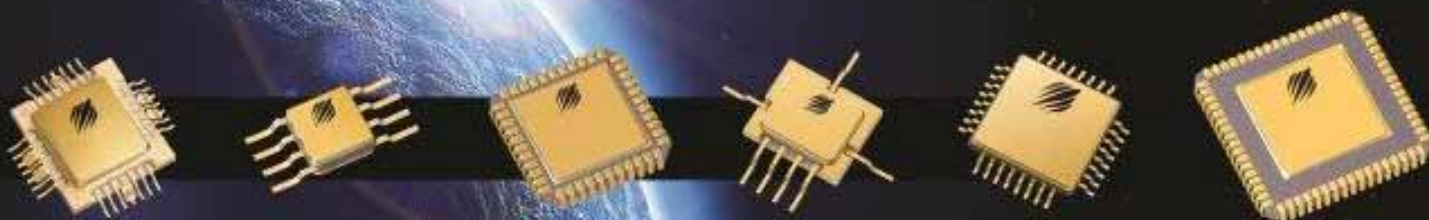




2013
High-Reliability Products
Product Selection Guide
Second Edition



Welcome to Peregrine Semiconductor

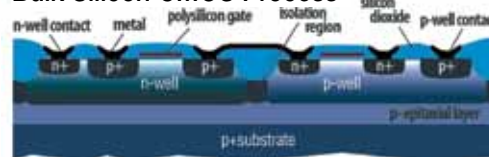
Peregrine Semiconductor is a fabless provider of high-performance radio-frequency (RF) integrated circuits (ICs). Our products deliver what we believe is an industry leading combination of performance and monolithic integration, and we leverage our extensive RF design expertise and systems knowledge to develop RFIC solutions that address the stringent performance, integration, and reliability requirements of High-Reliability (Hi-Rel) markets. Additionally, because UltraCMOS® devices are fabricated in standard high-volume CMOS facilities, products benefit from the fundamental reliability, cost effectiveness, high yields, scalability and integration of CMOS, while achieving the high performance levels historically expected from SiGe and GaAs. It is this combination of attributes which enables ease-of-development essential to timely and cost-effective application design by our customers.

UltraCMOS® RF Process Technology

UltraCMOS is an advanced form of Silicon-on-Insulator (SOI) semiconductor process that has long been recognized as a technically-superior process. It achieves significant RF performance making it well suited for demanding Hi-Rel designs. UltraCMOS technology circuitry is processed on an Ultra-Thin Silicon (UTSi®) layer atop a dielectric sapphire wafer. As a result, variable capacitances in the junction region are virtually eliminated, which improves the transistor's voltage handling, linearity, and reduces the overall current drain. Additionally, high-quality passive and RF functions, as well as digital circuitry can be integrated on a single die.

An important advantage of Peregrine's UltraCMOS technology is that it is naturally radiation hardened. Single Event Latch-up (SEL) is the radiation-induced latch-up of a CMOS logic gate. This can happen when a high-energy particle strikes the parasitic thyristor that is inherent to bulk silicon designs and causes a short circuit from power to ground within the device. This is often catastrophic and results in permanent damage, requiring, at a minimum, a power down to recover. However, UltraCMOS products do not contain the bulk parasitics found in standard CMOS devices, making latch-up virtually impossible.

Bulk Silicon CMOS Process



UltraCMOS® Process



Bulk CMOS process vs UltraCMOS process. The Bulk parasitics which cause SEL are eliminated in the UltraCMOS process, making latchup impossible.

Monolithic Integration

Another fundamental benefit of UltraCMOS products for Hi-Rel applications is its inherent ability to integrate RF, mixed-signal analog, digital and EEPROM on the same device. This high level of monolithic integration results in a smaller IC, which helps reduce overall design size and the number of external components required.

Quality and Reliability

We are committed to providing high quality products and services that meet or exceed our customers' expectations. We have developed and implemented a quality management system to create an organizational environment designed to meet the highest level of quality and reliability standards. Our quality management system has been certified and maintained to ISO 9001 standards since 2001. We achieved AS9100 Quality Management System Standards certification in 2003 to address the strict quality system requirements of the aerospace industry. In early 2012, we further improved the robustness of our quality management system by receiving our ISO/TS 16949:2009 Quality Management System certification by the automotive industry.

Peregrine's Hi-Rel products use the test methods and procedures defined under MIL-STD 883 or ESCC9000 and the general specification MIL-PRF-38535, to fabricate, assemble, test, screen and qualify for space level applications.





Rad-Hard Process for Space Applications

Radiation Tolerance

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® process technology addresses these concerns with an inherent radiation tolerance.

Total Ionizing Dose (TID)

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 measurement for key parameters are critical data points for device qualification.

Enhanced Low Dose Rate Sensitivity (ELDRS)

Peregrine's Hi-Rel products are ELDRS-free. This is an inherent advantage because 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 Enhanced Low Dose Rate Sensitivity (ELDRS).



Single Event Effects (SEE)

Single Event Effects (SEE) 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 which 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. The UltraCMOS device construction eliminates 4-layer devices and all forms of latchup including SEL. The device design rules constrain operating voltages to less than one third BV_{ox} 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.

High-Reliability RF Products

Peregrine Semiconductor's S-level standard and semi-custom UltraCMOS® Silicon-on-Sapphire (SOS) RFICs are based on our high-volume commercial products, yet 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 and isolation while providing an exceptionally rugged performance solution for space applications.

Hi-Rel RF Switches

Product Description	Operating Frequency (MHz)	IIP3 (dBm @ 2 GHz)	P1dB (dBm @ 2 GHz)	Insertion Loss (dB @ 1 GHz)	Isolation (dB @ 1 GHz)	Typical I _{dd} (μA @ 3V)	V _{dd} Range (V)	ESD HBM (V)	Package
PE9354 - SPDT	10-3000	55	31	0.55	32	28	2.7-3.3	200	8L CFP, DIE
PE95420 - SPDT	1-8500	60	33	0.85	55	100 @ 3.3V	3.0-3.6	2000	7L CQFP, DIE
NEW PE95421 - SPDT	1-8500	60	33	0.85	55	100 @ 3.3V	3.0-3.6	1000	7L CQFP, DIE

Digital Step Attenuators

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) - 50 Ω

Product Description	Attenuation	Programming Mode	Operating Freq. (MHz)	Insertion Loss (dB)	Input IP3 (dBm)	Attenuation Accuracy (1 GHz)	Switching Speed (μs)	ESD HBM (V)	Package
PE94302 - 6-bit	31.5 range / 0.5 steps	Parallel, Serial	1-4000	1.5	52	±(0.55dB+7% of setting)	1	500	28L CQFP, DIE

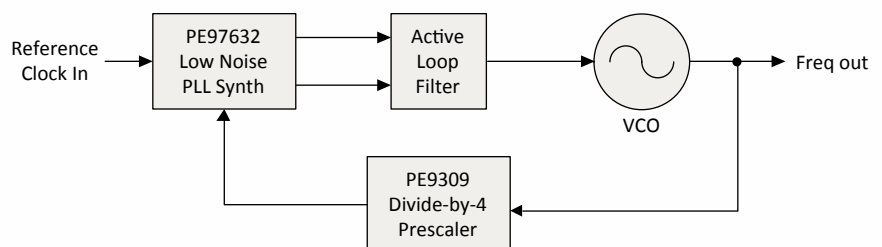
Prescalers

The high-performance UltraCMOS RF Prescaler family offers a fixed divide ratio of 2, 4, or 8 and an operating frequency ranging from DC to 13.5 GHz on a nominal 3V supply while drawing between 6.5 and 16 mA. Packaged in a small 8-lead CFP, and also available in die form, these devices have excellent sensitivity and are well suited for microwave PLL synthesis solutions.

Hi-Rel Prescalers

Product Description	Input Operating Frequency (MHz)	Divide Ratio	Typical I _{dd} mA @ 3V)	V _{dd} Range (V)	ESD HBM (V)	Package
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 hardness.



Phase Locked-Loop (PLL) Frequency Synthesizers

Peregrine's Integer-N and Fractional-N Phase Locked-Loop (PLL) Frequency Synthesizers deliver superior phase noise performance where low phase noise is critical. The PE97022/PE97042 Integer-N and the PE97632 Fractional-N offer excellent normalized phase noise (-216 dBc/Hz), 10/11 dual modulus prescaler and selectable Programming Modes. The new PE97240 Integer-N features improved normalized phase noise (-230 dBc/Hz) and offers additional 5/6 prescaler divide ratio.

Hi-Rel Integer-N Phase Locked-Loop (PLL) Frequency Synthesizers^{1,2}

Product Description	Det Type	Programming Mode	Normalized Phase Noise (dBc/Hz)	Max Input Operating Freq. (GHz) RF PLL	(MHz) Ref.	(MHz) Compare	Reference Counters	Typical Idd (mA @ 3V)	Vdd Range (V)	ESD HBM (V)	Package
PE9601	CP	Par, Ser, Hardwire	-210	2.2	100	20	6-bit	24	2.85-3.15	1000	44L CQFJ, DIE
PE9701	CP	Par, Ser, Hardwire	-210	3.0	100	20	6-bit	24	2.85-3.15	1000	44L CQFJ, DIE
PE9702	PD	Par, Ser, Hardwire	-210	3.0	100	20	6-bit	24	2.85-3.15	1000	44L CQFJ, DIE
PE9704	PD	Serial, Hardwire	-210	3.0	100	20	6-bit	24	2.85-3.15	1000	44L CQFJ, DIE
PE97022	PD	Par, Ser, Hardwire	-216	3.5	100	50	6-bit	45 ⁴	2.85-3.45	1000	44L CQFJ, DIE
PE97042	PD	Serial, Hardwire	-216	3.5	100	50	6-bit	45 ⁴	2.85-3.45	1000	44L CQFJ, DIE
NEW PE97240 ³	PD	Serial, Hardwire	-230	5	100	100	6-bit	75 @ 2.8V	2.65-2.95	1000	44L CQFP, DIE

Note 1: Prescaler = 10/11

Note 2: Main Counters M, A = 9-bit, 4bit

Note 3: Prescaler = 5/6 and 10/11

Note 4: Typical Idd = 45 mA @ 3.3V

Hi-Rel Delta-Sigma Modulated Fractional-N Frequency Synthesizers^{1,4}

Product Description	Programming Mode	Normalized Phase Noise (dBc/Hz)	Max Input Operating Freq. (GHz) RF PLL	(MHz) Ref.	(MHz) Compare	Reference Counters	Typical Idd (mA @ 3V)	Vdd Range (V)	ESD HBM (V)	Package
PE9763 Low Phase Noise 3rd Order DSM	Ser, Hardwire	-210	3.2	100	50	6-bit	30	2.85-3.15	1000	68L CQFJ, DIE
PE97632 ² Ultra-Low Phase Noise 3rd Order DSM	Ser, Hardwire	-216	3.5	100	50	6-bit	40 ³	2.85-3.45	1000	68L CQFJ, DIE

Note 1: Prescaler = 10/11

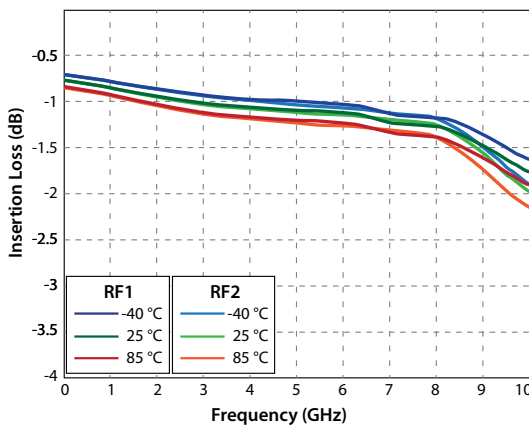
Note 2: The PE97632 is pin for pin compatible with the PE9763 in up/down mode

Note 3: Typical Idd = 40 mA @ 3.3V

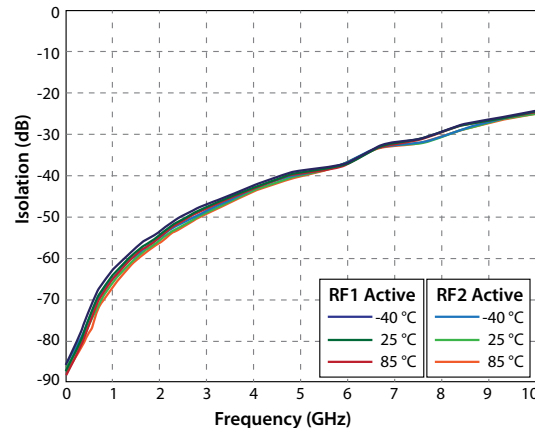
Note 4: Main Counters M, A, K = 9-bit, 4-bit, 18-bit

UltraCMOS® Delivers High Linearity and Low Phase Noise

PE95420 Insertion Loss: RF1 and RF2 @ 3.3V

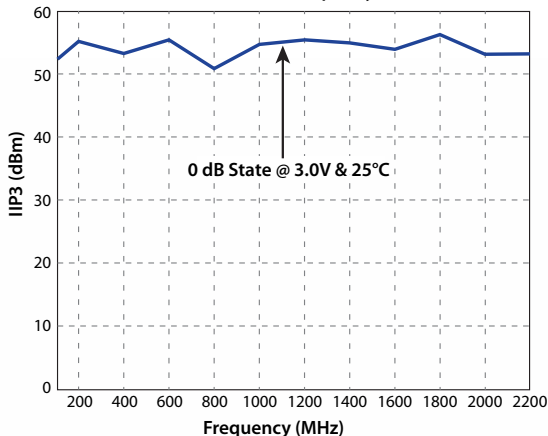


PE95420 Isolation RF1-RF2 @ 3.3V



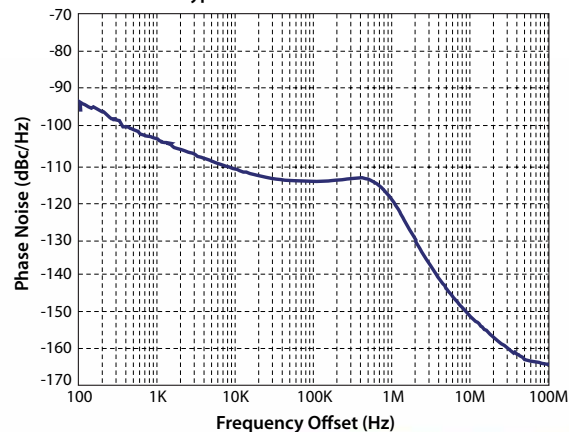
The PE95420 SPDT switch is the first Hi-Rel product to integrate HaRP™ technology enhancements. These enhancements allow for excellent linearity, and minimize gate lag, insertion loss and phase drift.

PE94302 IIP3 vs Frequency @ 25°C



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

Typical Phase Noise for PE97240



VDD = 2.8V
Temp = 25°C
Fvco = 4 GHz
Fcomp = 50 MHz
Loop Bandwidth = 500 kHz

High-Reliability Power Management Products

Peregrine's new Power Management Products follow a steep tradition of high performance and efficiency. The flagship power management family supports DC to DC conversion with radiation hardened Point-of-Load (POL) Synchronous Buck Regulators with integrated switches. These devices offer Single Event Effects (SEE) immunity to a Linear Energy Transfer (LET) greater than 90 MeV•cm²/mg and radiation hardness of 100 KRad(Si), and replace multi-chip modules by offering superior performance, smaller size and reduced weight in sensitive space applications.

Rad-Hard Point-of-Load DC-DC Buck Regulators

Part Number	Part Description	I _{out} (Max) (A)	V _{in} (Min) (V)	V _{in} (Max) (V)	V _{out} (Min) (V)	V _{out} (Max) (V)	Async Switching Frequency (kHz)	Sync Switching Frequency (kHz)	ESD HBM (V)	Package
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 Hardened Point-of-Load (POL) Synchronous Buck Regulators

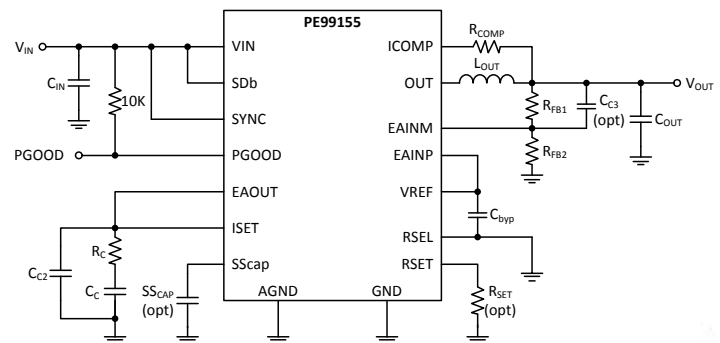
- ▶ Integrated synchronous FET switches with 93% peak efficiency
- ▶ Peak current mode control and voltage mode control for wide loop bandwidth and excellent load step response
- ▶ Better than 1% initial accuracy at 25°C
- ▶ Powers up into pre-biased loads allowing safe start-up with load applied
- ▶ 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
- ▶ The UltraCMOS® process does not exhibit Enhanced Low Dose Rate Sensitivity (ELDRS) since bipolar minority carrier elements are not used

Test Results

Radiation Hardness	
TID	100 Krad(Si)
SEL	> 90 MeV•cm ² /mg
SEB	> 90 MeV•cm ² /mg
SET	> 90 MeV•cm ² /mg
SEFI	> 90 MeV•cm ² /mg
SEGR	> 90 MeV•cm ² /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 enhanced low-dose-rate sensitivity (ELDRS) since bipolar minority carrier elements are not used

Simplified Application



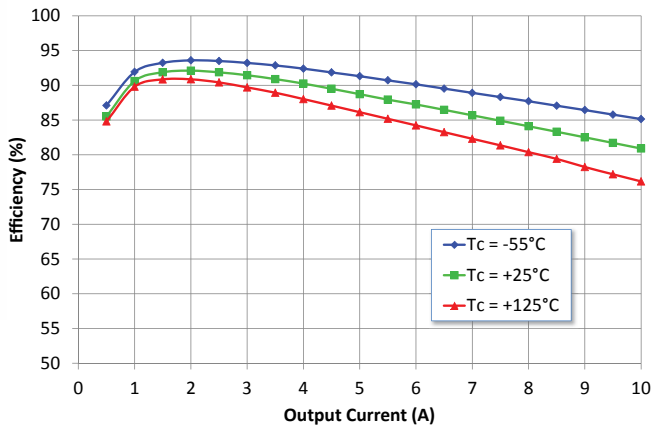
Single-chip solution showing a minimal external component count.

psemi.com

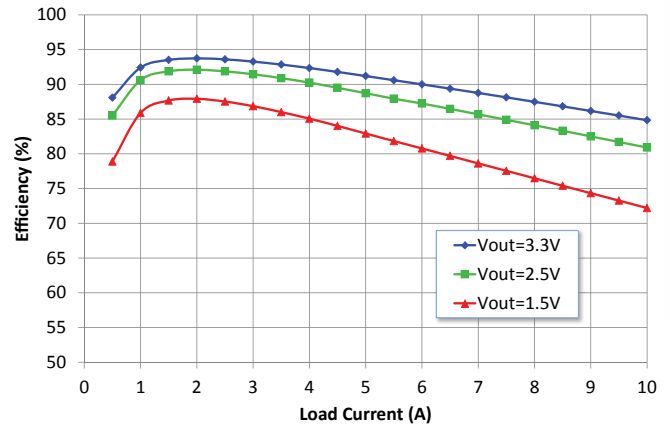
Visit our website for the most current list of technical resources for our Hi-Rel products.

Power Conversion Efficiency Curves

PE99155 Efficiency versus Load Current
VIN=5V, VOUT=2.5V, Fsw=1MHz

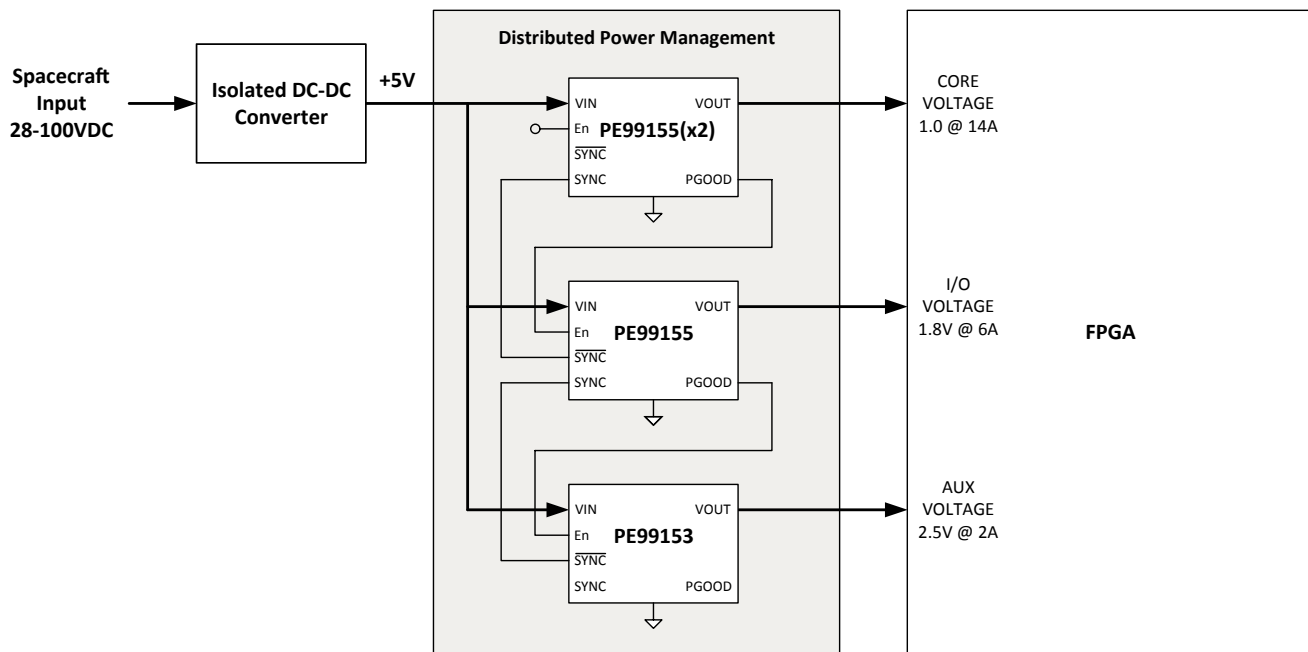


PE99155 Efficiency versus Load Current
VIN=5V, Fsw=1MHz, Tcase=+25°C



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

Distributed Power Architecture

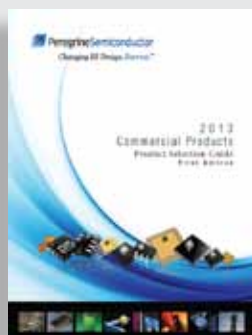


A distributed power architecture example using the intermediate bus to supply several POL buck regulators reduces distribution losses through smaller cables and connectors, which reduces size, weight and cost.

Commercial Products

In addition to its High-Reliability products for space applications, Peregrine Semiconductor also provides solutions for commercial markets including broadband, industrial, mobile wireless device, test and measurement equipment, and wireless infrastructure.

Scan the QR code to learn more about Peregrine's High-Reliability products.



Application Notes

- | | | | |
|------|--|------|--|
| AN10 | Connecting the PE3336, PE9601, and PE9701 to a Serial Bus Interface | AN23 | Migrating from PE9704 to PE97042 |
| AN16 | Using Peregrine PLL in System Clock Applications | AN24 | Migrating from PE9763 to PE97632 |
| AN17 | OC-12 622.08 MHz Reference Clock Design | AN27 | Using Blocking Capacitors with UltraCMOS® Devices |
| AN18 | RF Switch Performance Advantages of UltraCMOS® Technology over GaAs Technology | AN32 | Radiation-Hardened Power Management Solution for Xilinx Virtex-5 Space-Grade FPGAs |
| AN22 | Migrating from PE9702 to PE97022 | AN34 | Implementing Design Features of the PE9915x Point-of-Load Buck Regulator |

Ceramic Packaging. Hermetically Sealed, Rigorously Tested.

All High-Reliability products are also available in die form.



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