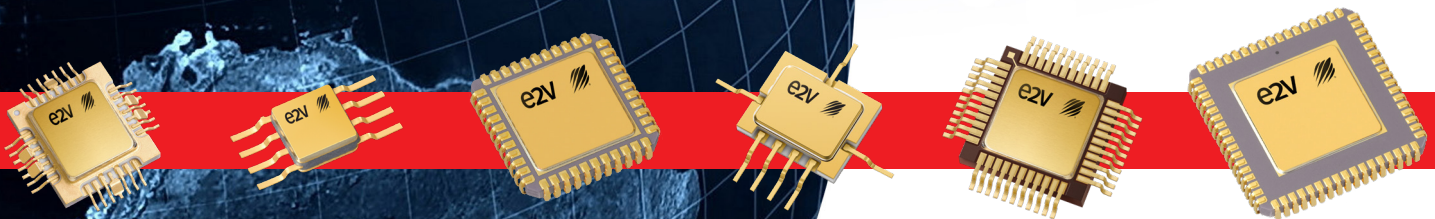
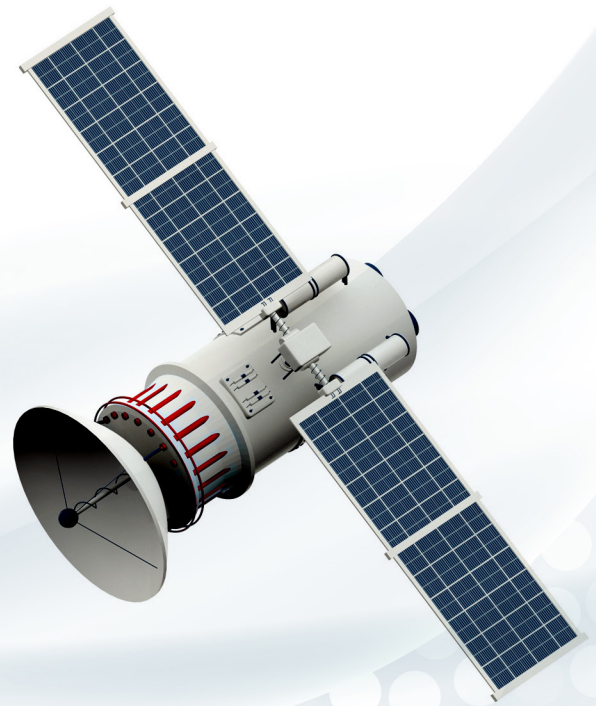




# High Reliability Product Catalog



## Two Leaders: e2v inc + Peregrine Semiconductor

Peregrine Semiconductor's radio frequency integrated circuits (RFICs) and DC-DC power management space products are now available in the e2v high-reliability (Hi-Rel) product portfolio. This strategic relationship combines Peregrine's expertise and proven track record in Hi-Rel RF and power management products with e2v's leadership position in aerospace & defense qualified semiconductor products.

### Leader in RF Innovation

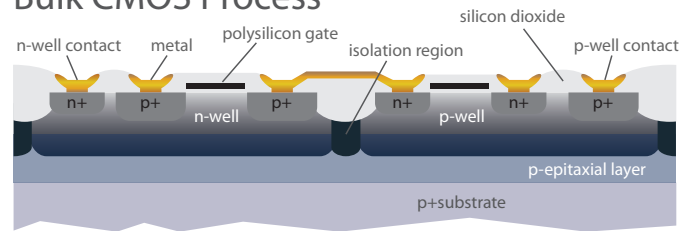
Peregrine Semiconductor Corporation, a Murata company, is the founder of RF silicon on insulator (SOI) and is a leading fabless provider of high-performance, integrated RF solutions. For Hi-Rel applications, Peregrine designs and manufactures RFICs and power management products. Peregrine has over 15 years of flight heritage; the company's products have been used in missions to seven planets and several asteroids, along with providing reliable communications to hundreds of satellite systems. A Murata company since December 2014, Peregrine holds more than 200 filed and pending patents and has shipped over 2.5 billion units.

### Leader in Aerospace & Defense

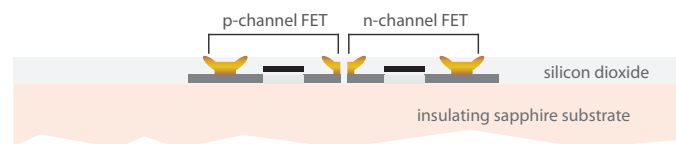
Bringing life to technology, e2v inc is a leading provider of specialist technology for high-performance systems and equipment.

For over 30 years, e2v inc has manufactured high-reliability semiconductor solutions for leading global aerospace & defense companies. Through partnerships with semiconductor manufacturers, e2v supports complete QML solutions to help customers solve design challenges. With over 3,600 QML-approved products, e2v offers one of the largest Hi-Rel product portfolios on the market.

### Bulk CMOS Process



### ULTRACMOS® Process



Peregrine's Hi-Rel products do not contain the bulk parasitics found in standard CMOS devices, making latch-up virtually impossible.

### UltraCMOS® Technology

Advancing RF SOI since 1988, Peregrine delivers the superior performance, monolithic integration and reliability required by demanding Hi-Rel designs. Central to Peregrine's success is its UltraCMOS® technology—a patented, advanced form of RF SOI. For Hi-Rel products, UltraCMOS technology circuitry is processed on an ultra-thin silicon layer atop a dielectric sapphire wafer. Variable capacitances in the junction region are virtually eliminated, reducing the overall current drain and improving the transistor's voltage handling and linearity. UltraCMOS technology is inherently radiation tolerant. Peregrine's Hi-Rel products do not contain the bulk parasitics found in standard CMOS devices, making latch-up virtually impossible.

Only UltraCMOS technology enables intelligent integration—a unique design ability to integrate RF, digital and analog components onto a single, monolithic die. This high level of integration results in a smaller IC, reducing overall design size and the number of external components required.

# UltraCMOS: Radiation Tolerant Technology for Space Applications

The primary radiation concerns in the space environment are total ionizing dose (TID), enhanced low dose rate sensitivity (ELDRS) and single event effects (SEE). Peregrine's UltraCMOS technology addresses these concerns with inherent radiation tolerance.

## Total Ionizing Dose

Peregrine performs total dose testing in accordance with MIL-STD-883, Method 1019. TID degradation or gain drifts of component parameters cause changes to circuit supply and leakage currents, threshold voltages and propagation times. Program missions will determine the level of TID tolerance required. For example, low-earth-orbit, low-lifetime missions may require 30-50 kRad(Si), while deep-space, longer-lifetime missions may require 100 kRad(Si) or more. Pre- and post-radiation measurements for key parameters are critical data points for device qualification. Peregrine's Hi-Rel RFICs and DC-DC power management solutions deliver 100 kRad(Si) TID.

## Enhanced Low Dose Rate Sensitivity

Peregrine's Hi-Rel products are inherently ELDRS-free. ELDRS can degrade certain types of bipolar devices more severely at very low-dose rates than at higher-dose rates. Semiconductors based on bipolar technology are subject to "enhanced" total ionizing dose degradation at very low-dose rates. CMOS technology does not use bipolar (minority carrier) elements and does not exhibit ELDRS.

## Single Event Effects

SEEs occur when a high-energy particle passes through the active region of a semiconductor, triggering non-destructive effects such as upset, multiple-bit upset or analog transients, or destructive effects such as latch-up, gate rupture and burnout. As a high-energy-charged particle enters the silicon at a high velocity, it exerts a force on the bound electrons and separates them from the lattice, freeing substantial local charge

to be collected across any junction within a diffusion length. The collection produces current spikes that can have various effects on the circuit.

Non-destructive or "soft-error effects" momentarily or permanently change the state of a device or cell/node, affecting its functionality. These types of errors are defined as single event upset (SEU), single event transient (SET) and single event functional interrupt (SEFI) errors.

Destructive or "hard-error effects" interrupt device function and can permanently damage the device without prompt external mitigation. These types of errors are defined as single event latch-up (SEL), single event gate rupture (SEGR) and single event burnout (SEB) events.

The ultra-thin epitaxial layer in UltraCMOS technology produces the lowest-possible SEU charge collection of any production silicon technology and simplifies the circuit design needed to achieve SEU, SET and SEFI immunity. UltraCMOS device construction eliminates four-layer devices and all forms of latch-up, including SEL. The device design rules constrain operating voltages to less than one-third BVox and operating at these voltages prevents any SEGR. SEB is not observed in this technology, where high-current bipolar junction transistors (BJT) gain is absent by construction.

**ULTRACMOS®**

- ✓ SEE Tolerant
- ✓ SEL Immune
- ✓ TID=100 kRad(Si)
- ✓ ELDRS-free process

# High Reliability RF Products

Peregrine Semiconductor's S-level standard and semi-custom UltraCMOS® silicon-on-sapphire (SOS) RFICs are based on Peregrine's high-volume commercial products and are designed to meet the rad-hard, low-power needs of space applications. UltraCMOS technology delivers a cost-effective solution compared to the higher-voltage GaAs, SiGe or bulk silicon devices.

## RF Switches

Peregrine's Hi-Rel RF switches feature high linearity, isolation and exceptionally rugged performance for space applications.

### Hi-Rel RF Switches — 50Ω

Product Description*	Part Number	Operating Frequency (MHz)		Linearity IIP3 (dBm)	P0.1dB (dBm)	Insertion Loss (dB)	Isolation (dB)		Typical I <sub>DD</sub> (μA)	V <sub>DD</sub> (V)	V <sub>SS</sub> (V)	ESD HBM (V)	Package
		Min	Max				Min	Max					
SPDT, R	PE9354	10	3000	55	31	0.55	28	32	28	2.7–3.3	—	200	8L CFP, Die
SPDT, A	PE95420	1	8500	60	33	0.77	38	75.6	100	3.0–3.6	–3.6 to –3.0	2000	7L CQFP
<b>NEW</b> SPDT, A	PE95421	1	8500	60	33	0.77	38	75.6	100	3.0–3.6	–3.6 to –3.0	1000	7L CQFP

**Note:** \* Absorptive (A) or Reflective (R).

## Digital Step Attenuator

The PE94302 digital step attenuator (DSA) provides highly competitive IP3, accuracy, temperature stability and ESD protection, with lower distortion and power consumption. The combination of these features enables excellent performance and cost-effectiveness.

### Hi-Rel Digital Step Attenuators (Monolithic) — 50Ω

Part Number, Product Description	Attenuation (dB) (range / steps)	Programming Mode	Operating Frequency (MHz)		Insertion Loss (dB)	Input IP3 (dBm)	Attenuation Accuracy (dB @ 1 GHz)	Switching Speed (ns)	ESD HBM (V)	Package
			Min	Max						
PE94302 – 6-bit	31.5 / 0.5	Parallel, Serial	0.25	4000	1.5	52	±(0.55 + 7% of setting)	1	500	28L CQFP, Die

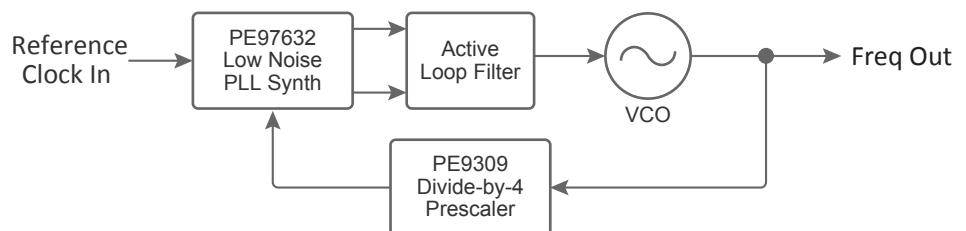
## Prescalers

The high-performance UltraCMOS RF prescaler family offers a fixed divide ratio of 2, 4 or 8. These prescalers operate across a frequency range from DC to 13.5 GHz on a nominal 3V supply while drawing between 6.5 and 16 mA. These devices have excellent sensitivity and are well suited for microwave phase-locked loop (PLL) synthesis solutions.

### Hi-Rel Prescalers

Part Number, Product Description	Operating Frequency (MHz)		Divide Ratio	Typical I <sub>DD</sub> (μA)	V <sub>DD</sub> Range (V)	ESD HBM (V)	Package
	Min	Max					
PE9301 – Divide-by-2	1500	3500	2	13	2.85–3.15	250	8L CFP, Die
PE9303 – Divide-by-8	1500	3500	8	14	2.85–3.15	250	8L CFP, Die
PE9304 – Divide-by-2	1000	7000	2	14	2.85–3.15	500	8L CFP, Die
PE9309 – Divide-by-4	3000	13500	4	16 @ 2.6V	2.45–2.75	250	8L CFP, Die
PE9311 – Divide-by-2	DC	1500	2	6.5	2.85–3.15	1000	8L CFP, Die
PE9312 – Divide-by-4	DC	1500	4	6.5	2.85–3.15	1000	8L CFP, Die
PE9313 – Divide-by-8	DC	1500	8	6.5	2.85–3.15	1000	8L CFP, Die

The PE93xx prescalers extend the upper frequency range of a PLL synthesizer while offering low power, small size and radiation tolerance.



## Phase-locked Loop Frequency Synthesizers

Peregrine's integer-N and fractional-N PLL frequency synthesizers deliver superior phase noise performance where low phase noise is critical. The new PE97240 integer-N and PE97640 fractional-N PLLs feature improved normalized phase noise of  $-230$  and  $-225$  dBc/Hz, respectively, and offer an additional 5/6 prescaler divide ratio.

### Hi-Rel Integer-N PLL Frequency Synthesizers\*

Part Number	Det Type	Programming Mode	Normalized Phase Noise (dBc/Hz)	Max Input Operating Freq			Prescaler	Reference Counters	Typical I <sub>DD</sub> (mA)	V <sub>DD</sub> Range (V)	ESD HBM (V)	Package
				(GHz) RF PLL	(MHz) Ref	(MHz) Compare						
PE9601	CP	Par, Ser, Hardware	-210	2.2	100	20	10/11	6-bit	24	2.85-3.15	1000	44L CQFJ, Die
PE9701	CP	Par, Ser, Hardware	-210	3.0	100	20	10/11	6-bit	24	2.85-3.15	1000	44L CQFJ, Die
PE9702	PD	Par, Ser, Hardware	-210	3.0	100	20	10/11	6-bit	24	2.85-3.15	1000	44L CQFJ, Die
PE9704	PD	Serial, Hardware	-210	3.0	100	20	10/11	6-bit	24	2.85-3.15	1000	44L CQFJ, Die
PE97022	PD	Par, Ser, Hardware	-216	3.5	100	50	10/11	6-bit	45	2.85-3.45	1000	44L CQFJ, Die
PE97042	PD	Serial, Hardware	-216	3.5	100	50	10/11	6-bit	45	2.85-3.45	1000	44L CQFJ, Die
<b>NEW</b> PE97240	PD	Serial, Hardware	-230	5	100	100	5/6 and 10/11	6-bit	75	2.6-2.8	1000	44L CQFP

Note: \* Main Counters M, A = 9-bit, 4-bit.

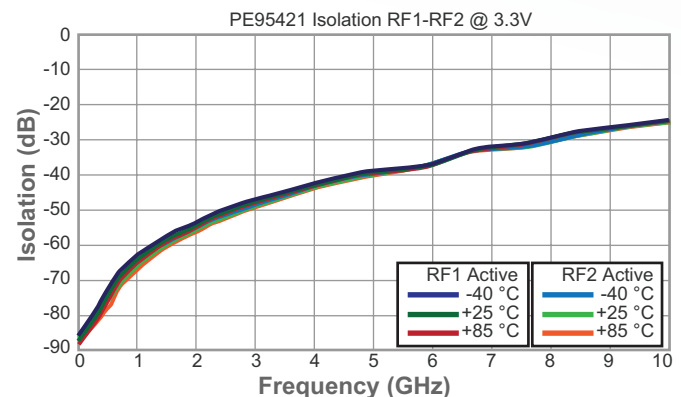
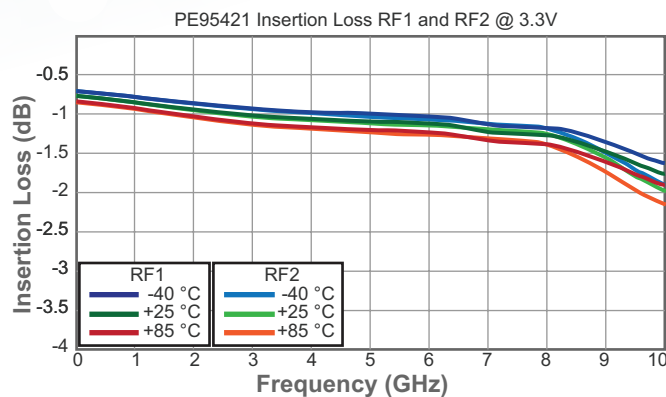
### Hi-Rel Delta-Sigma Modulated Fractional-N PLL Frequency Synthesizers\*

Part Number	Description	Programming Mode	Normalized Phase Noise (dBc/Hz)	Max Input Operating Freq			Prescaler	Reference Counters	Typical I <sub>DD</sub> (mA)	V <sub>DD</sub> Range (V)	ESD HBM (V)	Package
				(GHz) RF PLL	(MHz) Ref	(MHz) Compare						
PE9763	Low Phase Noise 3rd Order DSM	Ser, Hardware	-210	3.2	100	50	10/11	6-bit	30	2.85-3.15	1000	68L CQFJ, Die
PE97632	Ultra-Low Phase Noise 3rd Order DSM	Ser, Hardware	-216	3.5	100	50	10/11	6-bit	40	2.85-3.15	1000	68L CQFJ, Die
<b>NEW</b> PE97640	Ultra-Low Phase Noise 3rd Order DSM	Ser, Hardware	-225	5.0	100	50	5/6 and 10/11	6-bit	80	2.6-2.8	1000	64L CQFP

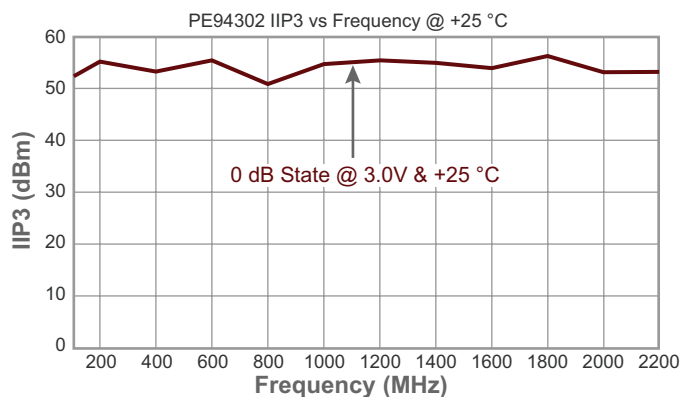
Note: \* Main Counters M, A, K = 9-bit, 4-bit, 18-bit.

## UltraCMOS Technology Delivers High Linearity and Low Phase Noise

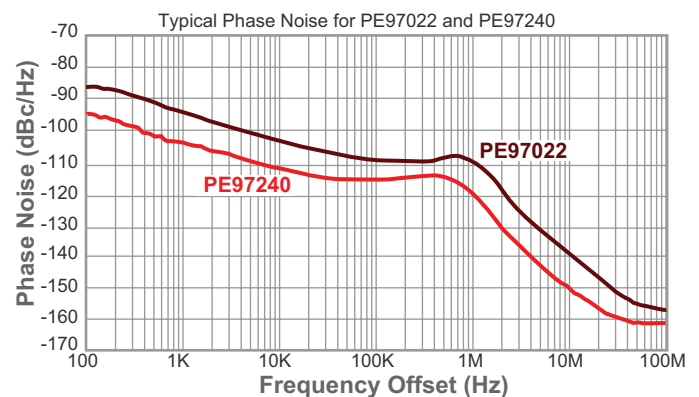
HarP™ technology enhancements allow for excellent linearity, and minimize gate lag, insertion loss and phase drift.



The PE94302 DSA features unprecedented levels of broadband linearity down to 100 kHz.



PE97022 and PE97240 phase noise: V<sub>DD</sub> = 2.8V, temp = +25°C, F<sub>vc0</sub> = 4 GHz, F<sub>comp</sub> = 50 MHz, loop bandwidth = 500 kHz



# High Reliability Power Management Products

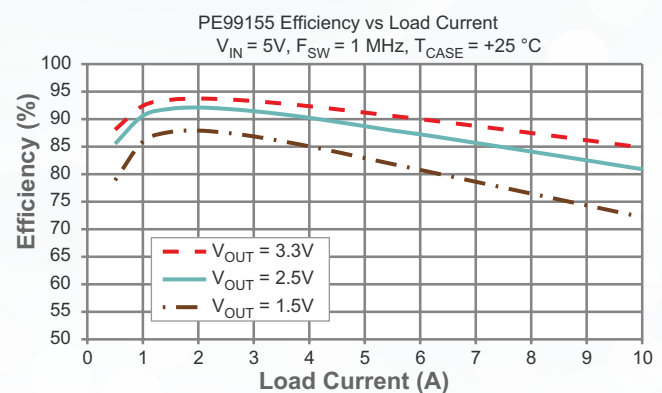
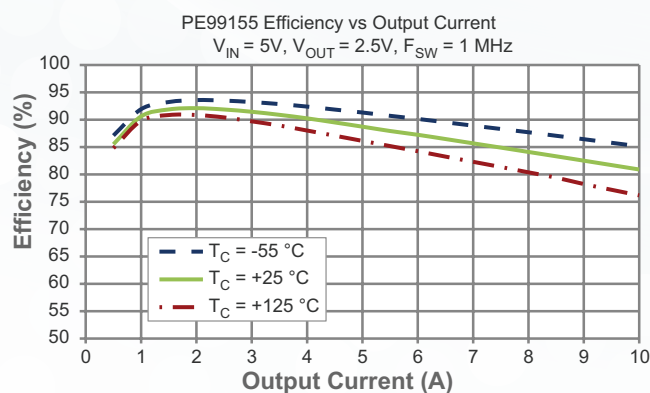
Peregrine's power management products follow a steep tradition of high performance and efficiency. The flagship power management family supports DC to DC conversion with radiation-tolerant point-of-load (POL) synchronous buck regulators with integrated switches. These devices offer SEE immunity to a linear energy transfer (LET) greater than 90 MeV.cm<sup>2</sup>/mg and TID of 100 kRad(Si). By offering superior performance, smaller size and reduced weight, these power management products can replace multichip modules in sensitive space applications.

Hi-Rel Point-of-Load DC-DC Buck Regulators											
Part Number	Product Description	I <sub>OUT</sub> (Max) (A)	V <sub>IN</sub> (Min) (V)	V <sub>IN</sub> (Max) (A)	V <sub>OUT</sub> (Min) (V)	V <sub>OUT</sub> (Max) (V)	Async Switching Frequency (kHz)	Sync Switching Frequency (kHz)		ESD HBM (V)	Package
								Min	Max		
PE99151	2A DC-DC Buck Regulator	2	4.6	6	1	3.6	500/1000	100	5000	1000	32L CQFP, Die
PE99153	6A DC-DC Buck Regulator	6	4.6	6	1	3.6	500/1000	100	5000	1000	32L CQFP, Die
PE99155	10A DC-DC Buck Regulator	10	4.6	6	1	3.6	500/1000	100	5000	1000	32L CQFP, Die

## Radiation Tolerant POL Synchronous Buck Regulators

- Integrated synchronous FET switches with 93% peak efficiency.
- Peak current mode control and voltage mode control for wide loop bandwidth and excellent load step response.
- Better than 1% initial accuracy at +25 °C.
- Powers up into pre-biased loads allowing safe start-up with load applied.
- Adjustable switching frequency (100 kHz to 5 MHz) allows operation at the optimum frequency to minimize RF spur impact and minimize inductor size and weight.
- Inverted sync buffer pin for easy poly-phase operation, enabling ripple reduction and faster loop response.
- Adjustable soft-start with external capacitor to adjust load voltage/current rise-time.
- Integrated power good pin for sequencing and telemetry.
- Shutdown function pin for remote on/off control.
- Accurate and simple current sharing for higher power loads.
- Adjustable current threshold and over current protection.
- N+K redundant control through simple enable pin.
- Hermetic ceramic package with exposed thermal pad.
- Inherently ELDRS-free as bipolar minority carrier elements are not used.

## Power Conversion Efficiency Curves



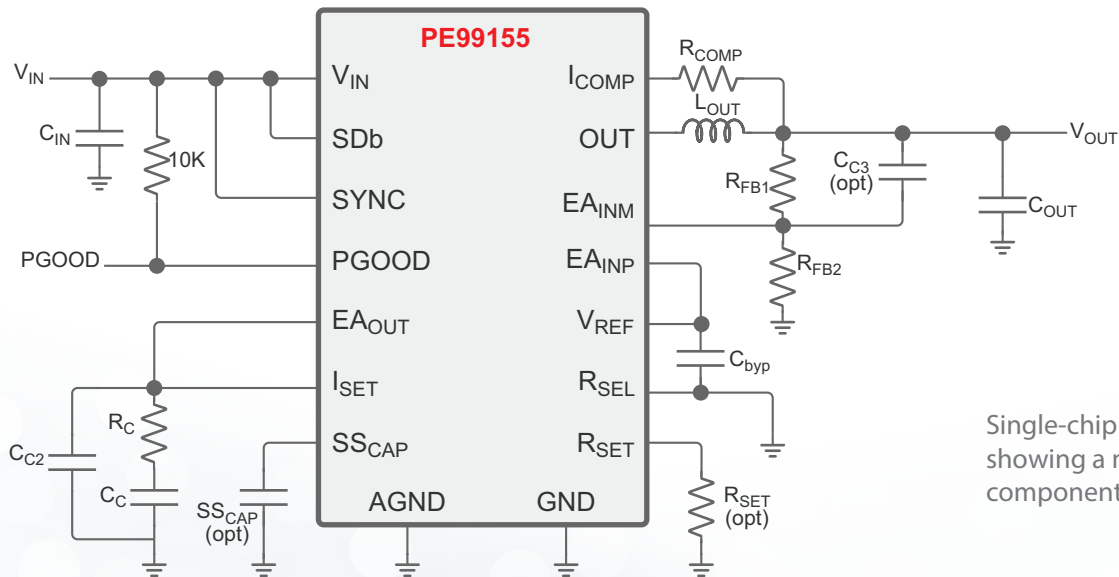
The PE9915x POL buck regulators are capable of supplying high load currents at low output voltages while maintaining high efficiency.

## Test Results

Radiation Hardness	
TID	100 kRad(Si)
SEL	> 90 MeV·cm <sup>2</sup> /mg
SEB	> 90 MeV·cm <sup>2</sup> /mg
SET	> 90 MeV·cm <sup>2</sup> /mg
SEFI	> 90 MeV·cm <sup>2</sup> /mg
SEGR	> 90 MeV·cm <sup>2</sup> /mg

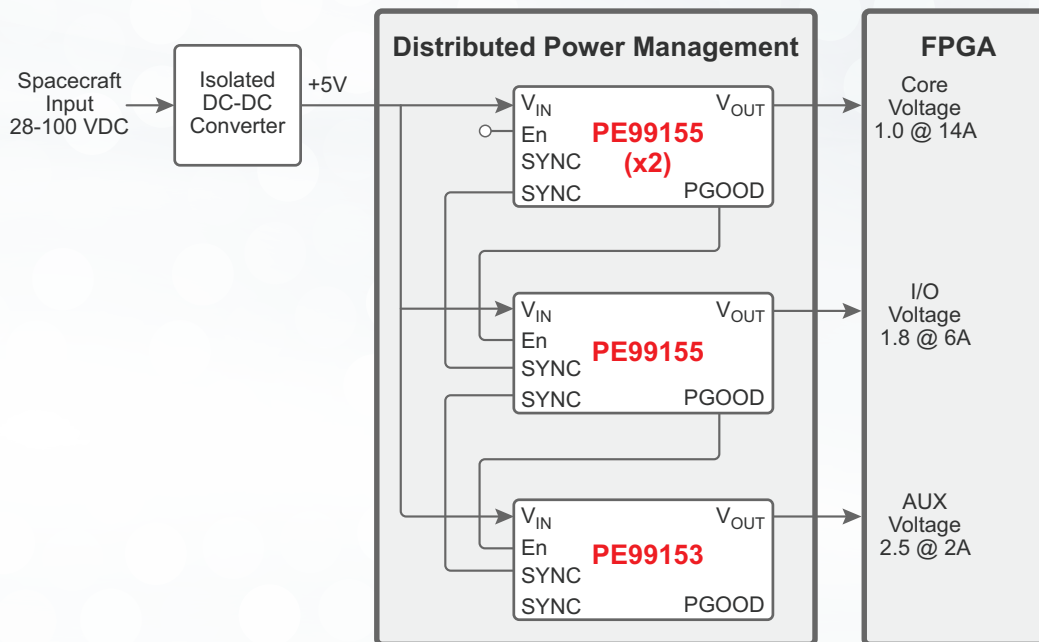
- SEL, SEB, SEGR, SEU, SEFI: None observed, Au/60 degrees.
- SET: No events exceeding 30 mV transient observed @ Au, LET = 90, 60 degrees normal incidence.
- The UltraCMOS process does not exhibit ELDRS since bipolar minority carrier elements are not used.

## Simplified Application Schematic



Single-chip solution showing a minimal external component count.

## Distributed Power Architecture



A distributed power architecture example using the intermediate bus to supply several POL synchronous buck regulators reduces distribution losses through smaller cables and connectors, which reduces size, weight and cost.

# Quality and Reliability

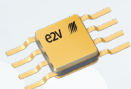
Peregrine and e2v are committed to providing high-quality products that exceed customers' expectations. Both Peregrine and e2v maintain AS9100C certification to address the strict quality systems requirements of the aerospace industry.

Peregrine and e2v Hi-Rel products use the test methods and procedures defined under MIL-STD-883 and MIL-PRF-38535 to fabricate, assemble, test, screen and qualify space-level applications.

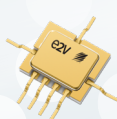
## Ceramic Packaging. Hermetically Sealed, Rigorously Tested.

High-reliability die available on select products.

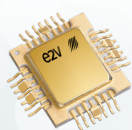
**8L CFP**  
4.6 × 4.6 × 1.8



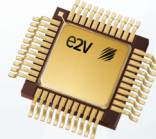
**7L CQFP**  
6.6 × 5.5 × 1.7



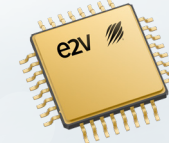
**28L CQFP**  
9.1 × 9.9 × 1.3



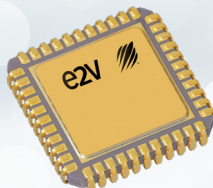
**44L CQFP**  
9.83 × 9.83 × 1.48



**32L CQFP**  
12.57 × 13.08 × 1.15



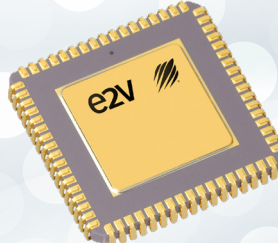
**44L CQFJ**  
16.5 × 16.5 × 2.9



**64L CQFP**  
13.1 × 13.1 × 1.6



**68L CQFJ**  
24.1 × 24.1 × 3.1



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[e2v-us.com](http://e2v-us.com)

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