>
<td>Bipolar</td>
<td>LM7171AMWGLOV&lt;br&gt;LM7171AMWGQMLV&lt;br&gt;LM7171AMWGQMLV&lt;br&gt;LM7171AMQMLV&lt;br&gt;LM7171AMQMLV&lt;br&gt;LM7171AMQMLV</td>
<td>Operational amplifiers</td>
<td>10</td>
<td>NAC</td>
<td>CLGA</td>
<td>EAR99</td>
</tr>
<tr>
<td>LM6628QML-SP</td>
<td>Dual wideband, low noise, voltage feedback op amp</td>
<td>Yes</td>
<td>300</td>
<td>Bipolar</td>
<td>LM6628WGQMLV&lt;br&gt;LM6628J-0MLV&lt;br&gt;LM6628J-0MLV&lt;br&gt;LM6628J-0MLV&lt;br&gt;LM6628J-0MLV&lt;br&gt;LM6628J-0MLV</td>
<td>Operational amplifiers</td>
<td>10</td>
<td>NAC</td>
<td>CLGA</td>
<td>EAR99</td>
</tr>
<tr>
<td>LM6671QML-SP</td>
<td>Dual wideband video op amp</td>
<td>Yes</td>
<td>300</td>
<td>Bipolar</td>
<td>LM6671JFQMLV</td>
<td>Operational amplifiers</td>
<td>8</td>
<td>NAB</td>
<td>CDIP</td>
<td>EAR99</td>
</tr>
<tr>
<td>LM6702QML-SP</td>
<td>1.7-GHz, ultra-low-distortion, wideband op amp</td>
<td>Yes</td>
<td>300</td>
<td>Bipolar</td>
<td>LM6702WGQMLV&lt;br&gt;LM6702WGQMLV&lt;br&gt;LM6702JG0MLV&lt;br&gt;LM6702JG0MLV&lt;br&gt;LM6702JG0MLV&lt;br&gt;LM6702JG0MLV</td>
<td>Operational amplifiers</td>
<td>10</td>
<td>NAC</td>
<td>CLGA</td>
<td>EAR99</td>
</tr>
<tr>
<td>LM7011QML-SP</td>
<td>Dual, high-precision, rail-to-rail output operational amplifier</td>
<td>Yes</td>
<td>50</td>
<td>77.5</td>
<td>LMP2012 MDE&lt;br&gt;LMP2012 MDR&lt;br&gt;LMP2012WGQMLV&lt;br&gt;LMP2012WGQMLV&lt;br&gt;LMP2012QML-SP</td>
<td>Operational amplifiers</td>
<td>0</td>
<td>Y</td>
<td>DIESEL</td>
<td>EAR99</td>
</tr>
<tr>
<td>OPA4277-SP</td>
<td>High-precision operational amplifier</td>
<td>Yes</td>
<td>50</td>
<td>85</td>
<td>5962L1620901VXC&lt;br&gt;5962L1620901VXC&lt;br&gt;OPA4277HFR/EM&lt;br&gt;5962L1620901VXA</td>
<td>Operational amplifiers</td>
<td>0</td>
<td>KGD</td>
<td>DIESEL</td>
<td>EAR99</td>
</tr>
<tr>
<td>OPA4277-SP</td>
<td>Rad-tolerant class V, wideband operational amplifier</td>
<td>No</td>
<td>150</td>
<td>Bipolar</td>
<td>5962-0721901VHA</td>
<td>Operational amplifiers</td>
<td>10</td>
<td>HKK</td>
<td>CFP</td>
<td>EAR99</td>
</tr>
<tr>
<td>OPA4277-SP</td>
<td>Rad-tolerant class V, wideband, fully differential amplifier</td>
<td>No</td>
<td>150</td>
<td>Bipolar</td>
<td>5962-0722201VFA</td>
<td>Operational amplifiers</td>
<td>16</td>
<td>HKT</td>
<td>CFP</td>
<td>EAR99</td>
</tr>
<tr>
<td>OPA4277-SP</td>
<td>Rad-tolerant class V, wideband, fully differential amplifier</td>
<td>No</td>
<td>150</td>
<td>Bipolar</td>
<td>5962-0722301VFA</td>
<td>Operational amplifiers</td>
<td>16</td>
<td>HKT</td>
<td>CFP</td>
<td>EAR99</td>
</tr>
<tr>
<td>TLC2210QML-SP</td>
<td>Space low-noise precision advanced LinCMOS™ single operational amplifier</td>
<td>No</td>
<td>–</td>
<td>–</td>
<td>5962-9088203V2A</td>
<td>Operational amplifiers</td>
<td>20</td>
<td>FK</td>
<td>LCCC</td>
<td>EAR99</td>
</tr>
</tbody>
</table>

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## Data Converters

<table>
<thead>
<tr>
<th>Generic Part Number</th>
<th>Description</th>
<th>RHA Version Available</th>
<th>Max TID (krad)1</th>
<th>MAX SEL (MeV-cm²/mg)1</th>
<th>Orderable Material</th>
<th>Subfamily</th>
<th>Pin</th>
<th>PKG</th>
<th>PKG Group</th>
<th>ECCN²</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC08D1520QML-SP</td>
<td>8-bit, dual 1.5-GSPS or single 3.0 GSPS, analog-to-digital converter (ADC)</td>
<td>Yes</td>
<td>300</td>
<td>120</td>
<td>5962F0721401VZC ADC08D1520WGF0V ADC08D1520WGMPR</td>
<td>Analog to digital converters</td>
<td>128</td>
<td>NBC</td>
<td>COFP</td>
<td>–</td>
</tr>
<tr>
<td>ADC10D1000QML-SP</td>
<td>Low power, 10-bit, dual 1.0 GSPS or single 2.0 GSPS A/D converter</td>
<td>Yes</td>
<td>100</td>
<td>120</td>
<td>ADC10D1000LOAZ ADC10D1000CCMLS ADC10D1000CCMPR</td>
<td>Analog to digital converters</td>
<td>256</td>
<td>PVA</td>
<td>CLGA</td>
<td>–</td>
</tr>
<tr>
<td>ADC12D1600QML-SP</td>
<td>12-bit, dual 1.6-GSPS or single 3.2-GSPS, analog-to-digital converter (ADC)</td>
<td>Yes</td>
<td>300</td>
<td>120</td>
<td>ADC12D1600CCMLS ADC12D1600CCMPR</td>
<td>Analog to digital converters</td>
<td>376</td>
<td>NAA</td>
<td>CCGA</td>
<td>–</td>
</tr>
<tr>
<td>ADC12D1620QML-SP</td>
<td>12-bit, dual 1.6-GSPS or single 3.2-GSPS, RF-sampling analog-to-digital converter (ADC)</td>
<td>Yes</td>
<td>300</td>
<td>120</td>
<td>ADC12D1620CCMLS ADC12D1620CCMPR</td>
<td>Analog to digital converters</td>
<td>376</td>
<td>NAA</td>
<td>CCGA</td>
<td>–</td>
</tr>
<tr>
<td>ADC12DJ3200QML-SP</td>
<td>12-bit, 3.2-GSPS or single 6.4-GSPS, RF-sampling analog-to-digital converter (ADC)</td>
<td>Yes</td>
<td>300</td>
<td>120</td>
<td>ADC12DJ3200V1XC ADC12DJ3200ZMX/EM</td>
<td>Analog to digital converters</td>
<td>196</td>
<td>ZMX</td>
<td>CLGA</td>
<td>–</td>
</tr>
<tr>
<td>ADC128S102QML-SP</td>
<td>8-channel, 50 kSPS to 1 MSPS, 12-bit A/D converter</td>
<td>Yes</td>
<td>100</td>
<td>120</td>
<td>5962R0722701V9A ADC128S102MDR 5962R0722701VZA ADC128S102WGMPR 5962R0722701VFA ADC128S102WQGV</td>
<td>Analog to digital converters</td>
<td>0</td>
<td>Y</td>
<td>DIESEL</td>
<td>–</td>
</tr>
<tr>
<td>ADC14155QML-SP</td>
<td>14-bit, 155-MSPS, 1.1-GHz input bandwidth analog-to-digital converter (ADC)</td>
<td>Yes</td>
<td>100</td>
<td>121</td>
<td>5962R0626001VXC ADC14155NB/A/EM ADC14155W-MLS ADC14155W-MPR</td>
<td>Analog to digital converters</td>
<td>48</td>
<td>NAB</td>
<td>COFP</td>
<td>–</td>
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<tr>
<td>ADS1278-SP</td>
<td>Radiation hardened 24-bit 8-ch simultaneous-sampling Delta-Sigma ADC</td>
<td>Yes</td>
<td>75</td>
<td>68</td>
<td>ADS1278MHOQ-MLS ADS1278WH Q-MLS ADS1278HFOQ/EM</td>
<td>Analog to digital converters</td>
<td>84</td>
<td>HFO</td>
<td>CFP</td>
<td>EAR99</td>
</tr>
<tr>
<td>ADS1282-SP</td>
<td>High-resolution analog-to-digital converter</td>
<td>Yes</td>
<td>50</td>
<td>40</td>
<td>5962L1423101VXC 5962L1423102VXC ADS1282HKE/EM</td>
<td>Analog to digital converters</td>
<td>28</td>
<td>HKV</td>
<td>CFP</td>
<td>EAR99</td>
</tr>
<tr>
<td>ADS5400-SP</td>
<td>12-bit, 1.0-GSPS analog-to-digital converter (ADC)</td>
<td>No</td>
<td>50</td>
<td>–</td>
<td>5962-0924001VXC ADS5400HFS/EM ADS5400MHFSV</td>
<td>Analog to digital converters</td>
<td>100</td>
<td>HFS</td>
<td>CFP</td>
<td>–</td>
</tr>
<tr>
<td>ADS5424-SP</td>
<td>14-bit, 125-MSPS analog-to-digital converter (ADC)</td>
<td>No</td>
<td>150</td>
<td>–</td>
<td>5962-0720601VXC ADS5424HFG/EM</td>
<td>Analog to digital converters</td>
<td>52</td>
<td>HFG</td>
<td>CFP</td>
<td>–</td>
</tr>
<tr>
<td>ADS5444-SP</td>
<td>13-bit, 250-MSPS analog-to-digital converter (ADC)</td>
<td>No</td>
<td>–</td>
<td>86</td>
<td>5962-0720701VXC ADS5444HFG/EM</td>
<td>Analog to digital converters</td>
<td>84</td>
<td>HFG</td>
<td>CFP</td>
<td>–</td>
</tr>
<tr>
<td>ADS5463-SP</td>
<td>12-bit, 500-MSPS analog-to-digital converter (ADC)</td>
<td>Yes</td>
<td>100</td>
<td>86</td>
<td>5962-0720801VXC ADS5463HFG/EM</td>
<td>Analog to digital converters</td>
<td>84</td>
<td>HFG</td>
<td>CFP</td>
<td>–</td>
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<tr>
<td>ADS5474-SP</td>
<td>14-bit, 400-MSPS analog-to-digital converter (ADC)</td>
<td>Yes</td>
<td>100</td>
<td>87</td>
<td>5962R1320801VXC ADS5474HFG/EM ADS5474MHFSV</td>
<td>Analog to digital converters</td>
<td>84</td>
<td>HFG</td>
<td>CFP</td>
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</tr>
</tbody>
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<th>Subfamily</th>
<th>Pin</th>
<th>PKG</th>
<th>PKG Group</th>
<th>ECCN²</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAC121S101QML-SP</td>
<td>12-bit micro power digital-to-analog converter with rail-to-rail output</td>
<td>Yes</td>
<td>100</td>
<td>120</td>
<td>DAC121S101 MDP</td>
<td>0</td>
<td>Y</td>
<td>DIESEALE</td>
<td>EAR99</td>
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</tr>
<tr>
<td>DAC121S101 MDP</td>
<td>12-bit micro power digital-to-analog converter with rail-to-rail output</td>
<td>Yes</td>
<td>100</td>
<td>120</td>
<td>DAC121S101 MDP</td>
<td>0</td>
<td>Y</td>
<td>DIESEALE</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>DAC121S101 MDR</td>
<td>12-bit micro power digital-to-analog converter with rail-to-rail output</td>
<td>Yes</td>
<td>100</td>
<td>120</td>
<td>DAC121S101 MDR</td>
<td>10</td>
<td>NAC</td>
<td>CLGA</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>DAC121S101WGMPR</td>
<td>12-bit, 2.4-GSPS, 1×–2× interpolating digital-to-analog converter (DAC) - QML-V qualified</td>
<td>No</td>
<td>100</td>
<td>–</td>
<td>DAC121S101WGMPR</td>
<td>5962-0724001VXA</td>
<td>Analog to digital converters</td>
<td>192</td>
<td>GEM</td>
<td>BGA</td>
</tr>
<tr>
<td>DAC121S101WGRLV</td>
<td>12-bit, 2.4-GSPS, 1×–2× interpolating digital-to-analog converter (DAC) - QML-V qualified</td>
<td>No</td>
<td>100</td>
<td>–</td>
<td>DAC121S101WGRLV</td>
<td>5962-0724002VXA</td>
<td>Analog to digital converters</td>
<td>52</td>
<td>HFG</td>
<td>CFP</td>
</tr>
<tr>
<td>DAC121S101WGRQV</td>
<td>12-bit, 2.4-GSPS, 1×–2× interpolating digital-to-analog converter (DAC) - QML-V qualified</td>
<td>No</td>
<td>100</td>
<td>–</td>
<td>DAC121S101WGRQV</td>
<td>5962-0724003VXA</td>
<td>Analog to digital converters</td>
<td>52</td>
<td>HFG</td>
<td>CFP</td>
</tr>
<tr>
<td>DAC5670-SP</td>
<td>14-bit, 2.4-GSPS, 1×–2× interpolating digital-to-analog converter (DAC) - QML-V qualified</td>
<td>No</td>
<td>100</td>
<td>–</td>
<td>DAC5670-SP</td>
<td>5962-0724701VXA</td>
<td>Analog to digital converters</td>
<td>52</td>
<td>HFG</td>
<td>CFP</td>
</tr>
<tr>
<td>DAC5670 MDR</td>
<td>14-bit, 2.4-GSPS, 1×–2× interpolating digital-to-analog converter (DAC) - QML-V qualified</td>
<td>No</td>
<td>100</td>
<td>–</td>
<td>DAC5670 MDR</td>
<td>5962-0724702VXA</td>
<td>Analog to digital converters</td>
<td>52</td>
<td>HFG</td>
<td>CFP</td>
</tr>
<tr>
<td>DAC5675A-SP</td>
<td>14-bit, 2.4-GSPS, 1×–2× interpolating digital-to-analog converter (DAC) - QML-V qualified</td>
<td>No</td>
<td>100</td>
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<td>Analog to digital converters</td>
<td>52</td>
<td>HFG</td>
<td>CFP</td>
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<tr>
<td>DAC5675AHFG/EM</td>
<td>14-bit, 2.4-GSPS, 1×–2× interpolating digital-to-analog converter (DAC) - QML-V qualified</td>
<td>No</td>
<td>100</td>
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<td>Analog to digital converters</td>
<td>52</td>
<td>HFG</td>
<td>CFP</td>
</tr>
<tr>
<td>LM98640QML-SP</td>
<td>Dual-channel, 14-bit, 40-MSPS analog front end with LVDS output</td>
<td>Yes</td>
<td>100</td>
<td>120</td>
<td>LM98640QML-SP</td>
<td>5962-0724705VXA</td>
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<td>52</td>
<td>HFG</td>
<td>CFP</td>
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<tr>
<td>LM98640W-MLS</td>
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<td>LM98640W-MLS</td>
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<tr>
<td>CDCLVP111-SP</td>
<td>1:10 high-speed clock buffer with selectable input clock driver</td>
<td>No</td>
<td>75</td>
<td>69</td>
<td>CDCLVP111-SP</td>
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<tr>
<td>CDCLVP111HFG/EM</td>
<td>1:10 high-speed clock buffer with selectable input clock driver</td>
<td>No</td>
<td>75</td>
<td>69</td>
<td>CDCLVP111HFG/EM</td>
<td>5962-1620702VXA</td>
<td>Clock buffer</td>
<td>36</td>
<td>HFB</td>
<td>EAR99</td>
</tr>
<tr>
<td>CDCM7005-SP</td>
<td>3.3-V high-performance rad-tolerant class V, clock synchronizer and jitter cleaner</td>
<td>No</td>
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<td>CDCM7005-SP</td>
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<td>52</td>
<td>HFG</td>
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<tr>
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<td>CFP</td>
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<tr>
<td>SE555-SP</td>
<td>QML class V precision timer</td>
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<td>25</td>
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<td>JG</td>
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</table>

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### Clock + Timing

<table>
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<tr>
<th>Generic Part Number</th>
<th>Description</th>
<th>RHA Version Available</th>
<th>Max TID (krad)</th>
<th>Max SEL (MeV-cm²/mg)</th>
<th>Orderable Material</th>
<th>Subfamily</th>
<th>Pin</th>
<th>PKG</th>
<th>PKG Group</th>
<th>ECCN²</th>
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<tbody>
<tr>
<td>LMX2615-SP</td>
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<td>1:10 high-speed clock buffer with selectable input clock driver</td>
<td>No</td>
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<td>69</td>
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<td>69</td>
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<td>HFB</td>
<td>EAR99</td>
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<tr>
<td>CDCM7005-SP</td>
<td>3.3-V high-performance rad-tolerant class V, clock synchronizer and jitter cleaner</td>
<td>No</td>
<td>50</td>
<td>–</td>
<td>CDCM7005-SP</td>
<td>5962-0723001VXC</td>
<td>Clock jitter cleaner</td>
<td>52</td>
<td>HFG</td>
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<tr>
<td>CDCM7005HFG/EM</td>
<td>3.3-V high-performance rad-tolerant class V, clock synchronizer and jitter cleaner</td>
<td>No</td>
<td>50</td>
<td>–</td>
<td>CDCM7005HFG/EM</td>
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<td>Clock jitter cleaner</td>
<td>52</td>
<td>HFG</td>
<td>EAR99</td>
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<tr>
<td>SE555-SP</td>
<td>QML class V precision timer</td>
<td>No</td>
<td>25</td>
<td>–</td>
<td>SE555-SP</td>
<td>5962-8855001VPA</td>
<td>Timer</td>
<td>8</td>
<td>JG</td>
<td>CDIP</td>
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</tbody>
</table>

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### Embedded Processing + Memory

<table>
<thead>
<tr>
<th>Generic Part Number</th>
<th>Description</th>
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<th>Max TID (krad)</th>
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<th>PKG</th>
<th>PKG Group</th>
<th>ECCN²</th>
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<tr>
<td>MSP430FR5969-SP</td>
<td>Radiation-hardened mixed-digital microcontroller</td>
<td>Yes</td>
<td>50</td>
<td>72</td>
<td>MSP430™ FRxx FRAM Products</td>
<td>48</td>
<td>PHP</td>
<td>HTOFP</td>
<td>EAR99</td>
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<tr>
<td>MSP430FR5969SRGZT</td>
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<td>Yes</td>
<td>50</td>
<td>72</td>
<td>MSP430™ FRxx FRAM Products</td>
<td>48</td>
<td>PHP</td>
<td>HTOFP</td>
<td>EAR99</td>
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</tr>
<tr>
<td>SMV512K32-SP</td>
<td>Floating-point digital signal processor</td>
<td>No</td>
<td>100</td>
<td>89</td>
<td>SMV512K32-SP</td>
<td>256</td>
<td>HFB</td>
<td>CFP</td>
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<td>EAR99</td>
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<tr>
<td>SMV512K32HFG/EM</td>
<td>Floating-point digital signal processor</td>
<td>No</td>
<td>100</td>
<td>89</td>
<td>SMV512K32HFG/EM</td>
<td>256</td>
<td>HFB</td>
<td>CFP</td>
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<tr>
<td>SMV512K32-SP</td>
<td>Floating-point digital signal processor</td>
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<tr>
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<td>Floating-point digital signal processor</td>
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<td>100</td>
<td>89</td>
<td>SMV512K32HFG/EM</td>
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<td>HFB</td>
<td>CFP</td>
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<td>EAR99</td>
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</tbody>
</table>

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## Space-Grade Parts List

### Interface

<table>
<thead>
<tr>
<th>Generic Part Number</th>
<th>Description</th>
<th>RHA Version Available</th>
<th>Max TID (krad)</th>
<th>MAX SEL (MeV-cm²/mg)</th>
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<th>Pin</th>
<th>PKG</th>
<th>PKG Group</th>
<th>ECCN²</th>
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</thead>
<tbody>
<tr>
<td>AM26LS33A-SP</td>
<td>QML class V quadruple differential line receivers</td>
<td>No</td>
<td>25</td>
<td>–</td>
<td>5962-7802007VEA</td>
<td>Differential driver/receiver (non RS-422/485)</td>
<td>16</td>
<td>J</td>
<td>CDIP</td>
<td>EAR99</td>
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<tr>
<td>SN16F950ML-SP</td>
<td>EIA-485/EIA-422A differential bus transceivers</td>
<td>Yes</td>
<td>300</td>
<td>Bipolar</td>
<td>DS16F95 MDR, DS16F9510V1HA, DS16F95WFQMLV</td>
<td>RS-232/422/485 products</td>
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<td>Y</td>
<td>NAD</td>
<td>CLGA</td>
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<tr>
<td>DS590C010ML-SP</td>
<td>Quad high-speed differential line drivers</td>
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<td>300</td>
<td>Bipolar</td>
<td>5962F7802302VFA, DS26F31MFQMLV</td>
<td>Differential driver/receiver (non RS-422/485)</td>
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<td>Y</td>
<td>NAD</td>
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<td>DS26F32MQML-SP</td>
<td>Quad differential line receivers</td>
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<td>Y</td>
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<td>CLGA</td>
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<td>DS90C031QML-SP</td>
<td>LVDS quad CMOS differential line driver</td>
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<td>100</td>
<td>120</td>
<td>DS90C031 MDR, DS90C031 WQMLV</td>
<td>LVDS/M-LVDS/ECL/CML products</td>
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<td>Y</td>
<td>NAC</td>
<td>CLGA</td>
</tr>
<tr>
<td>DS90LV031QML-SP</td>
<td>3-V LVDS quad CMOS differential line driver</td>
<td>No</td>
<td>–</td>
<td>–</td>
<td>DS90LV031AWGMLS</td>
<td>LVDS/M-LVDS/ECL/CML products</td>
<td>16</td>
<td>Y</td>
<td>NAC</td>
<td>CLGA</td>
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<tr>
<td>DS90LV032QML-SP</td>
<td>3-V LVDS quad CMOS differential line receiver</td>
<td>No</td>
<td>–</td>
<td>–</td>
<td>DS90LV032AW-MLS</td>
<td>LVDS/M-LVDS/ECL/CML products</td>
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<td>Y</td>
<td>NAC</td>
<td>CLGA</td>
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<tr>
<td>SN55HVD233-SP</td>
<td>Radiation hardness assured (RHA) 3.3-V CAN transceiver with standby mode, loop-back</td>
<td>Yes</td>
<td>50</td>
<td>86</td>
<td>5962L1420901VXC, HVD233HKV/EM</td>
<td>CAN products</td>
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<td>2x2 crosspoint switch: LVDS outputs</td>
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<td>100</td>
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<td>W</td>
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<td>SN55LVDS31-SP</td>
<td>Quad LVDS transmitter</td>
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<td>110</td>
<td>5962-9762101VFA</td>
<td>LVDS/M-LVDS/ECL/CML products</td>
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<td>W</td>
<td>CFP</td>
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</tr>
<tr>
<td>SN55LVDS32-SP</td>
<td>Quad LVDS receiver</td>
<td>No</td>
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<td>SN55LVDS33-SP</td>
<td>High-speed differential receiver</td>
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<td>LVDS/M-LVDS/ECL/CML products</td>
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<td>W</td>
<td>CFP</td>
<td>EAR99</td>
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<tr>
<td>TLK2711-SP</td>
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<td>No</td>
<td>25</td>
<td>67.9</td>
<td>5962-0522101VXC, TLK2711HFG/EM</td>
<td>Serializers, deserializers</td>
<td>88</td>
<td>HFG</td>
<td>CFP</td>
<td>EAR99</td>
</tr>
</tbody>
</table>

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## Space-Grade Parts List

### Power Management

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<tr>
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<th>Description</th>
<th>RHA Version Available</th>
<th>Max TID (krad)</th>
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<th>Subfamily</th>
<th>Pin</th>
<th>PKG Group</th>
<th>ECCN</th>
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</thead>
<tbody>
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<td>LM117HVQML-SP</td>
<td>Space-grade 60-V input 1.5-A adjustable output linear regulator / LDO</td>
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<td>Linear regulators (LDOs)</td>
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<td>Linear regulators (LDOs)</td>
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<td>EAR99</td>
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<td>2.5V reference diode</td>
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## Power Management (cont’d)

<table>
<thead>
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<th>Generic Part Number</th>
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1) Devices with “–” in the radiation data columns do not have updated detailed radiation data or reports
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Space-Grade Parts List

Power Management (cont’d)

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1) Devices with “–” in the radiation data columns do not have updated detailed radiation data or reports
2) ECCN information for products that are EAR99 are shown. For up-to-date ECCN information on any product, please request from: gtc_eccn-hts-naftateam@list.ti.com.
## Space-Grade Parts List

### Sensing

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### Logic

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## Space-Grade Parts List

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<th>Max TID (krad)(^1)</th>
<th>MAX SEL (MeV-cm(^2)/mg)(^1)</th>
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## Space-Grade Parts List

### Logic (cont’d)

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## Space-Enhanced Plastic Parts List

### Space-Enhanced Plastic Products

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<td>80-V, low-/high-side, zero-drift, current sense amp w/ enhanced PWM rejection in space-enhanced plastic package</td>
<td>INA240PMWPSEP, INA240PMWTPSEP, V62/18615-01XE, V62/18615-01XE-T</td>
<td>Current sense amplifiers</td>
<td>8 PW</td>
<td>TSSOP</td>
<td>EAR99</td>
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<td>SN65C1166EMPWSEP</td>
<td>Dual differential drivers and receivers with ± 8-kV IEC ESD protection in space-enhanced plastic</td>
<td>V62/18615-01XE, V62/18615-01XE-T</td>
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<td>TLV1704AMWPSEP, TLV1704AMWTPSEP, V62/18613-01XE, V62/18613-01XE-T</td>
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</tbody>
</table>

¹ ECCN information for products that are EAR99 are shown. For up-to-date ECCN information on any product, please request from: gtc_eccn-hts-naftateam@list.ti.com.

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