SPACE BRIEF

March 2024

Welcome to Edition 43 of our Space Brief newsletter. Space Brief is a quarterly newsletter that brings you the latest news about our Radiation-Tolerant (RT) and Radiation-Hardened (RH) products. It provides information about new products, updates on qualification and radiation testing, links to formal customer notifications and news about workshops and conferences where Microchip will be presenting or exhibiting. Space Brief is a great resource for design and system engineers, scientists and program managers in the space industry.

Feel free to forward Space Brief to your colleagues and let them know they can subscribe by visiting our Space Brief newsletter sign-up page.

Thank you,

The Microchip Aerospace and Defense Team

Table of Contents

Microchip Space Forum Survey

As we plan for future Space Forum events that cater to your interests and needs, we value your opinion. Whether you've previously attended or are a part of the space community, your feedback is important to us.

Please take a moment to share your thoughts and suggestions. Your input will help us continue delivering enriching and informative experiences for all space enthusiasts at future Space Forum events. Thank you for being a part of our journey and we look forward to hearing from you.

Radiation-Tolerant (RT) PolarFire® FPGA Now in Space

The first flight heritage of a new product is critical to proving its flight worthiness and is essential in many space program requirements. In 2023, RT PolarFire FPGAs were onboard the Space Development Agency's Proliferated Warfighter Space Architecture (PWSA) Tranche-0 Tracking Layer satellites to perform important functions in the satellite payload.

PWSA is the agency's layered network of military satellites and supporting elements in a proliferated Low Earth Orbit (pLEO) constellation of satellites. Tranche-0 satellites are the first in this constellation to demonstrate the low-latency communication links that support the warfighter with a resilient network of integrated capabilities, including tracking of advanced missile threats in Low Earth Orbit (LEO).

RT PolarFire FPGAs deliver low power and expanded logic density with high transceiver speeds of up to 12.7 Gbps. Unlike SRAM-based FPGA alternatives, these devices do not exhibit any configuration Single-Event Upsets (SEUs) in radiation and therefore do not require mitigation, which can reduce engineering expenses and Bill of Materials (BOM) costs. As an integral component in Tranche-0 Tracking Layer satellites, the Technology Readiness Level (TRL) of RT PolarFire FPGAs has been elevated to nine. The first flight heritage of RT PolarFire FPGAs adds to existing designations that the devices have previously achieved, including QML Class Q and MIL-STD-883 Class B qualifications.

Contact Minh Nguyen, space product marketing manager, at Minh.Nguyen@microchip.com for questions and comments.

Microchip Plays Pivotal Role in Aditya L1, JAXA SLIM and XPoSAT Missions

We are proud to provide reliable and quality products for ISRO's Aditya L1 (also known as the Sun Mission) and X-Ray Polimeter Satellite (XPoSAT) and JAXA's SLIM/XRISM (Moon Lander, X-Ray Telescope) missions.

The success of these missions depends on the legacy and reliability of space products, which must be low in Size, Weight and Power (SWaP) and tolerant to harsh radiation environments. Radiation effects such as Single-Event Latch-Ups (SELs) and Single-Event Upsets (SEUs) in the configuration memory can hamper the entire mission. Space engineers need to choose products such as individual diodes and transistors, highly integrated microcontrollers (MCUs), FPGAs, space-grade clocks, oscillators and DC-DC power converters.

Power and reliability are key to the success of space missions. Space engineers highly desire components with proven flight heritage; we've contributed various high-reliability, space-grade components to the success of these missions, which are critical to explore new frontiers for the benefit of humanity.

On Aditya L1 mission, Hon'ble Prime Minister of India Shri Narendra Modi said: "India creates yet another landmark. India's first solar observatory Aditya-L1 reaches its destination. It is a testament to the relentless dedication of our scientists in realising among the most complex and intricate space missions. I join the nation in applauding this extraordinary feat. We will continue to pursue new frontiers of science for the benefit of humanity."

Here are more details on the missions mentioned above:

Aditya-L1 Mission

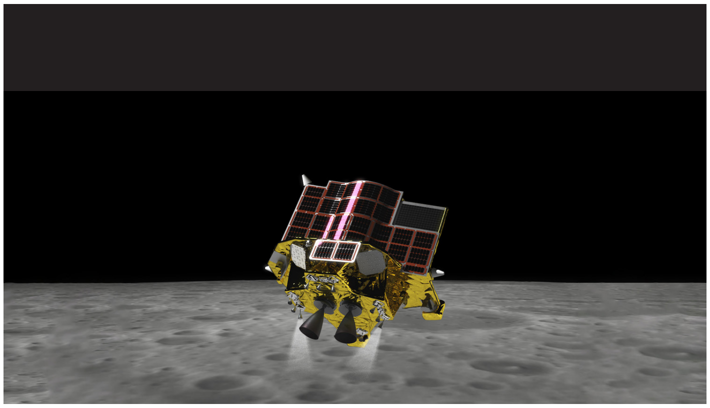
Aditya L1 is the first Indian space mission to study the Sun. The spacecraft is placed in a halo orbit around Lagrange point 1 (L1) of the Sun-Earth system, which is about 1.5 million kilometers from the Earth. This mission has seven payloads (VELC, SUIT, ASPEX, PAPA, SoLEXS, HEL1OS and a tri-axial, high-res digital magnetometer) to conduct studies of solar upper atmospheric dynamics, coronal heating, in-situ particles and plasma environments, magnetic field topology and more.

JAXA SLIM Mission

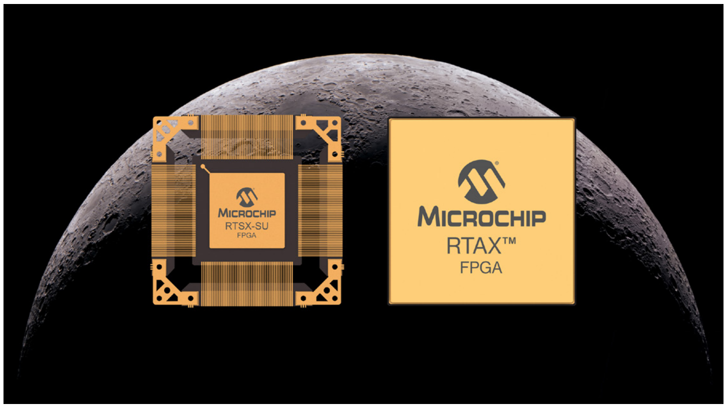
JAXA Smart Lander for Investigating Moon (SLIM) and X-ray Imaging and Spectroscopy (XRISM) are the first Japanese missions to the moon to demonstrate the accurate pinpoint landing techniques on the moon in smaller explorers. The mission will also study the origins of the moon and other planets using the lighter exploration system.

XpoSat Mission

X-Ray Polarimeter Satellite (XPoSat) is the first Indian space polarimetry mission to study the dynamics of bright deep space X-ray sources in extreme radiation conditions. The XPoSat spacecraft is designated for observation from LEO orbit of approximately 650 KM with a mission life of five years. This mission has two scientific payloads: primary payload Polarimeter Instrument in X-Rays (POLIX) is designed to measure polarimetry parameters in medium X-ray energy range of 8–30 keV photons and the secondary payload X-Ray Spectroscopy and Timing (XSPECT) payload, which will provide spectroscopic information in the range of 0.8–15 KeV.



JAXA SLIM Mission Image Courtesy: JAXA



For further information, please contact Puneet Kumar, business development manager, at Puneet.Kumar@microchip.com.

Our New Approach to Service New Space Market

In the past few years, the space industry has seen massive changes that are driven by New Space. The shift towards commercial spaceflight and large constellations of small satellites has driven down the total system cost and created new opportunities in various areas.

Typically operating in Low Earth Orbit (LEO), these small New Space satellites can be built for a fraction of the cost of a traditional spacecraft. These new space satellites are designed to last around five to eight years, compared to 15 to 20 years for traditional spacecraft.

The opportunities afforded by New Space mean that a company can create relatively quickly anything from its own IoT communications network, worldwide broadband Internet access or Earth observation system. One of the benefits is that creators get complete control over how their system is designed and operated.

Space-Grade Components in Plastic Packaging

Making this type of vision a reality is a seismic change in the way satellites are designed and built. Traditionally, those creating satellites have used high-end, space-grade electronic components assembled in ceramic packages.

Today's New Space designers are looking for low-cost plastic equivalents of the traditional space-grade components. But simply choosing a Commercial Off-the-Shelf (COTS) product and running electrical, mechanical or radiation test campaigns can be a risky and expensive exercise. Many COTS products are just simply not sufficiently robust enough for use in space and they pose higher risk for satellite designers. To bridge this gap, we are now offering plastic space-grade components at much lower costs than their traditional counterparts.

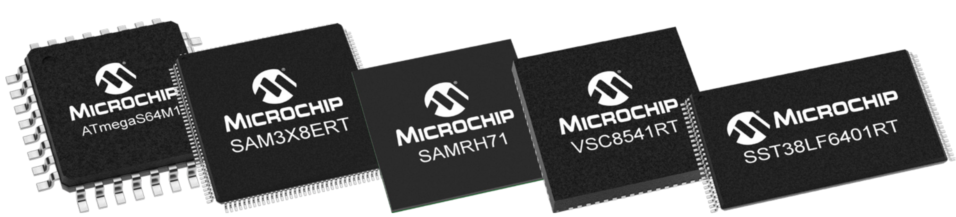
To help you make informed choices, we have an exciting update to enable access to our space-grade components in plastic packages. To facilitate opportunities asking for small volume on some of our Radiation-Tolerant (RT) and Radiation-Hardened (RH) parts, which are screened to the high-reliability plastic flow , we've decided to release constraints on quantity, allowing quotation and delivery by multiple of 10 parts. A minimum order quantity of 10 parts is now possible.

The applicable parts are listed below.

CATALOG PART NUMBER	CPN_DESC
AT17LV101-10JU-HP	1Mbit Serial Config. EEPROM-HP
ATMEGAS128-MD-HP	ATmegaS128 Rad Tolerant 8-bit Microcontroller - Plastic - HP
ATMEGAS64M1-MA-HP	ATmegaS64M1 Rad Tolerant 8-bit Microcontroller - Plastic - HP
MIC69303RTYME-HP	MIC69303 Rad Tolerant 3A, Low VIN, Single Supply Ldo - Plastic - HP
SAM3X8ERT-H8X-HP	SAM3X8ERT Rad Tolerant 32-bit Microcontroller - Plastic - HP
SAMD21J17DRT-V2X-HP	SAMD21 Rad Tolerant ARM Cortex-M0+ Microcontroller - Plastic - HP
SAMRH707F18B-4QB-HP	SAMRH707 Radiation Hardened 32-bit Microcontroller - Plastic - HiRel - HP
SAMRH71F20E-HFB-HP	SAMRH71 Radiation Hardened 32-bit Microcontroller - Plastic HiRel - HP
SAMV71Q21RT-H8X-HP	SAMV71Q21RT Rad Tolerant 32-bit Microcontroller - Plastic - HiRel - HP
SST26LF064-80-RT/SM-HP	SST26LF064 Rad Tolerant Memory - Plastic - HP
SST38LF6401-90-RT/TV-HP	SST38LF6401 Rad Tolerant Memory - Plastic - HP
VSC8540XMVRT-HP	VSC8540RT Fast Ethernet Phy - Plastic - HP
VSC8541XMVRT-HP	VSC8541RT Gigabit Ethernet Phy - Plastic - HP
VSC8541XMVRT-HP-BI	VSC8541RT Gigabit Ethernet Phy - Plastic - HP, with Burn-In
VSC8574RT-XKS-HP	VSC8574RT Rad Tolerant 4ports - Plastic - HP

In addition to these part numbers, we also offer lower-cost RT mixed-signal products and FPGAs in plastic packages.

For more information, please contact your local Microchip sales team.



SA50 Series Standard Radiation-Hardened DC-DC Converter for Space Power Solutions

Standard non-hybrid converter is available for easy customization to meet mission-specific needs.

To withstand harsh environments, space power converters must comply with various MIL standards. The power supplies used in the satellites also need to minimize size, weight, power and cost. We have more than 60 years of flight heritage in building space power products and can provide highly customized solutions for space power applications. Responding to the need of this market to provide standardized yet configurable power solutions, we offer the SA50 series of DC-DC radiation-hardened space power converters.

Our radiation-hardened SA50 series of DC-DC converters contains non-hermetic, non-hybrid converters that provide a galvanically isolated output of 50W. These modules are available in single- and triple-output configurations. Their export control classification is EAR99 and they are rated for a Total Ionizing Dose (TID) of 100 krad and a Linear Transfer Energy (LET) of 82 MeV/mg/cm2 to survive the toughest space missions.

The SA50-28 and SA50-120 series serve 28V and 120V bus systems, respectively. These SA50 space power converters can be used with our PolarFire FPGAs, microcontrollers (MCUs), LDOs, regulators and LX7720-RT motor control sensors for a complete electrical system solution. Designers can use these high-reliability radiation-hardened power solutions to greatly reduce system development time and mission risk.

Rad-Hard	TID 100Kk Rad SEE immunity 82 MeV-cm2/mg Qualified to Mil-Std-461, -883 and -202
High-Power	Scalable from 50W to 200W Small size Multiple outputs
High-Reliability	>8 x106 hours MTBF SMT construction with galvanic isolation Immunity from hot-jeopardy
Faster T2M	Standard modules for tailor-made needs Economies of scale for cost efficiency Schedule risk mitigation
High-Efficiency	Patented design to maximize performance Best in class efficiency Peak efficiency at full load
Greater Configurability	Paralleling and synchronization Companion EMI filter Flexibility to build customized solution

- 28V input (20V to 40V) for SA50-28 with external EMI filter SF200-28-28S
- 120V input (86V to 156V) for SA50-120 with built-in EMI filter
- Single outputs (3.3, 5, 12 and 28V)
- Triple outputs (3.3, ±12 or ±15V and 5, ±12 or ±15V)
- 50W per unit; four units can be paralleled for 200W
- 120-gram weight with small size (3.055″ × 2.055″ × 0.55″)
- Surface mount component design
- Inhibit, remote sense and synchronization
- UVLO, SC, OC/OV protection
- Mil-Std-883, -202 and -461
- Available off the shelf

Key applications include:

- Power conditioning units
- Electronic power converters
- Power distribution units
- System power bus converters
- Power processing units
- Ion propulsion thrusters

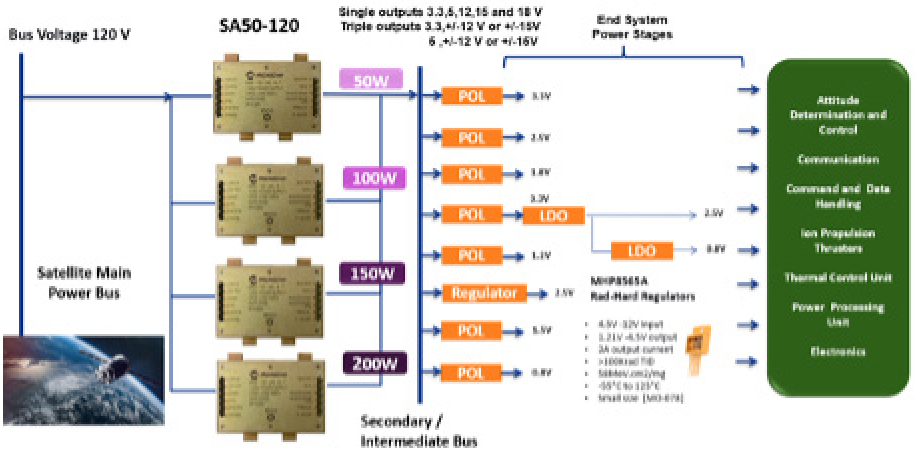


Figure: Simplified power architecture of satellite with SA50-120 series converter (built-in EMI filter) with Microchip's radiation-hardened regulator.

For further information, contact Amit Gole, product marketing manager, at amit.gole@microchip.com.

RTG4™ FPGAs With Lead-Free Bump Achieve QML Class Q Qualification

Products that have Qualified Manufacturers List (QML) designations are often the most trusted and readily accepted in space program designs. As designated by the Defense Logistics Agency (DLA), our RTG4 FPGAs with lead-free bump in Column Grid Array (CGA) and Land Grid Array (LGA) 1657-pin are now QML Class Q qualified. This certification is considered the gold standard in entry-level qualification, enabling designers to begin integrating RTG4 FPGAs into their space flight systems more easily. Because QML qualifications are standardized based on specific performance and quality requirements governed by the DLA, customers can streamline their design process by using QML-qualified products.

The following table lists all the available RTG4 FPGA DLA part numbers equivalent to B and E flows for the ceramic packaging. Refer to the DLA Cross Reference User Guide for the complete list of our Standard Microcircuit Drawing (SMD) part numbers.

DLA Part Number	Microchip Part Number
5962-1620828QXF	RT4G150-1CGG1657B
5962-1620829QXF	RT4G150-1CGG1657E
5962-1620832QXF	RT4G150-CGG1657B
5962-1620833QXF	RT4G150-CGG1657E
5962-1620836QXF	RT4G150L-CGG1657B
5962-1620837QXF	RT4G150L-CGG1657E
5962-1620830QZC	RT4G150-1LGG1657B
5962-1620831QZC	RT4G150-1LGG1657E
5962-1620834QZC	RT4G150-LGG1657B
5962-1620835QZC	RT4G150-LGG1657E
5962-1620838QZC	RT4G150L-LGG1657B
5962-1620839QZC	RT4G150L-LGG1657E

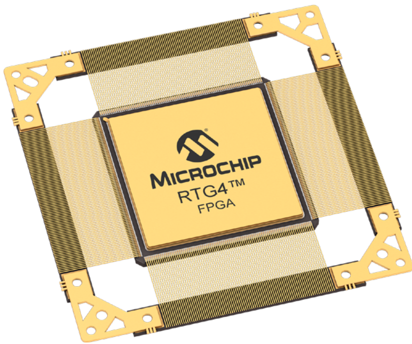
The next step for RTG4 FPGA family in CGG1657 packaging using lead-free bump is to achieve QML Class V qualification in the summer of 2024. Once the qualification is complete, the SMD numbers will be provided on the DLA website.

RTG4 FPGA CQG352 Lead-Free Bump Prototypes

We are thrilled to announce that RTG4 FPGA ceramic quad flat pack (CQG352) prototypes with lead-free bump are now available to order. They have gone through the full military temperature testing from −55°C to 125°C. The schedule for qualification on CQG352 is as follows:

- **CQG352 883B:** Expected first half of 2024, when CQG352 B-flow and E-flow orders can be placed using Microchip part numbers
- **CQG352 QML-Q and QML-V:** Expected in summer 2024, when CQG352 flight orders can be placed using DLA part numbers

Please be advised that the standard lead times will apply after completing the qualification.



As a reminder, the flip-chip bump is inside the FPGA package so there will be no impact to your design, reflow profile, thermal management or board assembly flow when converting to lead-free bump RTG4 FPGAs. RTG4 FPGAs in plastic packages (FC1657 and FCG1657) and RT PolarFire® FPGAs have always used the lead-free flip-chip bump.

For questions and comments, please contact Kritika Gautam, product marketing engineer, at kritika.gautam@microchip.com.

Reliability Report for Radiation-Tolerant (RT) FPGAs

Similar to our radiation reports, the reliability reports for our FPGA and SoC products are secured behind myMicrochip; the documents can be requested through our portal.

The reliability reports are comprehensive reports that show key reliability parameters such as FIT rate, ESD performance, silicon reliability life test data and package reliability data for all our FPGA families and mixed-signal products. Each page of the report contains a watermark that shows contact name, company and download date. Therefore, individual users are encouraged to apply for access to download their own copy of the report.

For questions and comments, please contact Kritika.Gautam@microchip.com.

RTAX-S/SL and RTAX-DSP Radiation-Tolerant FPGA Data Sheet Update

The data sheet for RTAX-S/SL and RTAX-DSP radiation-tolerant FPGAs has recently been updated. The latest ordering information, package thermal characteristics and screening flows are now available. For questions and comments, please contact Kritika Gautam, product marketing engineer, at kritika.gautam@microchip.com.

Mixed-Signal Power Protection ICs for Space

We continue to focus on radiation-hardened-by-design mixed-signal power protection ICs for space applications. Our initial offering occurred over a decade ago with the AAHS298B 8-channel high-side driver and the LX7710 eight-pair diode array. Both are QML-V and QML-Q certified and continue to be designed into new spacecraft programs with extensive and growing flight heritage.

The AAHS298B includes eight non-inverting channels that can be used to provide an interface from TTL level, 5V or 12V logic systems to relays, stepper and servo motors, solenoids and other loads. Each output is capable of sourcing 700 mA with a with-standing voltage of 50V, allowing manufacturers to develop more compact solutions. It includes an internal thermal shutdown feature to protect against over-current and soft-start occurrences. Additional features include:

- Single-Event Latch-Up (SEL) immunity to 117 MeV.cm^2/mg and 125°C (fluence of 107 particles/cm^2)
- Low-quiescent current consumption
- Internal ground clamp diodes
- Output breakdown voltage of 50V (minimum)
- Transistor-Transistor Logic (TTL), 5V and 12V logic compatibility

The LX7710 consists of eight series connected diode pairs that provide redundant protection should one fail in a short circuit event, ensuring reliability even in harsh space environments. The diodes within the Integrated Circuit (IC) are Electrostatic Discharge (ESD) protected, offer a minimum of 125 volts (V) breakdown voltage and can handle up to 700 milliamps (mA) of continuous current. Additional features include:

- Low leakage current
- Radiation tolerant to 100 krad (Si) TID
- Inherent latch-up immunity due to no power pin

Check out updated data sheets and radiation test reports along with information about our other mixed-signal ICs for space, including new power switch ICs.

For more information, please contact Dorian Johnson, product marketing manager, at Dorian.Johnson@microchip.com.

Overcoming Satellite Communication Challenges With GaN-on-SiC Power Amplifiers

RF systems need power amplifiers to deliver efficient, high-output linear power. As systems move to higher-order modulation schemes such as 64/128/256 Quadrature Amplitude Modulation (QAM), they must also deliver high linearity and efficiency in denser environments with stringent Peak-to-Average Power Ratio (PAPR). A new generation of Gallium Nitride (GaN)-on-Silicon Carbide (SiC) Monolithic Microwave Integrated Circuit (MMIC) PAs offers a solution to these challenges with the highest power density to generate efficient, high linear output power. This article goes into the requirements of 5G, satellite communication and aerospace and defense applications and how GaN-on-SiC PAs are overcoming the communication challenges in these RF applications.

RF Power Amplifier Opportunities and Challenges

The biggest growth opportunities and challenges for RF power amplifiers are in satellite communications. NASA has enabled private sector companies to launch thousands of Low Earth Orbit (LEO) satellites that are now circling the Earth and delivering broadband Internet access, navigation, maritime surveillance, remote sensing and other services. These RF applications consistently seek Size, Weight, Power and Cost (SWaP-C) benefits. Large dish antennas are being replaced with phased array antennas for satellite communications that require smaller size components for integration and lower weight components. High RF power, which is linear with high P1dB and IP3, to reduce distortion and is efficient with high PAE to minimize power consumption, is essential for these RF applications.

Satellite Communication Application

Geosynchronous satellites orbit 35800 km away from the Earth and LEO satellite constellations orbit less than 2000 km. There are data gateways connecting to the satellite constellation providing content and satellites communicating with the customer premise equipment at user homes.

Geosynchronous satellites have been providing connectivity in flights and airborne vehicles and on the ground in different parts of the world. Now with LEO satellite constellations, such as Starlink®, that are being deployed, there is exponential growth in LEO satellites with over 3,000 mass-produced small satellites in LEO from Starlink providing internet access to over million subscribers.

Satellite Communication RF Signal Chain

Earth stations transmit the uplink signals to satellites at a higher operating frequency, while satellites must transmit the lower operating frequency to be cost effective. Downlink signals from the satellite are received at the ground terminal and are selected using the band pass filter or a diplexer. Since it is received from the satellite, this signal is very small and is amplified using a low-noise amplifier, which is converted from RF frequency to baseband frequency using a mixer for signal processing. Some of the other components in the RF signal chain are filter banks, switches to select the RF signal, variable attenuators for signal conditioning, phase frequency detectors and prescalers to generate the local oscillator PLL frequency to transform the signal from RF to baseband.

On the transmit side, the baseband signal is up converted to RF frequency using a mixer and is amplified using a Power Amplifier to generate large output signal at RF frequency, which is then transmitted to the satellite as an uplink signal.

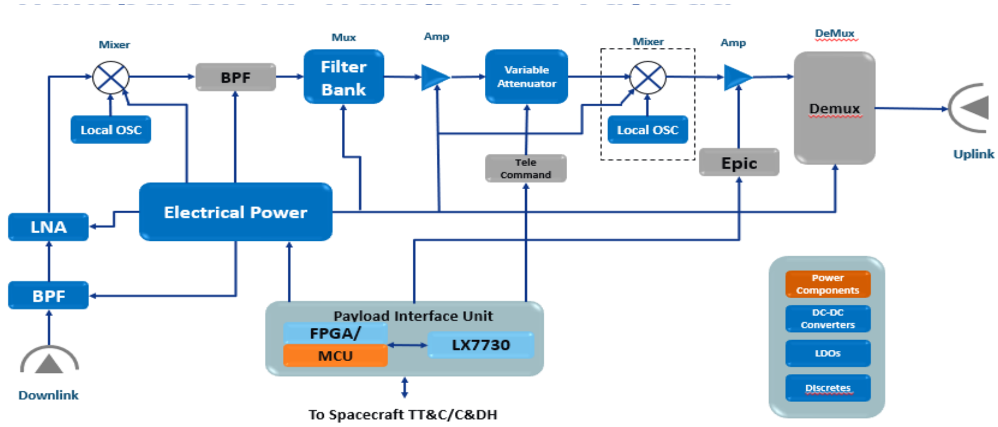


Figure 2: Satellite Communication RF Signal Chain

Component Selection for Satellite Communication Space Applications

We have over forty years of space heritage with RF components in various applications such as RF switching, communication data links, SAW filters and VCSOs. Our space solutions include Power Amplifiers, low-noise amplifiers, switches, voltage variable attenuators, diodes, SAW filters and VCSOs. We offer Commercial-Off-the-Shelf (COTS) RF components and RF components that are screened to radiation-tolerant or radiation-hardened specifications. GaAs HEMT transistors and GaN-on-SiC MMICs are developed on processes capable of radiation-hardened screening. Our diode products are developed on processes with space heritage. The diodes can be screened to MIL 750/883/19500/38534, ESA ESCC 5010 or to customer-provided specifications. Hermetic packages are available for most diodes. We have a long history of space heritage with SAW filters that have been used for space applications with screening capabilities per ESCC3502, MIL-PRF 38534 or other customer-provided standards. SAW filters have radiation tolerance up to 100 krad.

Parameter	COTS	Radiation-Tolerant	Radiation-Hardened
Radiation Tolerance	Under 1 krad (Si)	15 to 50 krad (Si)	Over 100 krad (Si)
Qualification	Industrial Temp. Range (−40°C to +85°C)	Characterized for radiation tolerance levels	NASA EEE-INST-002 componen t qualification
Mission Longevity	COTS for short duration mission	Longer duration missions	Extremely long missions
Manned/Unmanned	Not used for critical manned missions	Used in manned missions	Used in manned missions
Earth Orbit	Used in some LEO missions	Used for GEO, MEO, LEO	Used for GEO, MEO, LEO
Cost	Less expensive	More expensive	Significantly more expensive

Figure 3: COTS Versus Radiation-Tolerant Versus Radiation-Hardened RF Components

Power Amplifier (PA) Requirements

Power Amplifiers (PAs) play a key role as the transmitter in RF applications. One of the biggest PA requirements is that it can operate in its linear region to minimize RF distortion. Satellite communication systems that use higher-order modulation schemes such as 64/128/256 Quadrature Amplitude Modulation (QAM) are extremely sensitive to non-linear behavior. Another challenge is achieving satisfactory Peak-to-Average Power Ratio (PAPR)—that is, the ratio of the highest power the PA will produce to its average power. PAPR determines how much data can be sent and is proportional to the average power. At the same time, the size of the PA needed for a given format depends on the peak power. 5G mmWave Effective Isotropic Radiated Power (EIRP) requirements mandated by FCC include 43 dBm EIRP transmit power for mobile handsets and base station transportable power of 55 dBm EIRP. These and other conflicting challenges can only be met with GaN-on-SiC power amplifiers for satellite communication, 5G, aerospace and defense applications.

Gallium Nitride (GaN)-on-Silicon Carbide (SiC) PAs

GaN-on-SiC has high power density to generate high linear output power with high efficiency. GaN-on-SiC power amplifiers can operate at high frequencies in the Ka and Ku bands from 12 GHz to 40 GHz for satellite communication and 5G. They can also have broad bandwidths and high gain with better thermal properties to meet the requirements of RF applications. We provide RF solutions using GaN-on-SiC technology that meet the SWaP-C requirement for components. ICP2840 is a flagship device that operates in 27.5–31 GHz, providing Continuous Wave (CW) output power of 9 watts and pulsed output power of 10 watts with a gain of 22 dB and power added efficiency of 22%.

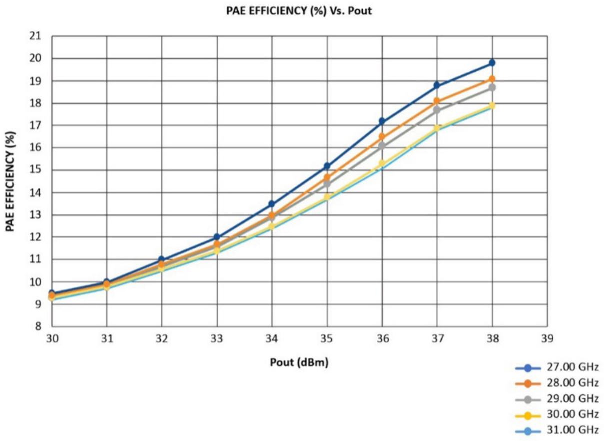


Figure 4: ICP2840 Linear PAE Across Frequency and Output Power Levels

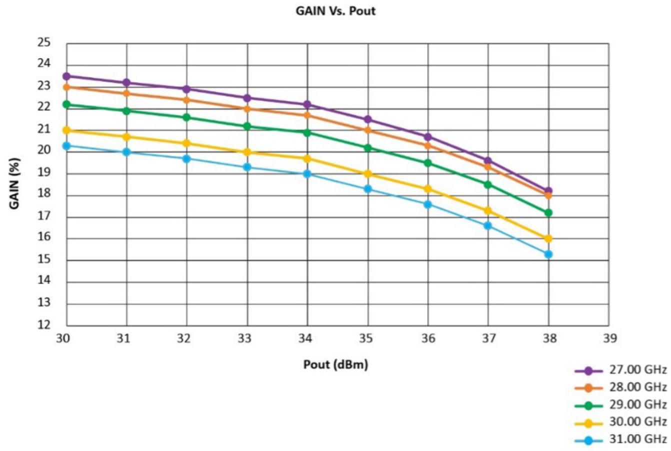


Figure 5: ICP2840 Linear Gain Across Frequency and Output Power Levels

Microchip K-Band Power Amplifiers

ICP2840 generates 9W continuous wave output power in the Ka band from 27.5–31 GHz for uplink frequency for satellite communication as well as 28 GHz 5G frequency band.

ICP2637 has a wide bandwidth from 23–30 GHz and generates 5W CW output power and is offered in a QFN package as well as in die form.

ICP1445 generates 35W pulsed output power in the 13–15.5 GHz frequency band.

ICP1543 operates in the Ku band of 12 to 18 GHz, generating 20W CW output power.

These PAs have high gain and power-added efficiency using GaN-on-SiC technology and meet the requirements at Ku/Ka band for 5G, satellite communication, aerospace and defense applications. GaN-on-SiC, with its high power density, provides a great power amplifier solution for these applications.

For more information, contact Baljit Chandhoke, product marketing manager, at Baljit.Chandhoke@microchip.com.