

Power Management Selection Guide

2Q 2007





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Texas Instruments (TI) offers complete power solutions with a full line of high-performance products. These products, which range from standard linear ICs to plug-in and integrated power solutions, are tailored to meet your design challenges. And, TI makes designing easier by providing leading-edge support tools such as training, a broad selection of evaluation modules (EVMs), application notes, comprehensive technical documentation and more. TI also offers samples and small orders (shipped within 24 hours via TI authorized distributors) that will help you accelerate your time-to-market.

Included in this selection guide you will find design factors, featured products, graphic representations of portfolios and parametric tables. A list of application notes and evaluation modules is included in each section of the guide.

TI Power Solutions: Power Behind Your Designs

TI provides power management integration, technology and value to help you drive innovation and grow market opportunities. This is coupled with collaboration, tools, service and delivery to help you get there faster. For more information or technical assistance, please see TI Worldwide Technical Support on page 75 of this selection guide or visit TI's Power Management web site at:

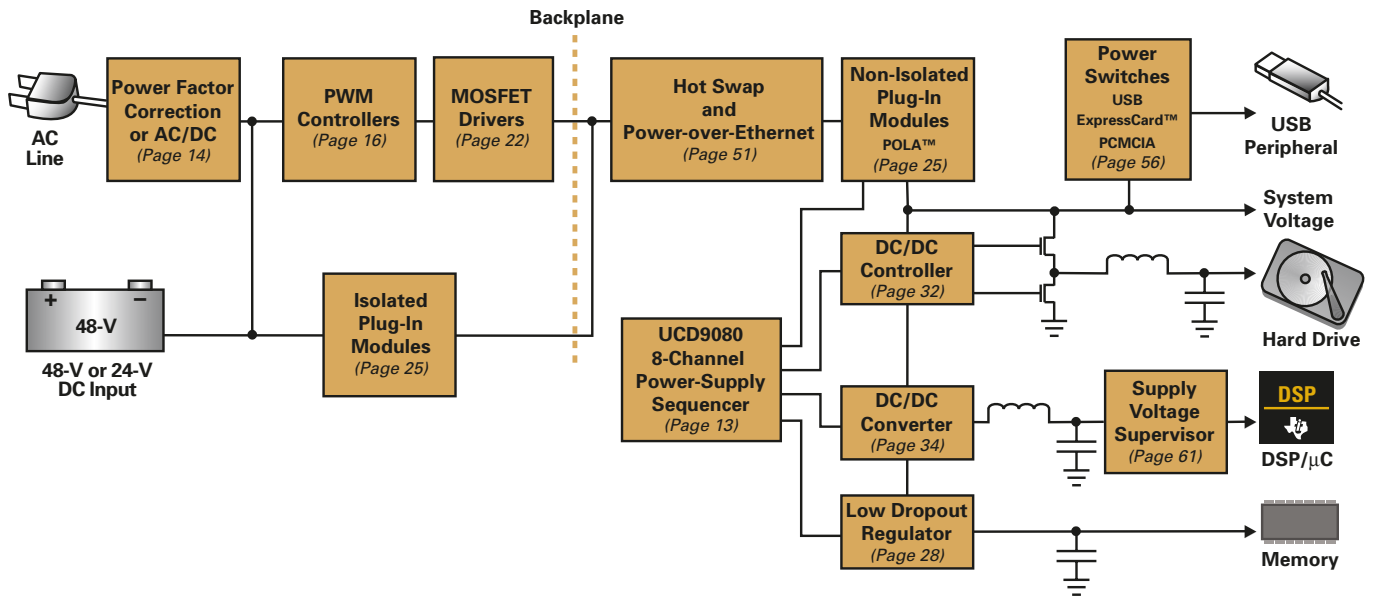
power.ti.com

Note: Military versions of some Power Management products are available. Please visit:
power.ti.com/militaryproducts

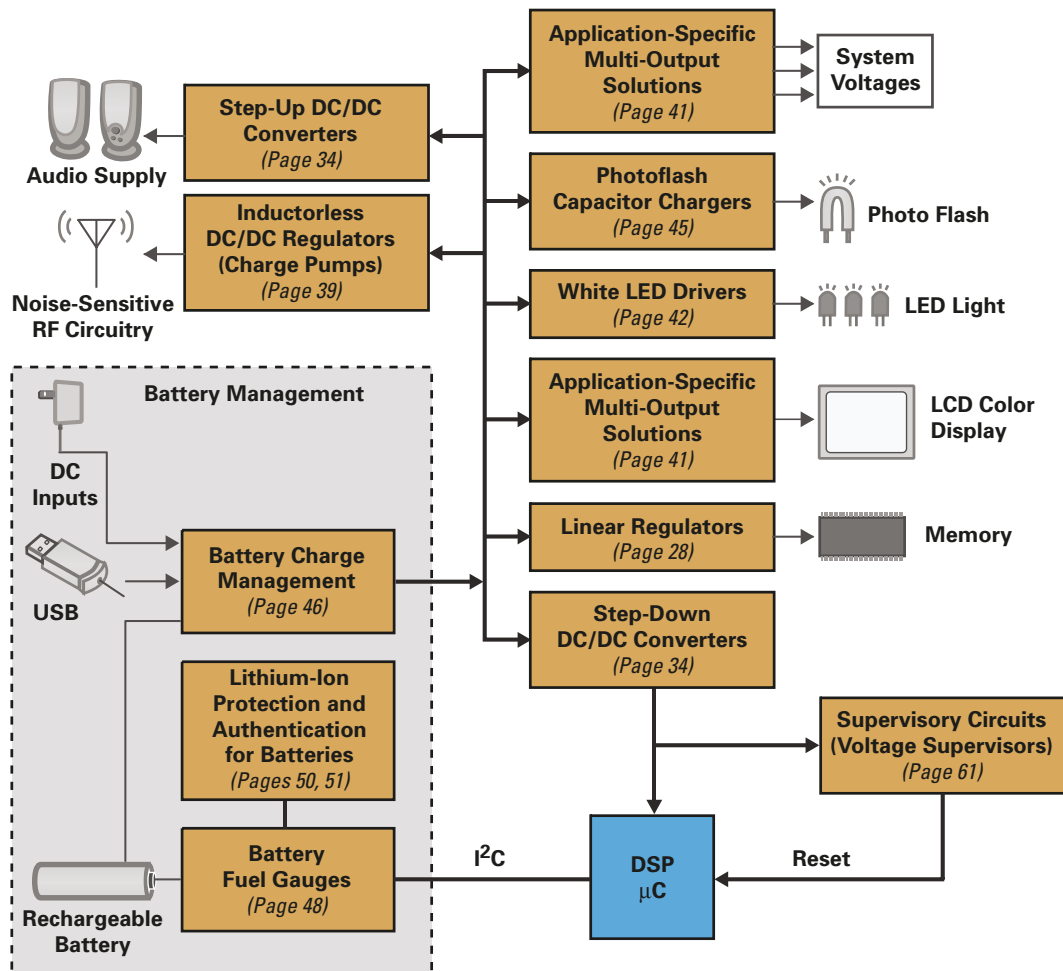
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Line Power Solutions



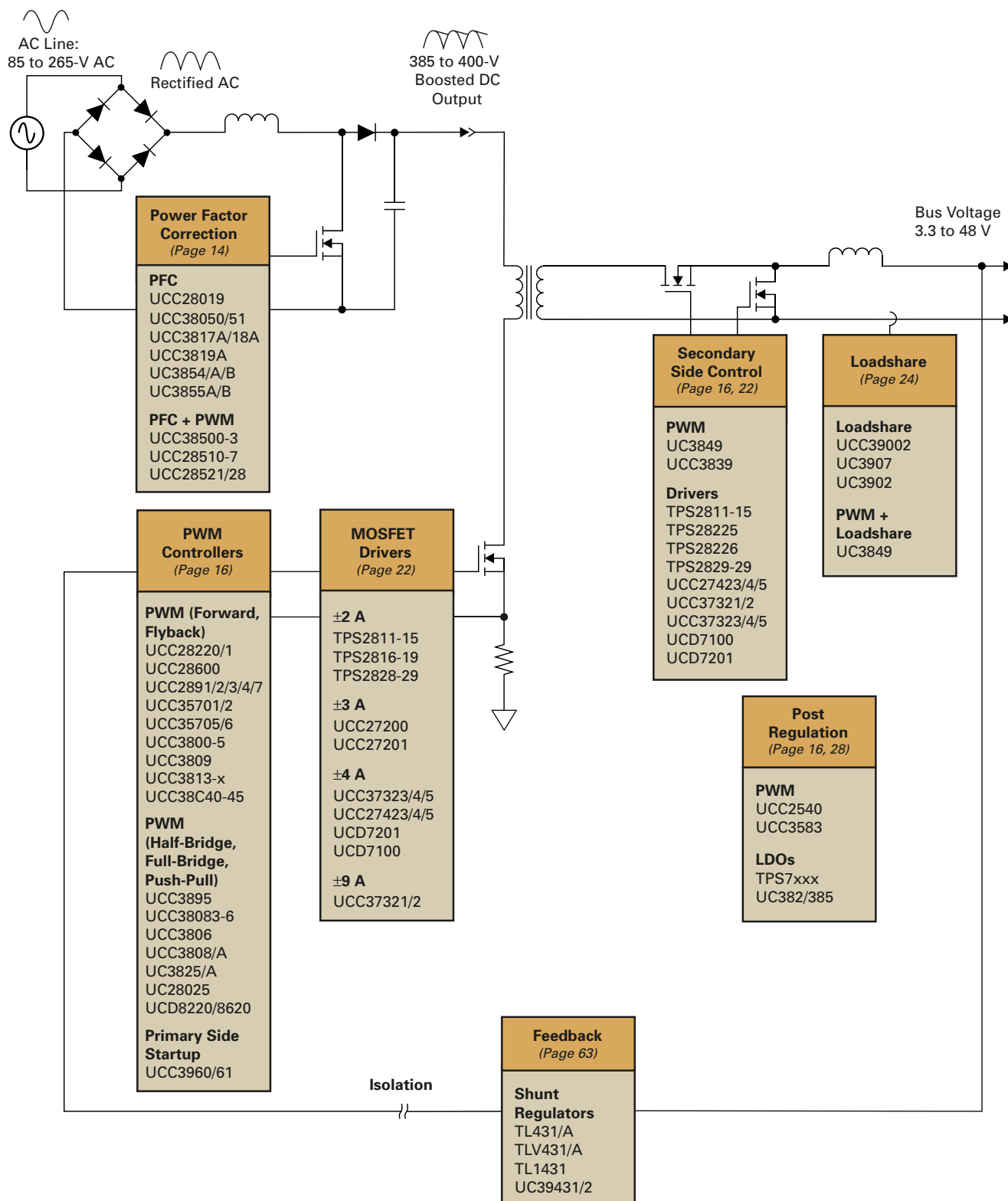
Portable Power Solutions





AC/DC Solutions

Isolated DC/DC Solutions



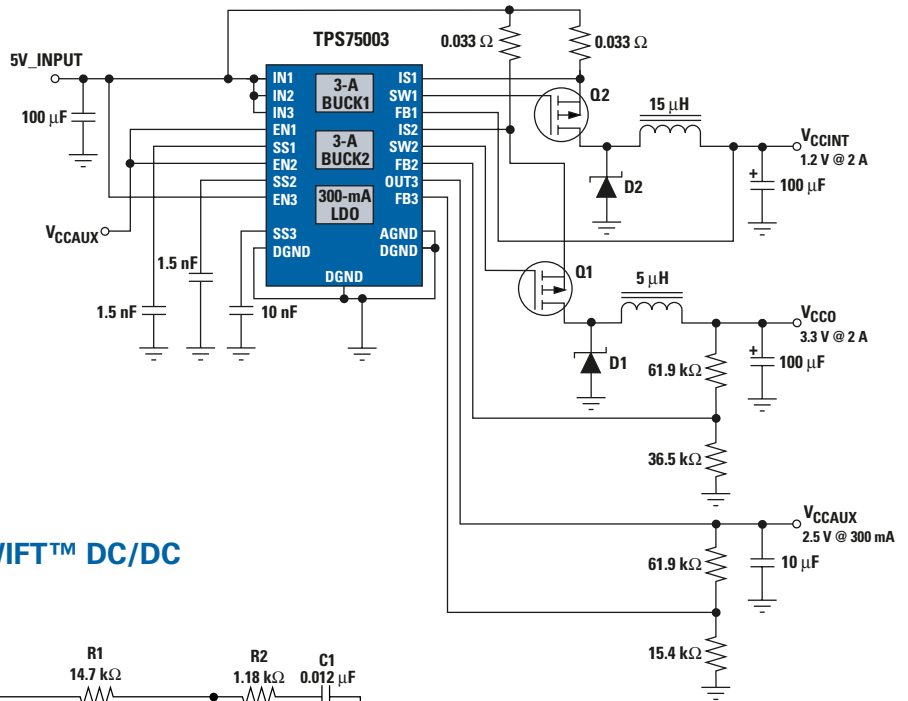


FPGA and CPLD Power Solutions

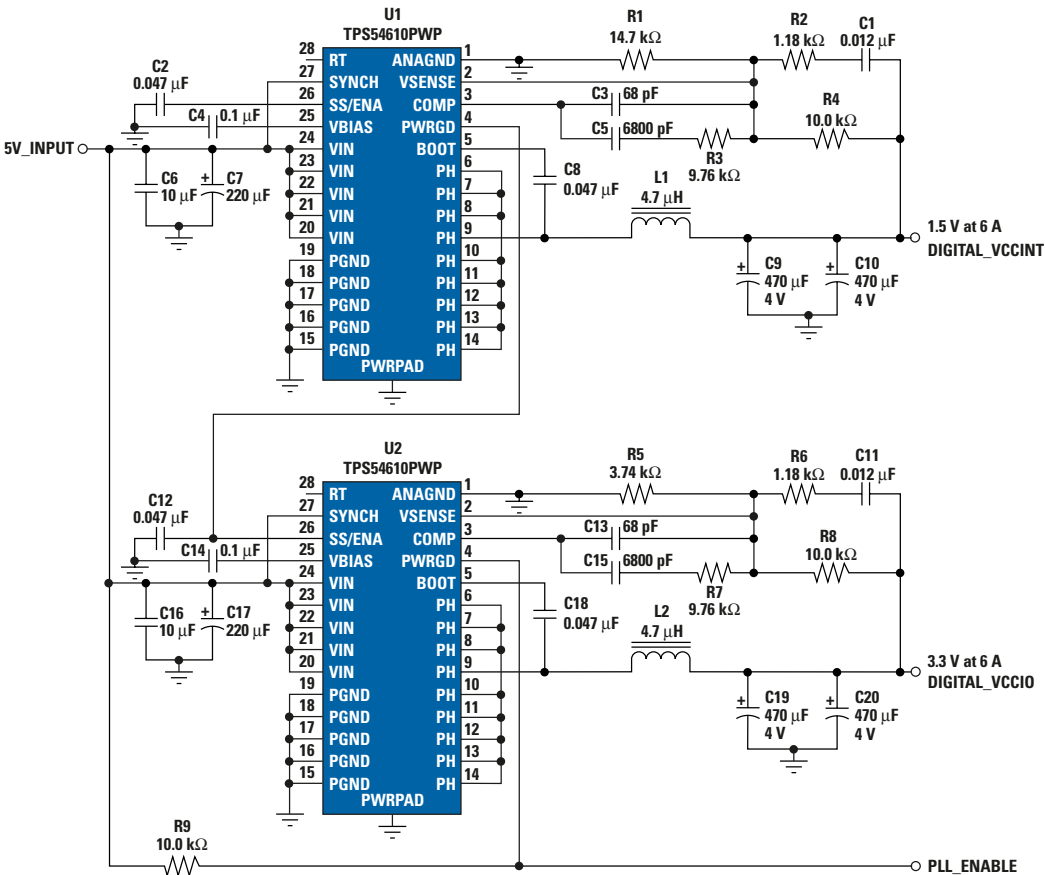
www.ti.com/xilinxfpga or www.ti.com/alterafpga

Access the sites for one-stop power management support for Xilinx® and Altera® FPGAs and CPLDs, including free downloads of power reference designs with complete schematics, bills-of-material and helpful implementation notes.

Highly Integrated TPS75003 Triple Supply Powering Spartan™-3

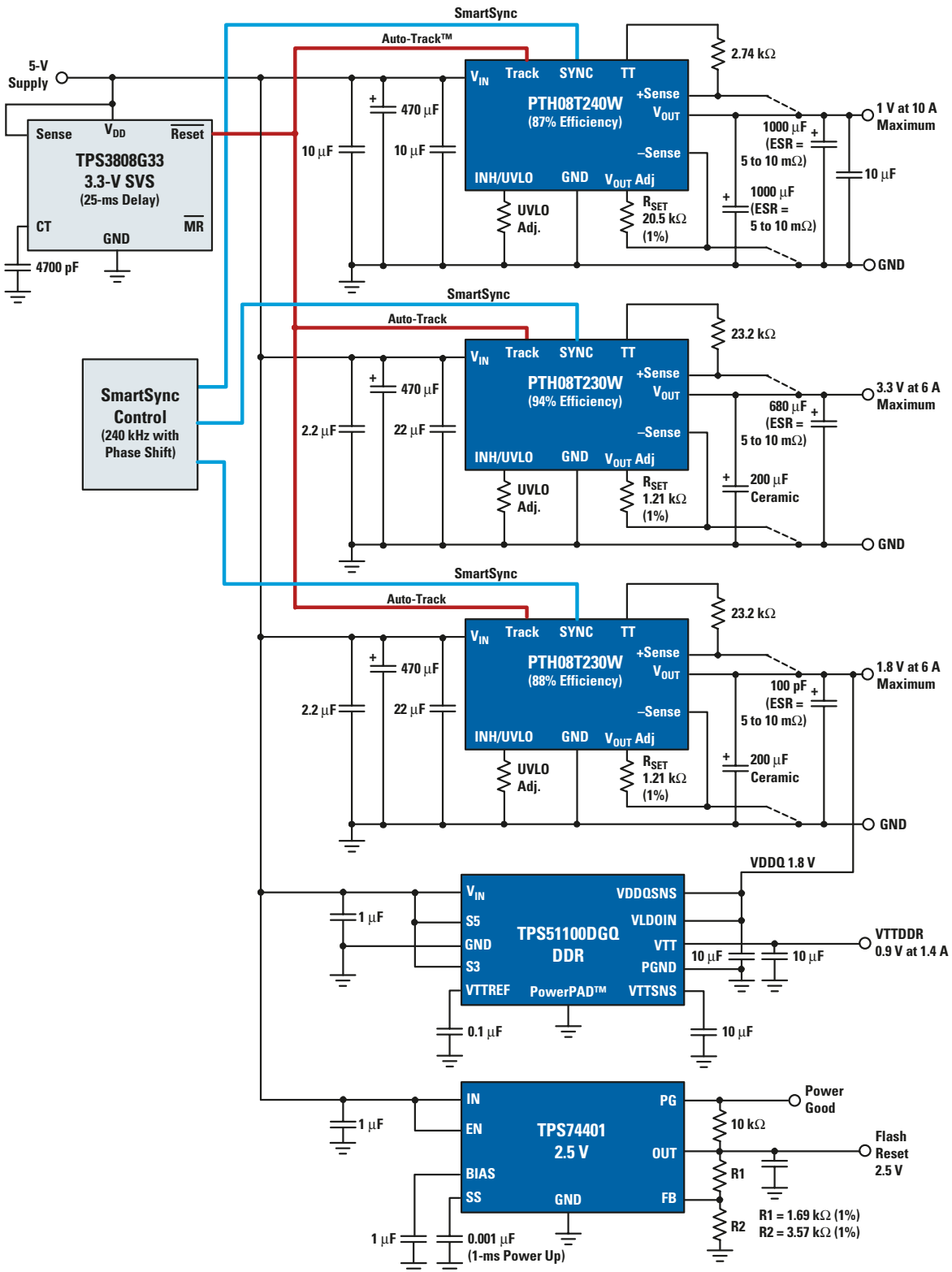


Two Highly Efficient TPS54610 6-A SWIFT™ DC/DC Converters Powering Stratix® II





Multiple T2 Modules with Frequency Synchronization via SmartSync and Sequenced with Auto-Track™ Power Xilinx® Virtex® 5 FPGA



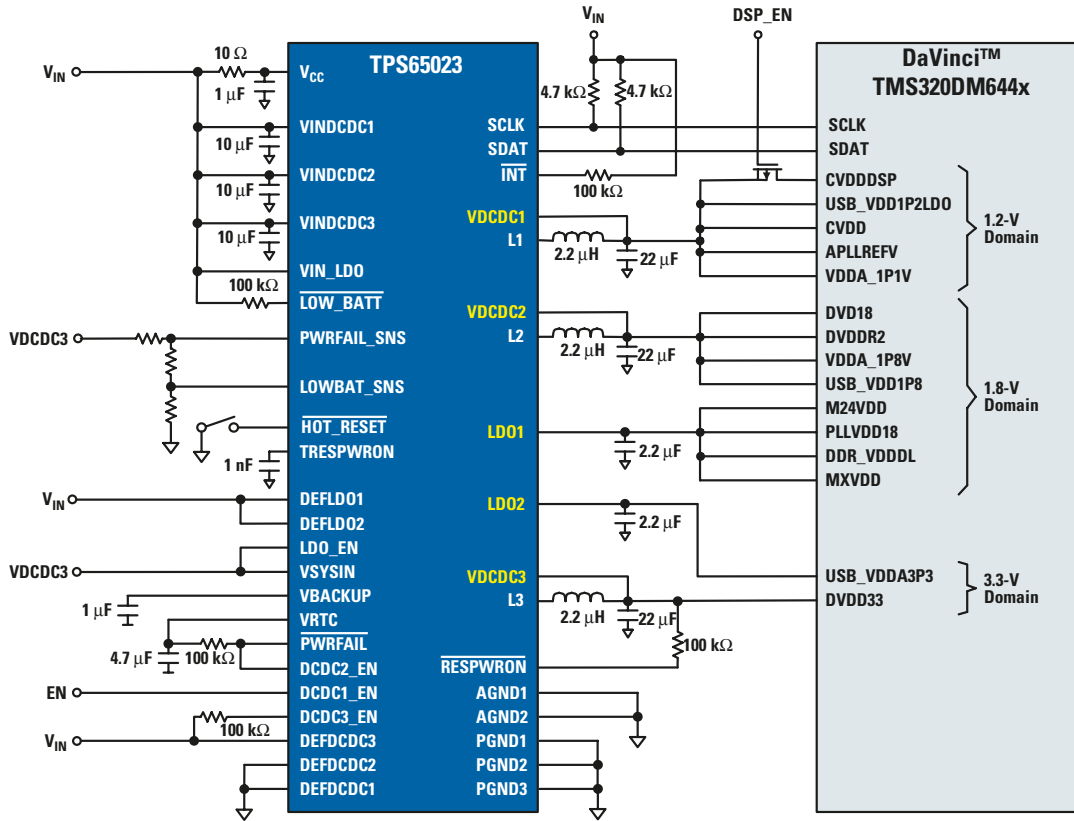


DSP Power Solutions

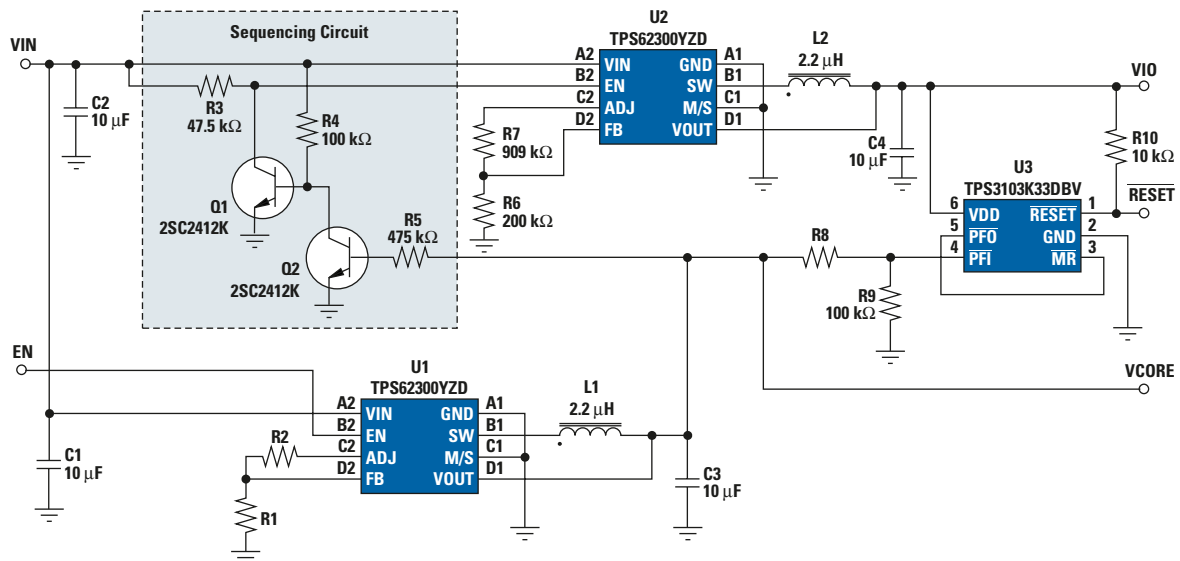
www.ti.com/dsppower

Access the site for one-stop DSP power management support, including free downloads of DSP power reference designs with complete schematics, bill-of-materials and helpful implementation notes.

6-Channel Power Management IC with 3 DC/DCs, 3 LDOs, I²C Interface and DVS, Optimized for DaVinci™ DSPs



Two Highly Power- and Space-Efficient TPS62300 500-mA DC/DC Converters Powering TMS320VC5503/07/09A DSP



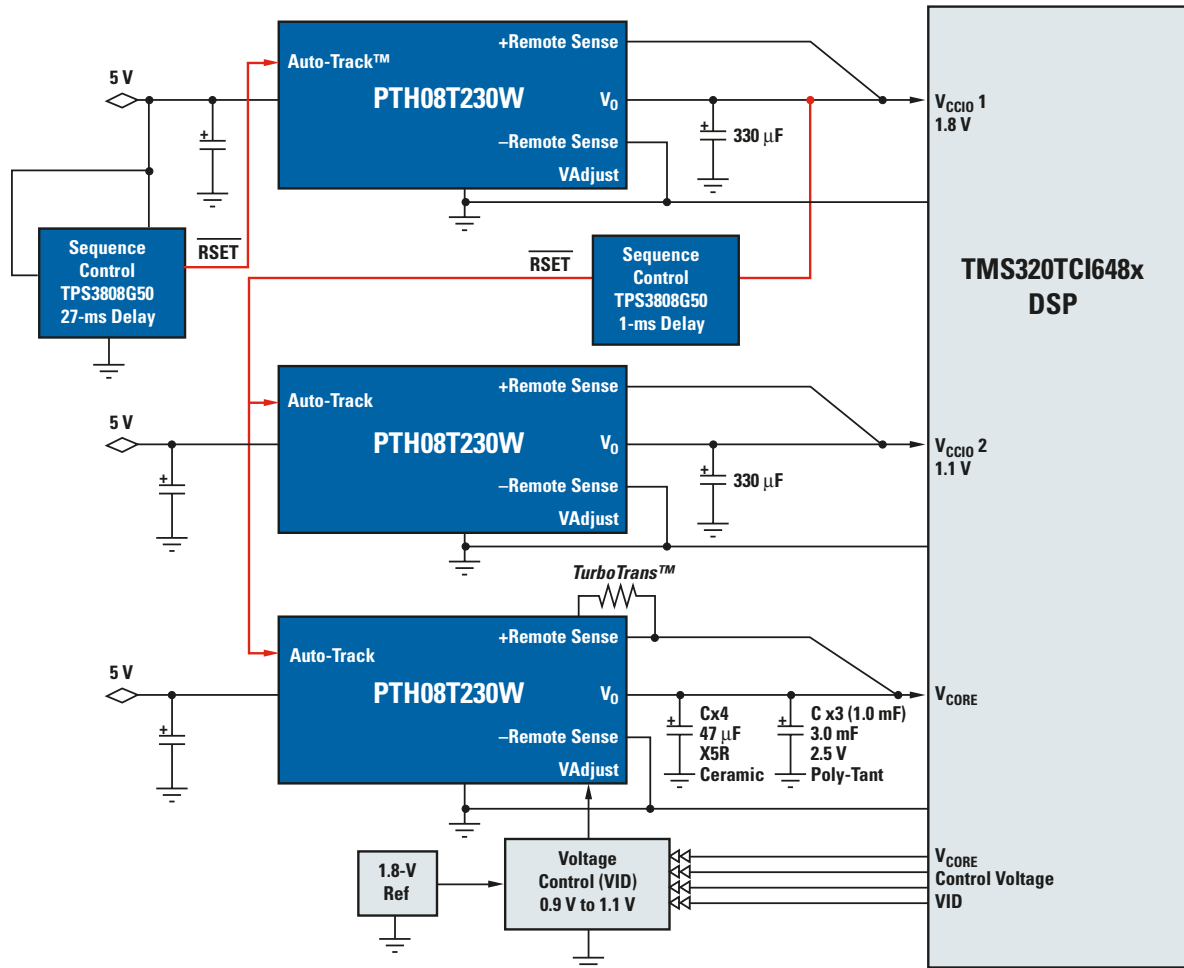


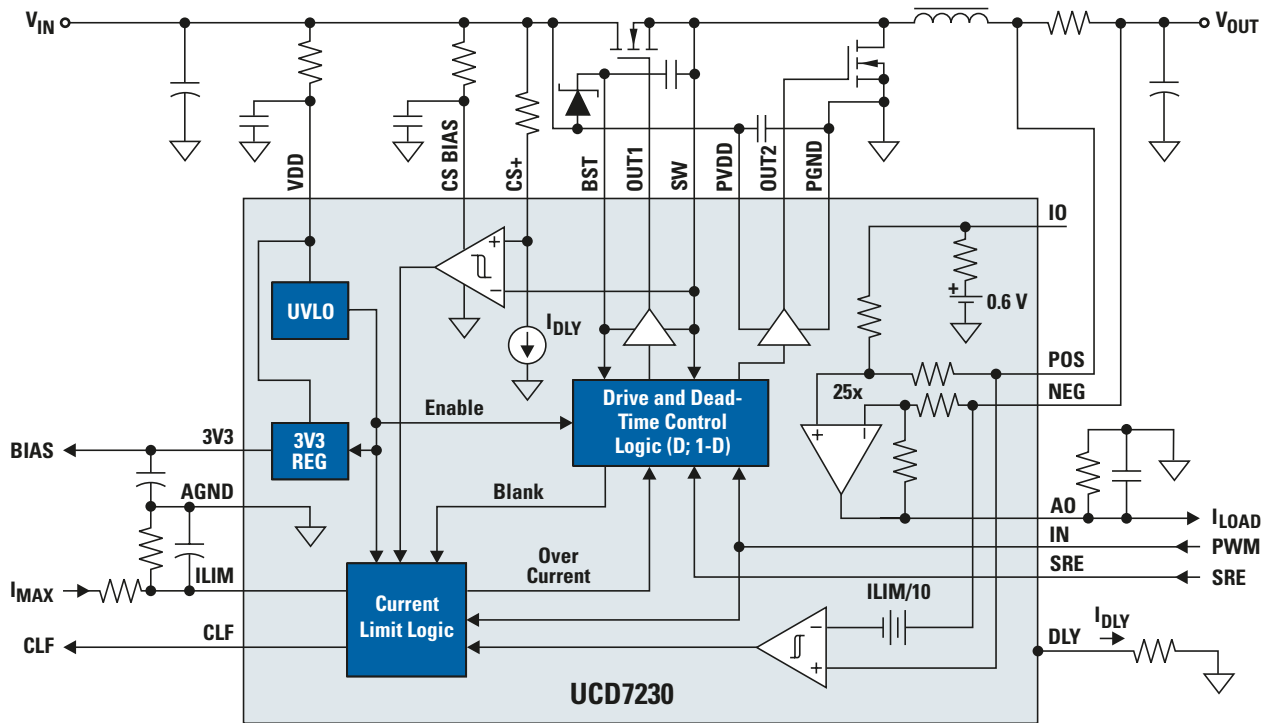
DSP Power Solutions

www.ti.com/dsppower

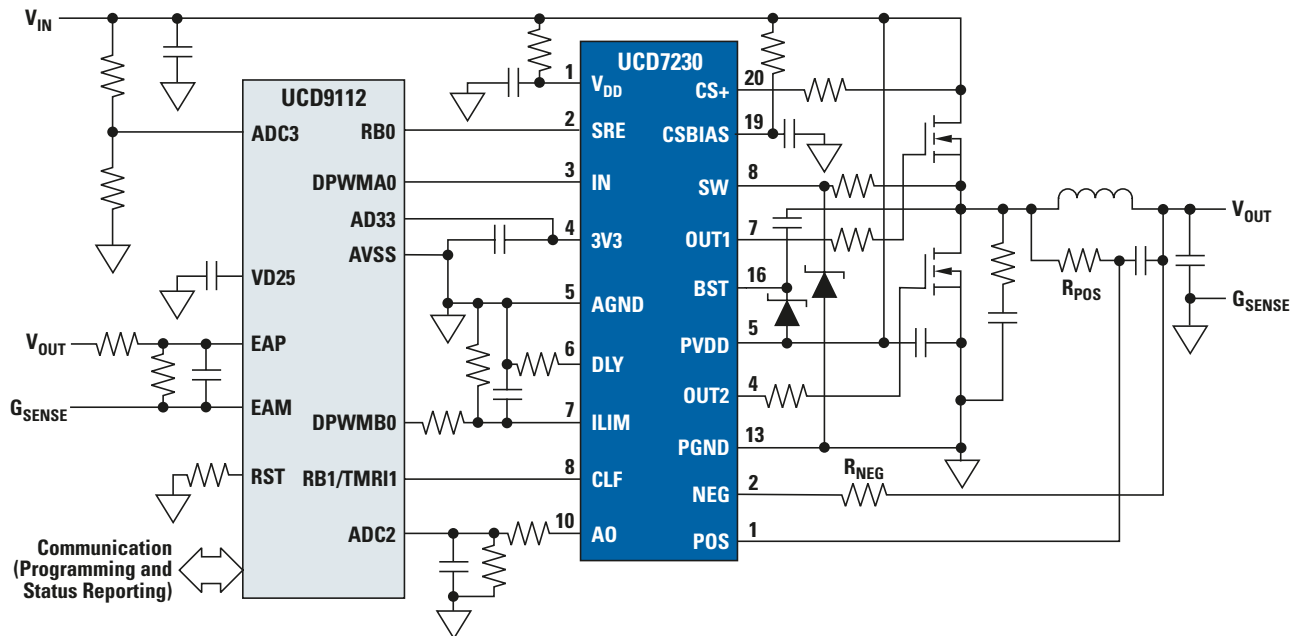
TI's TMS320TCI648x DSPs have very stringent power requirements—especially the processor core voltage (V_{CORE}) and input-output voltages (V_{CCIO}). The core-voltage requirements of these newest 3-GHz DSPs typically range from 0.9 V to 1.1 V but require tolerance levels of $\pm 3\%$. In addition, large current transients make the task of delivering reliable processor power even more challenging. To meet these challenges, TI's T2 plug-in power products offer extremely fast transient response. These compact and cost-effective devices have been designed to deliver reliable processor core power that reduces bulk capacitance.

TMS320TCI648x DSP Reference Design





UCD7230 functional diagram.



UCD7230 digital converter application.

Power-Supply Sequencer

UCD9080

Get samples and datasheets at: www.ti.com/sc/device/UCD9080

The UCD9080 power-supply sequencer controls the power sequencing of up to eight voltage rails and three independent digital I/Os with a single device. No external memory or clock is required, and the device runs from a single 3.3-V supply.

The UCD9080 monitors all the voltage rails at a sampling rate of 20 kHz with 3.5-mV resolution. It has a high degree of configurability to sequence the rails for power up and power down.

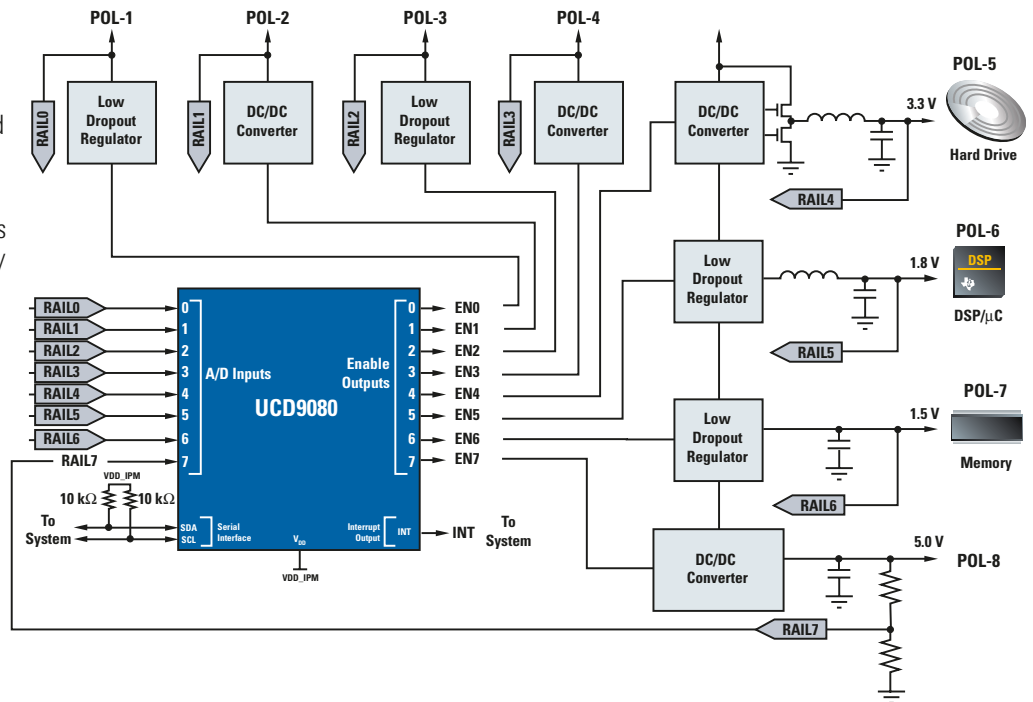
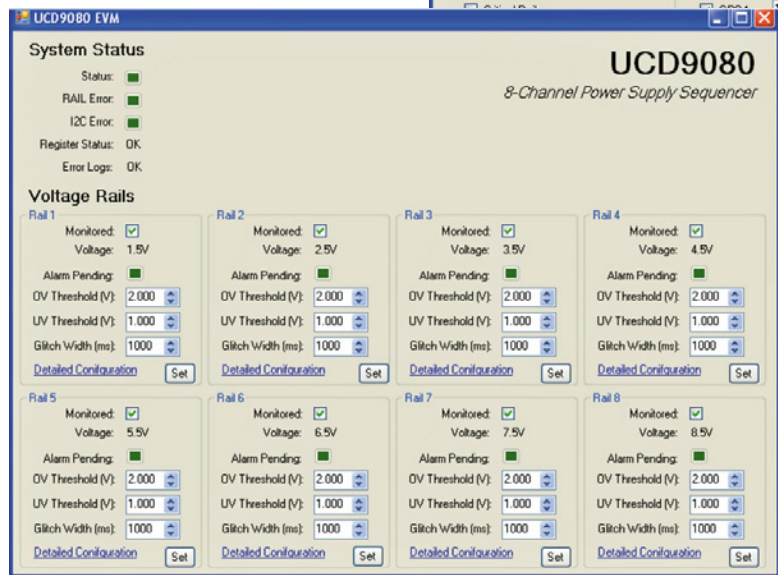
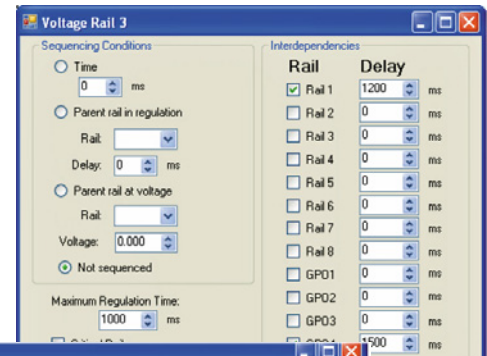
The UCD9080 also includes options such as resequencing in the event of faults such as rail failures. Rail sequencing can be based on timed events or on timed events in conjunction with other rails achieving regulation. In addition, each rail is monitored for glitches and under- and over-voltage threshold violations. Each rail that the UCD9080 monitors can be configured to shut down other rails as set in the configuration screen.

Features

- Single-chip design, operates from 3.3-V supply
- Additional GPIOs with control for device resets, LED control, etc.
- Under- and over-voltage monitoring
- Fast and flexible shut-down options through use of interdependency
- Error log and status monitoring provided through I²C interface
- Non-volatile error log storage to Flash for field debug of critical supply failures
- Configurable sequencing options, over-/under-voltage thresholds, shut-down response
- Easy-to-use Windows® operating system GUI

UCD9080 Sequencing Configuration

- Flexible sequencing options including:
 - Time-based
 - Sequence after another rail achieves regulation (plus time)
 - Sequence after another rail achieves a certain voltage level
- Power-up and power-down sequencing
- Configurable voltage-rail dependencies



→ Power Factor Correction (PFC)

Design Factors

Control Method

Average-Current Mode (ACM) —

Optimum control method to achieve PFC and low harmonic distortion.

Transition Mode (TM) — Simpler inexpensive control with high peak currents and filtering requirements.

Interleaved — TM- and ACM-compatible multiphase, high-power, high-density topology. Delivers better EMI, smaller magnetics and reduced ripple currents.

Zero-Voltage-Transition (ZVT) Mode —

A type of soft-switching technique, which reduces EMI and allows for higher frequency operations.

Protection

- Soft-start (programmable) provides controlled start-up.

- Over-current protection (OCP) provides protection during overload conditions.
- Over-voltage protection (OVP) prevents output capacitor, switches and load from overcharge condition.

Performance

- Voltage feed-forward for linearized performance and faster transient response over wide line voltage range.
- Multiplier linearity and zero power detect functions improve light load operation.
- Onboard high output current drive capability without external MOSFET drivers.

Flexibility

- Ability to work with a wide line voltage range.
- Different levels of under-voltage lockout thresholds for self bias and auxiliary bias applications.
- Ability to synchronize controllers to eliminate noise issues.

Power Level

- IEC requirements are applicable to all power supplies above 150 W.
- Higher power converters may require zero-current-switching (ZCS) and ZVT-switching techniques to achieve high efficiencies.
- Some of the simpler control techniques not usable at high power levels.

Features

From 50 W to 5 kW, TI PFC controllers deliver EN61000-3-2 compliance.

- Industry standard architecture.
- Deliver PF > 0.993.
- New BiCMOS generation reduces complexity.
- Optimized PFC/PWM “combo” controllers.
- Superior applications support.

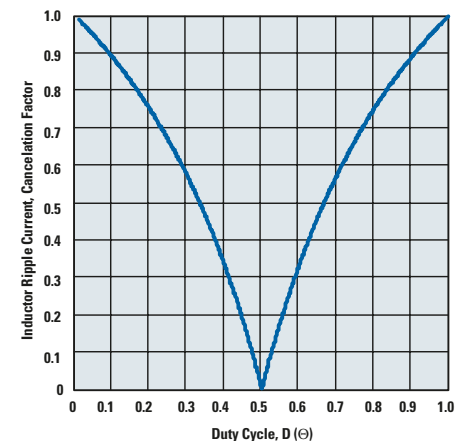
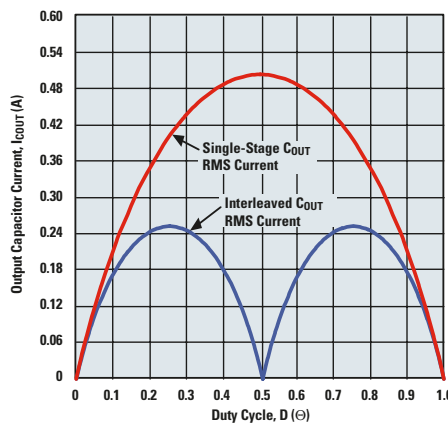
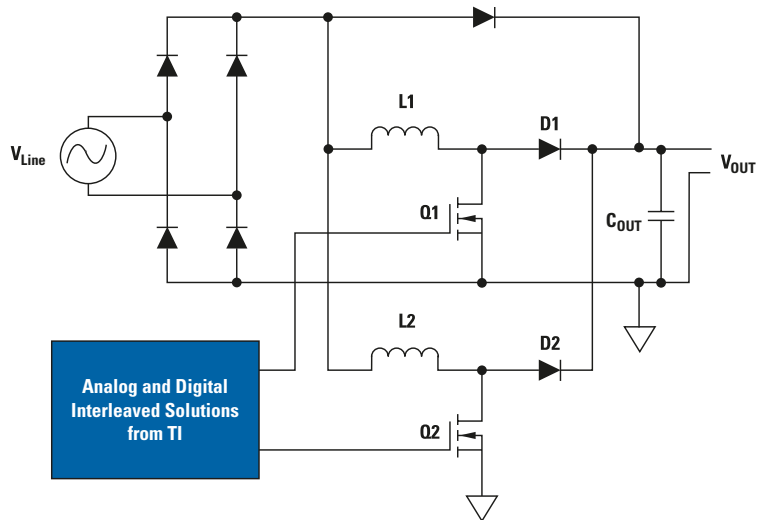
Interleaved PFC

Interleaving is a PFC method that is gaining popularity in external and embedded-type power-supply architectures. It is exceptionally flexible and provides many options such as passive-component size reductions, smaller EMI filtering circuits and higher efficiencies.

Another benefit of multiphase interleaving is that its scalability allows it to address many different power levels and applications.

Why Interleave?

- Input and output ripple current cancellation
- Reduces boost inductor volume
- Reduces output capacitor RMS current
- Reduces the EMI filter size





Selection Guide

Device	Description	Control Method ¹	Typical Power Level	Soft Switching ²	Max Frequency (kHz)	Start-Up Current (mA)	UVLO Thresholds (V)	PWM Prog. Max Duty Cycle	PWM Freq. Option	OVP	Price*
UCC28019	8-Pin PFC Controller	ACM	75 W to 600 W	—	65	0.01	10.5/9.5	—	—	—	0.80
UC3852	Transition Mode PFC Controller	TM	<150 W	—	Variable	1	16.3/11.5	—	—	—	1.70
UC3853/A	8-Pin PFC Controller	ACM	75 W to 300 W	—	125	0.25	11.5/9.5	—	—	✓	0.99
UC3854	PFC Controller	ACM	200 W to 2 kW+	—	200	1.5	16/10	—	—	—	1.15
UC3854A/B	Improved PFC Controller	ACM	200 W to 2 kW+	—	200	0.3	16/10 ('3854A) 10.5/10 ('3854B)	—	—	—	1.35
UC3855A/B	High Performance Soft Switching PFC Controller	ACM	400 W to 2 kW+	ZVT	500	0.15	16/10 ('3855A) 10.5/10 ('3855B)	—	—	✓	5.70
UCC38050/1	Transition Mode PFC Controller	TM	50 W to 400 W	—	Variable	0.75	15.8/9.7 ('38050) 12.5/9.7 ('38051)	—	—	✓	0.70
UCC3817A/8A	BICMOS PFC Controller	ACM	75 W to 2 kW+	—	400	0.1	16/10 ('3817A) 10.5/10 ('3818A)	—	—	✓	1.15
UCC3819A	Tracking Boost PFC Controller	ACM	75 W to 2 kW+	—	400	0.1	10.2/9.7	—	—	✓	1.15
UCC38500/1/2/3	PFC+PWM Combo Controller	ACM	75 W to 1 kW+	—	400	0.1	16/10 ('38500/2) 10.5/10 ('38501/3)	—	1x	✓	2.35
UCC28510/1/2/3	Advanced PFC+PWM Combo Controller	ACM	75 W to 1 kW+	—	600	0.1	16.6/9.3 ('28510/2) 10.2/9.7 ('28511/3)	✓ ³	1x	✓	1.80
UCC28514/5/6/7	Advanced PFC+PWM Combo Controller	ACM	75 W to 1 kW+	—	600	0.1	16.6/9.3 ('28514/6) 10.2/9.7 ('28515/7)	✓ ³	2x	✓	1.80
UCC28521/8	Advanced PWM/PFC Combo Controller with TEM/TEM Modulation	ACM	75 W to 1 kW+	—	600	0.1	10.2/9.7	✓ ³	2x	✓	1.80

¹ACM = average current mode; TM = transition mode.²ZVT = zero voltage transition.³Up to 90%.New devices are listed in **bold red**.

*Suggested resale price in U.S. dollars in quantities of 1,000.

Resources For a complete list of Resources, visit power.ti.com

Part Number	Description	Price*
Evaluation Modules (EVMs)		
UCC28051EVM	100-W Offline AC/DC Voltage Converter with PFC	49
UCC28514EVM	100-W AC/DC Power Converter with PFC Regulating a 12-V DC Output	49
UCC28521EVM	350-W Two-phase Interleaved Power Factor Corrected Pre-regulator	99
UCC28528EVM	350-W Two-phase Interleaved Power Factor Corrected Pre-regulator	99
UCC38050EVM	110-W Universal Line Input PFC Boost Converter	49
UCC38500	UCC38500 Evaluation Module: 100-W, Universal Line to 12-V Regulated Output	49
UCC3817	UCC3817 Evaluation Module: 385-V, 250-W PFC Boost Converter	49

*Suggested resale price in U.S. dollars.

Literature Number	Part Number	Description
Application Notes		
SLUA144	UC3854	UC3854 Controlled Power Factor Correction Circuit Design
SLVC018.ZIP	UCC38050	MathCAD Application Design Tool for Use with the UCC38050
SLUU138	UCC38050	100-W Critical Conduction Power Factor Corrected Preregulator
SLUA308	UCC3817	UCC3817 Current Sense Transformer Evaluation
SLUA296	UCCX8510-17	A New Synchronization Circuit for Power Converters
SLUA294	UCC3817A/18A/19A	Differences between UCC3817A/18A/19A and UCC3817/18/19
SLUA269	UCC3819	UCC3819 250-W PFC Boost Follower Preregulator Design
SLUA245	UCC3817	Synchronizing a PFC Controller from a Downstream Controller Gate Drive
SLUA196	UC3854A/B, UC3855A/B	UC3854A/B and UC3855A/B Provide Power Limiting with Sinusoidal Input Current for PFC Front Ends
SLUA177	UC3854A/B	UC3854A and UC3854B Advanced Power Factor Correction Control ICs
SEM1500	UCC28510	Designing High Power Factor Off-Line Power Supplies
SEM700	UC3854	Optimizing the Design of High Power Factor Switching Preregulator
SLYT097	UCC28517	100-W PFC Power Converter with 12-V, 8-W Bias Supply (Part 1)
SLYT092	UCC28517	100-W PFC Power Converter with 12-V, 8-W Bias Supply (Part 2)

PWM Power Supply Controllers

Single-Ended Topologies

Control Method

Voltage Mode — Simple, low-noise control method for wide input and output range requirements.

Current Mode — Fast transient response with built-in current limiting.

Level of Integration

- Integrated soft-start (programmable) provides predictable start-up.
- Internal leading edge blanking to suppress switching spike from MOSFET turn-on.

Performance

- Many voltage mode controllers have input voltage feedforward for instantaneous response to input line changes.
- Most controllers have onboard high current drive capability without external MOSFET drivers.

- Lower start-up current for offline applications (for BiCMOS products with UCC prefix).
- Low operating current (for BiCMOS products with UCC prefix) for light-load efficiency.
- Programmable minimum duty cycle clamp for light-load efficiency (UCC3581).

Features

- 10-W to 350-W offline and DC/DC power supplies.
- Single-ended topology power supplies, buck, boost, flyback and forward.

Double-Ended Topologies

Current Mode — Control technique featuring fast transient response with inherent cycle-by-cycle current limiting.

Voltage Mode — Versatile, low-noise control method for wide duty cycle ranges.

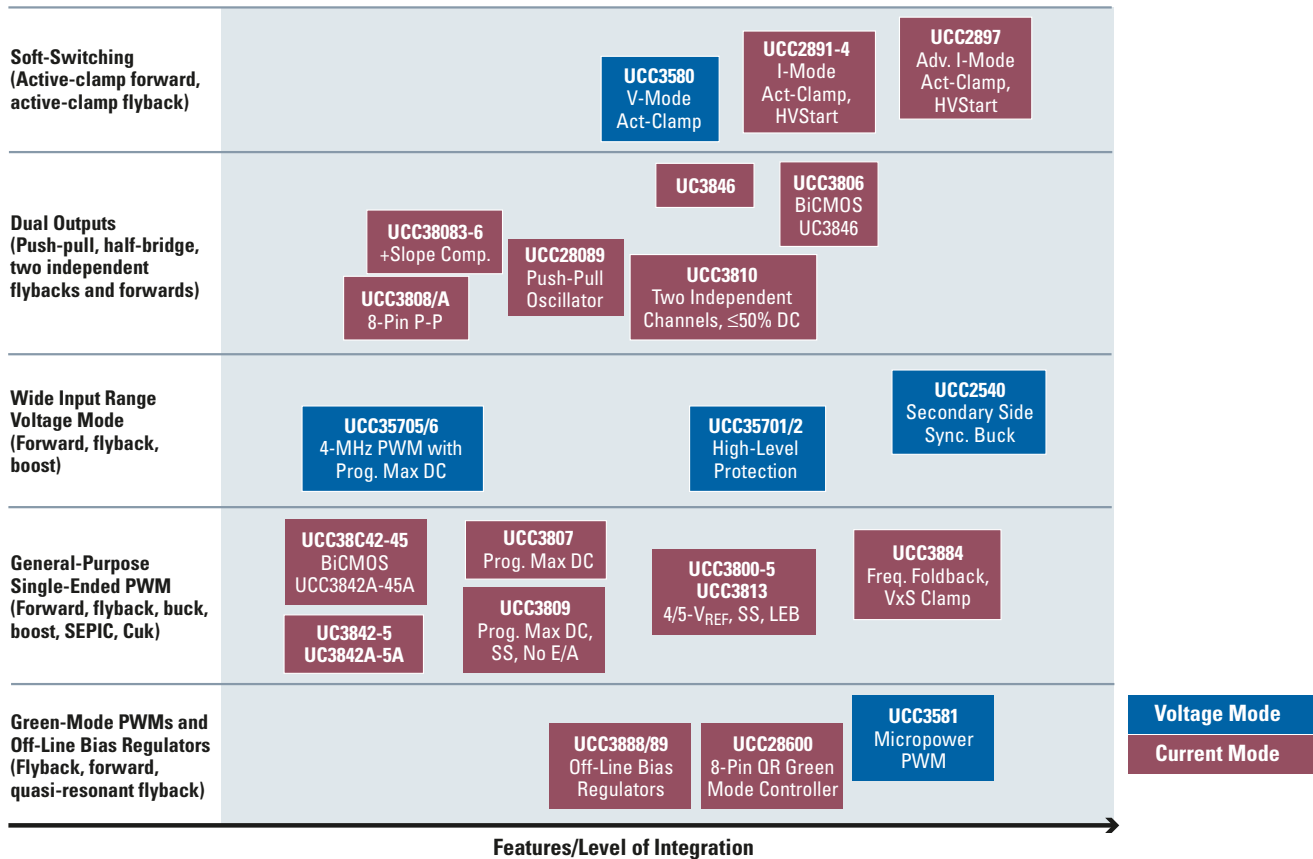
Soft Switching

- Zero Voltage Transition (ZVT) soft switching techniques minimize power loss at turn-on.
- Phase shifted, ZVT controllers maximize efficiency in full-bridge converters.

Protection

- Flexible over-current limiting circuitry provides programmable fault protection modes.
- Programmable soft-start executes predictable start-up on initialization and after faults.
- High speed, cycle-by-cycle current limiting.
- Maximum duty cycle clamp to prevent transformer saturation.
- Programmable deadtime control to prevent cross conduction of power switches.

Low- to Medium-Power PWM Controllers (25 W – 350 W)



➔ Linear and Low Dropout (LDO) Regulators

TI offers an extremely broad LDO portfolio covering applications from microampere keep-alive circuits to 7.5-A telecom loads. Key products are highlighted in the diagram on this page and the table on page 29. For a more comprehensive selection, please review pages 30–31 or visit power.ti.com for our complete portfolio.

Design Factors

Input Voltage — The minimum V_{IN} must be larger than $V_{OUT} + V_{DO}$, independent from the minimum value given in the selection table.

Efficiency — By neglecting the quiescent current (I_Q) of the LDO, efficiency can be calculated as V_{OUT}/V_{IN} .

Power Dissipation — $P_D = (V_{IN} - V_{OUT}) \times I_{OUT}$; P_D is limited by package, T_A and T_{JMAX} . Refer to application note SLVA118, "Digital Designer's Guide to Linear Voltage Regulators

and Thermal Management," for support. For higher power dissipation or requirements for higher efficiency, TI recommends step-down (buck) DC/DC converters/controllers (refer to pages 32–38 for products).

Capacitor Requirements — The output capacitor and especially its effective series resistance (ESR) are critical for stability. Therefore, some LDOs require tantalum output capacitors, which have high ESR. If an LDO is stable with no output capacitor or with low-ESR ceramic output capacitors, it is usually stable with all types of capacitors.

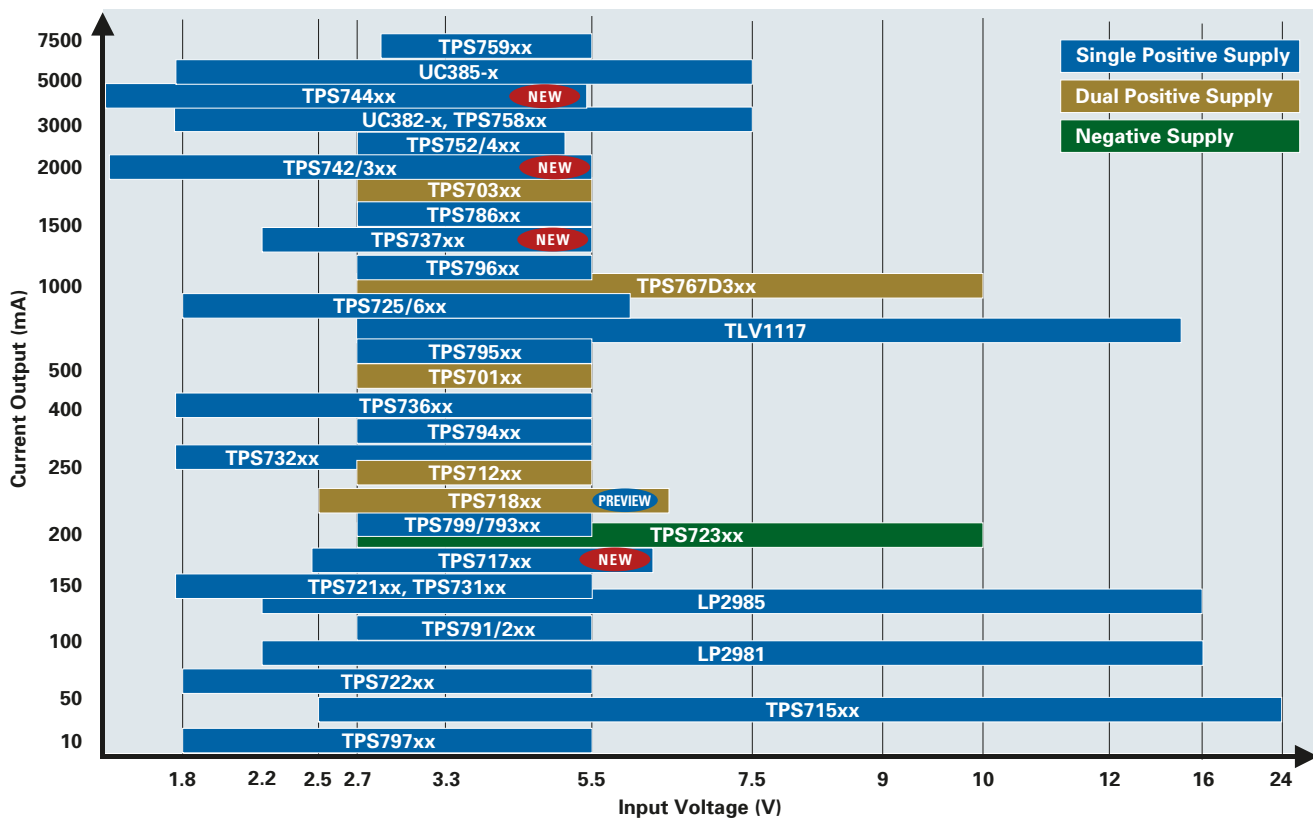
RF, Audio and Other Noise-Sensitive Applications — Select an LDO with high power supply ripple rejection (PSRR) for noise immunity from the input supply, and low output noise (< 50 μ Vrms). Some LDOs have a bypass (BP) pin for adding capacitance to lower the output noise.

PG/SVS — Devices such as microprocessors, DSPs and FPGAs require a minimum voltage for proper operation. The supply voltage supervisor (SVS) function monitors the system voltages and outputs a signal when the voltages drop below a certain value, so the system can reset and prevent malfunction. An SVS asserts the reset signal after a specified delay, while a power-good (PG) function does not have a delay.

Reverse Leakage Protection — In special applications where the voltage on the output of the LDO is higher than at the input, the reverse leakage protection feature prevents current from flowing from the LDO output to the input, which can be damaging to the input supply, especially if it is a battery.

Application-Specific Multi-Output Solutions — See page 41.

Linear and Low Dropout (LDO) Regulators Family of Products (selected models shown)



Inductorless DC/DC Regulators (Charge Pumps)

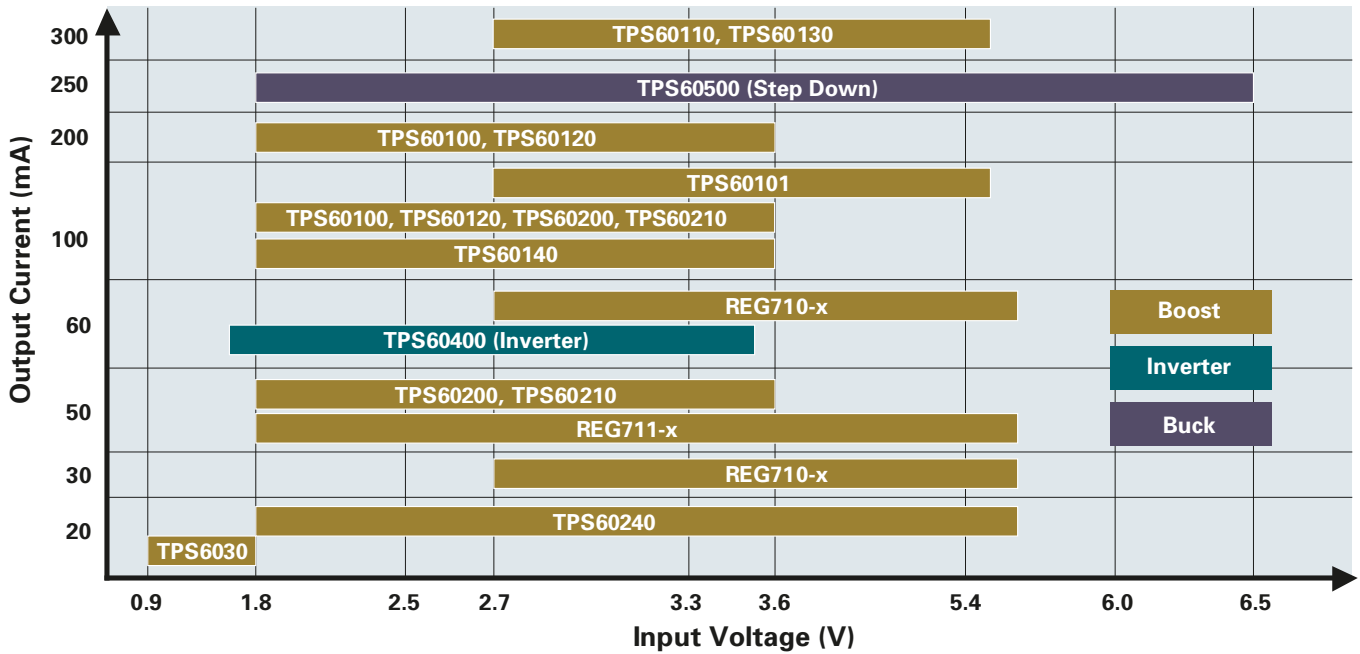
Design Factors

Efficiency and Solution Size — Use of charge pumps is recommended when a trade-off between efficiency and solution size needs to be made. Higher efficiency will directly translate into additional operating time in battery-powered applications. Charge pumps achieve peak efficiencies of 90% and typically require only a few capacitors for operation. No inductors, diodes or FETs are needed. Charge pumps come in small packages such as SOT-23 and MSOP-8, which further reduce solution size.

Output Current — Charge pump converters allow for small, power-efficient and cost-effective DC/DC solutions with output currents less than 300 mA and output voltage less than 6 V. If larger output currents, higher output voltages or greater efficiency are required, use of an inductive switching converter is more cost- and space-efficient (pages 32–38).

Output Ripple and Noise — TI charge pumps reduce output voltage ripple to a minimum by operating a pair of integrated charge pump loops with a phase shift of 180 degrees. This helps to avoid the cost of additional filtering at the output. Charge pumps also tend to generate less noise than an equivalent inductive switching converter of equal output current rating. This may be important in RF-sensitive or low-noise applications.

Inductorless DC/DC Regulators (Charge Pumps) Family of Products



Resources For a complete list of Resources, visit power.ti.com

Literature Number	Description
Application Notes	
SLVA082	Powering the TMS320VC5402 DSP Using the TPS60100, TPS76918, and the TPS3305-18
SLVA070A	TPS6010x/TPS6011x Charge Pump
SLVA098	Additional Negative Output with TPS601xx
SLVA099	Improved Start-up Performance for Charge Pumps TPS6030x
SLVA128	Optimizing Output Voltage Ripple for the REG710
SLVA133	TPS6031x Evaluation Using the TPS6030xEVM

Battery Charge Management

Design Factors

Battery Chemistry — Each battery chemistry has unique requirements for its charge algorithm, which is critical for maximizing its capacity, cycle life and safety.

Control Topology — A simple linear topology works well in applications with low-power (e.g., one- or two-cell Li-Ion) battery packs that are charged at less than 1 A.

A switchmode topology is ideally suited for large (e.g., 3 or 4 series Li-Ion or multiple NiCd/NiMH) battery packs that require charge rates >1 A. The switchmode conversion minimizes heat generation during charging.

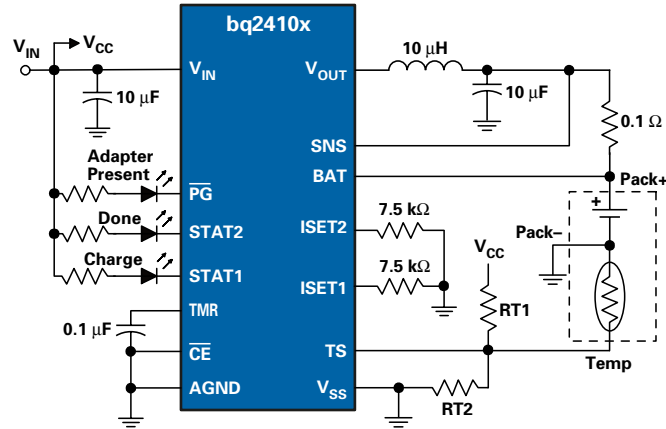
A charger using a current-limited topology requires a regulated or limited supply and simply gates the charging current.

2-A Synchronous Switchmode Charger

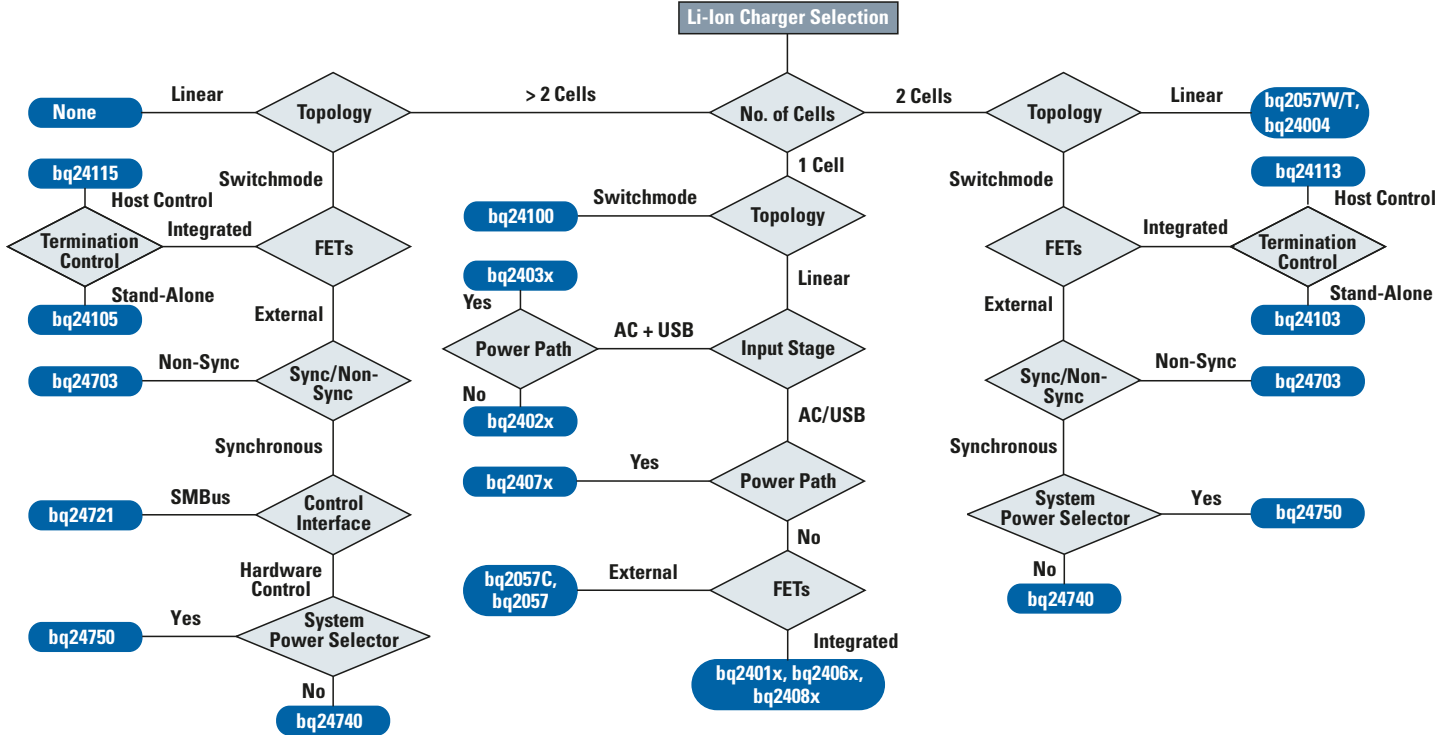
bq2410x

Get samples, datasheets and evaluation modules at: www.ti.com/sc/device/bq24100

The bq2410x are 2-A synchronous switchmode charge management devices for 1, 2 and 3 series Li-Ion or Li-Polymer battery packs.



Li-Ion Charger Selection Flowchart





Selection Guide

Device	Approx. Battery Capacity (mAh)	Min Max Series Cell	Number of LEDs	Communication Protocol	Other Features	Safety Enhancement	Packages	Price*
NiCd, NiMH Chemistry								
bq2013H	2000 to 15000	—	5	Single wire (HDQ)	Programmable offset error compensation	No	16-pin SOIC	3.70
bq2014H	500 to 6000	—	5	Single wire (HDQ)	Register compatible with bq2050H	No	16-pin SOIC	3.70
bq2016	1000 to 4500	—	5	Single wire (HDQ)	Automatic offset calibration	No	28-pin SSOP	3.00
Lithium-Ion, Lithium-Polymer Chemistry								
bq2050H	500 to 6000	—	5	Single wire (HDQ)	Register compatible with bq2014H	Yes	16-pin SOIC	3.70
bq2084	800 to 10000	2 to 4	3, 4 or 5	2 wire (SMBus)	SBS 1.1 works with bq29312 based on bq2083; includes bq2050 dataset via single wire interface	Yes	38-pin TSSOP	4.00
bq20z70	800 to 10000	2 to 4	No LED	HDQ and SMBus	Self learning, dynamic fuel gauge algorithm with bq29330	Yes	20-pin TSSOP	2.90
bq20z80	800 to 10000	2 to 4	3, 4 or 5	2 wire (SMBus)	SBS 1.1 with Impedance Track™ technology	Yes	38-pin TSSOP	4.60
bq20z90	800 to 10000	2 to 4	3, 4 or 5	2 wire (SMBus)	Self learning, dynamic fuel gauge algorithm with bq29330	Yes	30-pin TSSOP	3.30
bq27000	300 to 6000	1	—	HDQ	Single-cell fuel gauge with fixed-voltage EOD	No	10-pin DRK	1.95
bq27200	300 to 6000	1	—	I ² C	Single-cell fuel gauge with fixed-voltage EOD	No	10-pin DRK	1.95
bq27010	300 to 6000	1	—	HDQ	Single-cell fuel gauge with fixed-voltage EOD	No	10-pin DRK	1.95
Primary Lithium Chemistry								
bq2052	1000 to 12000	1	2, 4 or 5	Single wire (HDQ)	Automatic discharge compensation	No	16-pin SOIC	4.00
Lead Acid Chemistry								
bq2013H	2000 to 15000	10	5	Single wire (HDQ)	Programmable offset error compensation	No	16-pin SOIC	3.70
Multi-Chemistry								
bq2060A	800 to 10000	0.1	4 or 5	SMBus or HDQ16	SBS 1.1 extended cold temp cell modeling and high temp safety enhancement, improved bq2060	Yes	28-pin SSOP	3.90
Battery Monitors								
bq2019	>20000	1	—	Single wire (HDQ)	64-bit ID ROM and 1 program output non-volatile memory	—	8-pin TSSOP	1.95
bq2023	>20000	0.25	—	Single wire (SDQ)	64-bit ID ROM and 1 program output automatic offset error calibration	—	8-pin TSSOP	2.00
bq26200	>20000	0.25	—	Single wire (HDQ)	High-performance battery, coulomb counter	—	8-pin TSSOP	2.00
bq26220	>20000	0.25	—	Single wire (HDQ)	64-bit ID ROM and 1 program output on-chip voltage measurement	—	8-pin TSSOP	2.05

*Suggested resale price in U.S. dollars in quantities of 1,000.

New devices are listed in bold red.

Resources *For a complete list of Resources, visit power.ti.com*

Part Number	Description	Price*
Evaluation Modules (EVMS)		
bq2013HEVM-001	bq2013H Evaluation Kit for NiCd, 16.8 V	99
bq2014HEVM-001	bq2014H Evaluation Kit for NiMH, 10.8 V	99
bq2050HEVM-002	bq2050H Evaluation Kit for Li-Ion, 10.8 V	99
bq2060AEVM-001	bq2060A Evaluation Kit for Li-Ion	99
bq2060AEVM-002	bq2060A Evaluation Kit for NiMH	99
bq2084EVM-001	bq2084 Evaluation Kit also features the bq29312 and bq29400	99
bq20z70EVM-001	bq20z70 Evaluation kit also features the bq29330 and bq29412	99
bq20z80EVM-001	bq20z80 Evaluation kit also features the bq29312 and bq29400	99
bq20z90EVM-001	bq20z90 Evaluation kit also features the bq29330 and bq29412	99
bq26220EVM-001	bq26220 Evaluation Kit for Multi-Chemistry, 2.6 to 4.5 V	99
bq27000EVM	bq27000 Evaluation Module	99
bq27200EVM	bq27200 Evaluation Module	99

*Suggested resale price in U.S. dollars.

Literature Number	Description
Application Notes	
SLUA324	Getting Started with the bq20z80 and EVM
SLUA325	Feature Set Comparison Between bq2084 and bq20z80
SLVA100	Advanced Gas Gauge Host Firmware Guide for the TI Battery Monitor ICs
SLVA101	HDQ Communication Basics for TI's Battery Monitor ICs
SLVA102	Gas Gauging Basics Using TI's Battery Monitor ICs
SLVA114	Advanced Gas Gauge Host Firmware Flow Chart for the TI Battery Monitor ICs
SLVA 148	bq2083, bq2084, and bq2085 Calibration Procedure
SLVA149	Configuring the bq2060 and bq2060A EEPROMs
SLVA150	Avoiding Clock Jitter with the bq2085 Advanced Gas Gauge
SLVA151	Using Advance Features of the bq2060A Gas-Gauge IC
SLUA338	Configuring the bq27000/200 for Gas Gauge Applications
SLUA359	Using SHA-1 in bq20zxx Family of Gas Gauges
SLUA364	Theory and Implementation of Impedance Track Battery Fuel-Gauging Algorithm



Lithium-Ion Protection

Design Factors

Number of Series Cells — A battery is constructed from a string of series and parallel cells. Each series cell, or group of paralleled cells, requires protection from overcharge, overdischarge and short-circuit conditions.

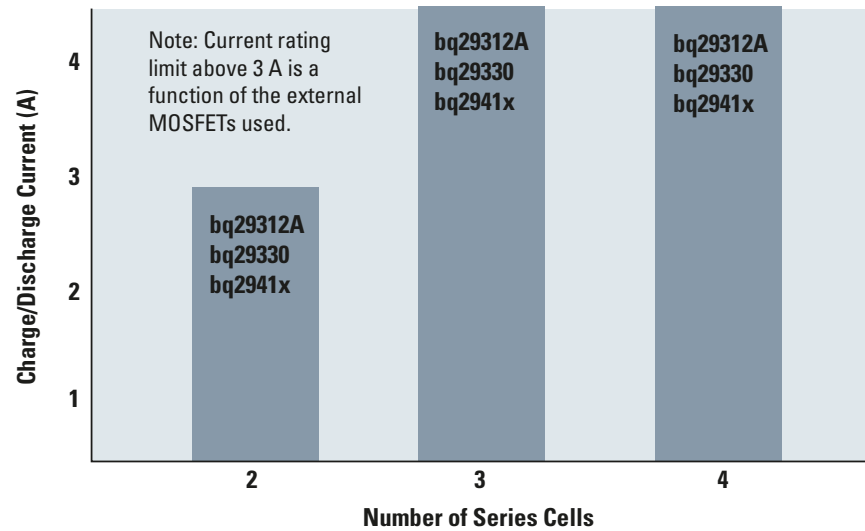
Threshold Voltage — Li-Ion and Li-polymer cells are produced by many manufacturers. Some manufacturers' technologies create cells of different maximum stress voltages, otherwise known as the "over-voltage threshold." This data is available from the cell supplier.

Threshold Tolerance — The over-voltage threshold has a tolerance that needs to be accounted for in the design for safety reasons.

Shutdown Current — In battery pack applications, constant current draw needs to be very low to preserve battery life.

Charge/Discharge Current — The pass element associated with each protection IC is rated for maximum current whether it be an internal or external FET.

Lithium-Ion Protection Family of Products



Features

- BiCMOS process results in low current consumption.
- Different over-voltage thresholds allow one design to work with several cell suppliers.
- Sleep current consumption of less than 3.5 μ A enables extended battery life.
- 50 mV precision internally trimmed thresholds maximize safety.
- Short-circuit protection eliminates the need for an external fuse.

Selection Guide

Device	Number of Series Cells	Charge/Discharge Current (A)	Threshold Voltage (V_{OV})	Shutdown Current (μ A)	Other Features	Available Packages	Price*
bq29312A	2, 3 or 4	External FET	bq2084 ¹ , bq20z80 ¹	1	Integrated LDO, works directly with bq2084 and bq20z80 gas gauge	24-pin TSSOP	1.30
bq29330	2, 3 or 4	External FET	bq20z90 ¹	1	Integrated LDO, works directly with bq20z90 gas gauge	20-pin TSSOP	1.45
bq2941x	2, 3 or 4	—	x = voltage level	1	Second overvoltage safety for chemical fuse activation	8-pin TSSOP	0.42

¹Controlled by bq208x, bq20z8x or bq20z9x gas gauge.

See individual datasheets for full details.

*Suggested resale price in U.S. dollars in quantities of 1,000.

Resources For a complete list of Resources, visit power.ti.com

Part Number	Description	Price*
Evaluation Modules (EVMs)		
bq2084EVM-001	bq2084 Evaluation Kit also features the bq29312 and bq29400	99
bq20z70EVM-001	bq20z70 Evaluation Kit also features the bq29330 and bq29412	99
bq20z80EVM-001	bq20z80 Evaluation Kit also features the bq29312 and bq29400	99
bq20z90EVM-001	bq20z90 Evaluation Kit also features the bq29330 and bq29412	99

*Suggested resale price in U.S. dollars.

Authentication for Batteries and Peripherals



Design Factors

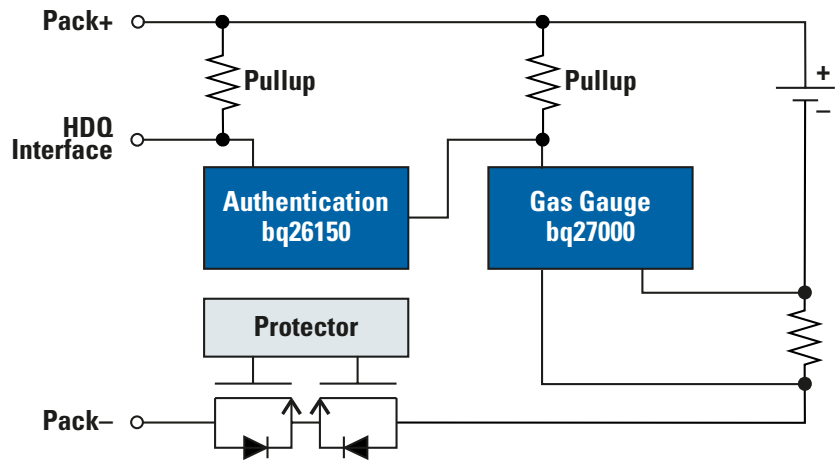
Original equipment manufacturers specify products to achieve required performance and safety goals. Authentication ensures that connected devices fulfill the established requirements and are safe for the consumer.

Features

TI authentication devices use three levels of security.

- **Identification Number** — The host controller can request an identification number that is answered with a fixed response.
- **CRC Algorithm** — The host processor sends a random challenge and reads the response that is an encoding of the challenge and a shared secret key through a CRC with a shared secret polynomial.
- **SHA-1 Encryption** — The host processor sends a random challenge and reads the response that is an encoding of the challenge and a shared secret key through the SHA-1 cryptographic primitive.

Single-Cell Battery Pack with Gas Gauge and Authentication



Selection Guide

Device	Interface	Pins	Security	Temp (°C)	Price*
bq2022	SDQ	3	ID number	-40 to 85	1.25
bq26150	HDQ	5	CRC algorithm	-20 to 70	1.25
bq26100	SDQ	5	SHA-1 encryption	-20 to 70	1.30

*Suggested resale price in U.S. dollars in quantities of 1,000.

Hot Swap and Power Distribution

Power-over-Ethernet



Design Factors

IEEE 802.3af Power-over-Ethernet — With approval of the IEEE 802.3af Power-over-Ethernet (PoE) standard, all data terminal equipment (DTE) now has the option to receive power over existing CAT-5 and CAT-3 cabling that is used for data transmission. The IEEE 802.3af standard defines the requirements associated with providing and receiving PoE cables. The Power Sourcing Equipment (PSE)

provides the power on the cable and the Powered Device (PD) receives the power. As part of the IEEE 802.3af standard, the interface between the PSE and the PD is defined as it relates to the detection and classification protocol.

Power Sourcing Equipment (PSE) — The TPS2384 Quad PSE Manager independently manages power for up to four Ethernet ports, reporting system status over a standard I²C

serial interface. The TPS2384 is the most integrated PSE solution on the market today with integrated power FETs and sense resistors.

Powered Devices (PDs) — Acting as an interface between the PSE and PD, the TPS23750 performs all detection, classification, inrush current limiting and switch FET control that is necessary for compliance with the IEEE 802.3af standard.

Hot Swap Power Management



What is ATCA?

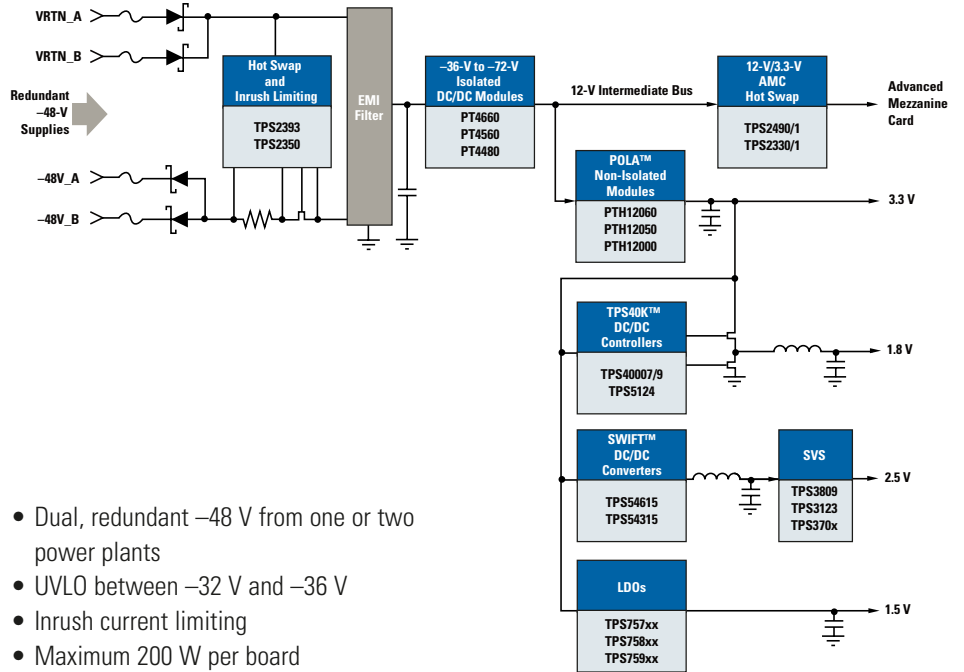
Advanced Telecommunications Computing Architecture (ATCA) is a new open standard for carrier grade communications equipment. The requirements for ATCA are defined in PICMG 3.0 specifications and include mechanical, shelf management, power distribution, data transport, thermal, regulatory guidelines and data/power connectors.

The ATCA PICMG 3.0 open standard has specific requirements for delivering dual -48-V power feeds to individual boards which may consume up to 200 W each.

ATCA Power Requirements

ATCA contains many requirements which are typical of a modern, hot swapped power system. It also contains some requirements which are particular to ATCA. Among the most challenging are the transient ride-through specifications which mandate that boards continue operation through a 5-ms short on both inputs. Boards must also continue operation through a 10- μ s, 100-V transient at the input.

ATCA Power Solutions

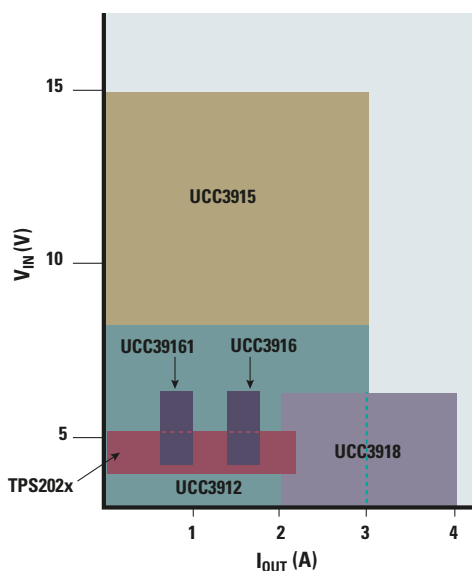


- Dual, redundant -48 V from one or two power plants
- UVLO between -32 V and -36 V
- Inrush current limiting
- Maximum 200 W per board
- Fuses on both -48-V feeds and both returns
- Isolation between A and B feeds/returns
- 5-ms holdup with input short to ground
- 60-W maximum for mezzanine cards
- 100-V transient capability

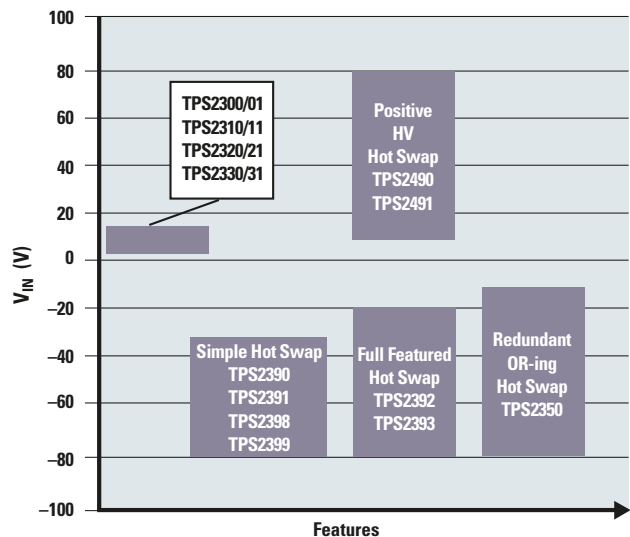
Hot Swap Power Management Family of Products

www.ti.com/atcapower

Hot Swap Power Switch ICs (Integrated Power FET)



Hot Swap Power Controller ICs (External Power FET)



Resources For a complete list of Resources, visit power.ti.com

Part Number	Description	Price*
Evaluation Modules (EVMs) and Tools		
TPS2375EVM	Power-over-Ethernet Powered Device Controller Evaluation Module	49
SLVC065	TPS2375/TPS2377 Design-in Calculation Tool	Free
TPS23750EVM-107	Power-over-Ethernet TPS23750 Powered Device Controller Evaluation Module Buck	49
TPS23750EVM-108	Power-over-Ethernet TPS23750 Powered Device Controller Evaluation Module Flyback	49
TPS2384EVM	Power-over-Ethernet Power Sourcing Equipment Controller Evaluation Module Auto Mode	149
TPS2384EVM-152	Power-over-Ethernet Power TPS2384 Sourcing Equipment Controller Evaluation Module Manual Mode	149
TPS2490EVM-001	TPS2490/1 Evaluation Module	49
TPS2490OR91CALC	TPS2490/1 Design-in Calculation Tool	Free

*Suggested resale price in U.S. dollars.

New evaluation modules are listed in **bold red**.

Literature Number	Part Number	Description
Application Notes		
SLUU221	TPS2363	PCIExpress Server Dual Slot Hot Plug User's Guide
SLUA331	UC2572	ATCA High Voltage Energy Storage Technique to Reduce Size and Cost of Transient Holdup Circuitry
SLVR248	TPS2490/TPS2231	ATCA AMC Hot Swap Reference Design
SLVR246a	TPS2393	–48-V ATCA Hot Swap Reference Design Using the TPS2393 (Rev. A)
SLUU212a	TPS2350	–48-V ATCA Hot Swap Reference Design Using the TPS2350 (Rev. A)
SLVA158	TPS2490/1	Hot Swap Design Using TPS2490/91 and MOSFET Transient Thermal Response
SLVA337	TPS2490/1	Undervoltage and Overvoltage Control for the TPS2490/91
SLVA362	TPS2490/1	Hot Plug Express Card
SLVA233a	TPS2384	Electrical Transient Immunity for Power-over-Ethernet
SLVA230	TPS2384	Implementation of a Port ON LED in PSE Systems
SLVA231	TPS2384	Proper Termination of Unused Port Connections
SLVA377	TPS2384	Using Standard Power-over-Ethernet Controllers for High-Powered Devices
SLVA223	TPS2384	Simple PSE Solution Delivers High Power-over-Ethernet to 31-35W PD Over Four Pairs
SLVA224	TPS2384	Simple PSE Solution Delivers High Power-over-Ethernet to 16-18W PD Over Two Pairs
SLVA229	TPS2384	Opto-Isolator Selection Guidelines: TPS2384 I ² C Interface
SLVA221	TPS2384	PSE Solution Delivers High Power-over-Ethernet to 25-W PD Over Two Pairs
SLVA328a	TPS2384	PSE Controller Interface Control (Rev. A)
SLUU206	TPS2375/TPS2376/TPS2377	Estimating Available Application Power for Power-over-Ethernet Applications
SLVA225	TPS2375/TPS2376/TPS2377	High Power PoE PD Using the TPS2375/77-1
SLUA220	TPS2375/TPS2376/TPS2377	Wall Adapter Powers IEEE 802.3af Powered Device
SLUA318	TPS2393	–48-V ATCA Module Hot Swap Using the TPS2393
SLVA158	TPS2490/TPS2491	Hot Swap Design Using the TPS2490/91 and MOSFET Transient Thermal Response
SLUA313	TPS2392/TPS2393	Protecting the TPS2392/TPS2393 Insertion Detection Inputs in Fused Applications
SLVA163	TPS2400	Overvoltage Protector for High Voltage Loads
SLVS368	—	Comparing Performance of Current Ramp and Voltage Ramp Hot Swap Controller ICs
SLUA187	UCC3912/15	Programmable Hot Swap Power Manager
SLUA198	UCC3912	Electronic Circuit Breaker ICs
SLUA131	UCC3912	Integrated Electronic Circuit Breaker IC for Hot Swap
SLUA211	UCC3918	Hot Swap Power Manager Evaluation Board and Schematic
SLUA283	TPS239x	A Universal Telecommunications Hot Swap Device Family
SLUA302	TPS2398/99, TPS2390/91	A Comparison of Telecom Hot Swap Managers TPS2398/99 vs TPS2390/91
SLUA291	TPS239x	–48-V Hot Swap Performance Competitive Comparison
SLUA306	TPS2398/99	Using the TPS2398/99 Hot Swap Controller with Power Trends PT4485
SLUA297	TPS2350	Boosting Supply Select Hysteresis on the TPS2350

PCMCIA and USB Devices **Design Factors (Continued)**

Ease of Use — USB allows simplified installation and improved performance for peripheral devices by eliminating the need to repeatedly load new drivers and establish individual settings. USB combines a multitude of existing interfaces into a single easy-to-use connector, greatly reducing system complexity and offering manufacturers the ability to develop highly integrated products.

Power Distribution Switches

TPS204xB/5xB — The TPS204xB/5xB families of 80-m Ω current-limiting power switches meet all the USB power management requirements for controlling downstream ports, and include additional features to improve the design reliability. For example, when an over-current condition exists, the device intelligently shuts down only the port that sees the fault.

TPS202x/3x/6x — The TPS202x/3x/6x families of low on-resistance current-limiting power switches allow ganging of multiple ports to a single switch, as described in Application Note SLVA049. Though ganging can be cost effective, all ports are affected by a fault.

Selection Guide

Device	Interface	Number of Ports	3.3-V $r_{DS(on)}$ (typ) (m Ω)	5.0-V $r_{DS(on)}$ (typ) (m Ω)	I_{OS} (min) (A)	Predecessor	Price*
PCMCIA/CardBus Switch Matrix ICs							
TPS2210A	3-line Serial	1	85	95	1	—	0.85
TPS2204A	3-line Serial	2	85	95	1	TPS2214/14A	1.95
TPS2220B	3-line Serial	1	85	95	1	TPS2220A	0.85
TPS2223A	3-line Serial	2	85	95	1	—	1.80
TPS2224A	3-line Serial	2	85	95	1	TPS2214/14A	1.95
TPS2226A	3-line Serial	2	85	95	1	TPS2206, TPS2216/16A	2.10
TPS2206A	3-line Serial	2	85	95	1	TPS2206, TPS2216/16A	2.10
TPS2205	8-line Parallel	2	70	100	1	TPS2201	2.90
TPS2211A	4-line Parallel	1	70	57	1	TPS2211	0.75
TPS2212	4-line Parallel	1	160	160	0.3	—	1.45
TPS2231	4-line Parallel	1	68	—	2.5	—	1.00
TPS2044B or 54B	Parallel	1 or 2	80	80	0.7	TPS2044/44A, TPS2054/54A	1.00
TPS2221	Interface Parallel	1	72	97	1	—	1.85
TPS2228	Interface Serial	2	72	97	1	—	3.10

*Suggested resale price in U.S. dollars in quantities of 1,000.



Design Factors

Topology — Shunt (two-terminal) vs. series (three-terminal). Shunt references are very similar to Zener diodes in operation as both require an external resistor for biasing. The external resistor determines the maximum current that can be supplied to the load as well as provide the minimum biasing current to maintain regulation. Shunt references should be considered when the load is nearly constant and power supply variations are minimal. Series references do not require any external components and they should be considered when the load is variable and lower voltage overhead is of the importance. They are also more immune to the power supply changes than shunt references.

Initial Accuracy — This parameter is of primary concern in systems where calibration is impossible or inconvenient. Usually, it is accomplished by the calibration of the overall system. Initial accuracy is specified with fixed input voltage and no load current (for series type) or fixed bias current (for shunt type).

Temperature Drift — Temperature drift is the change in output voltage due to the temperature change, expressed in ppm/°C. Buried Zener type references (e.g., REF02, REF102) typically have a lower temperature drift than bandgap type voltage references. Temperature drift can be specified in several ways (slope, butterfly and box), but the most common way is the box method calculated as:

$$TC \left(\frac{\text{ppm}}{^{\circ}\text{C}} \right) = \frac{(V_{\text{max}} - V_{\text{min}}) \times 10^6}{(T_{\text{max}} - T_{\text{min}}) \times V_{\text{nom}}}$$

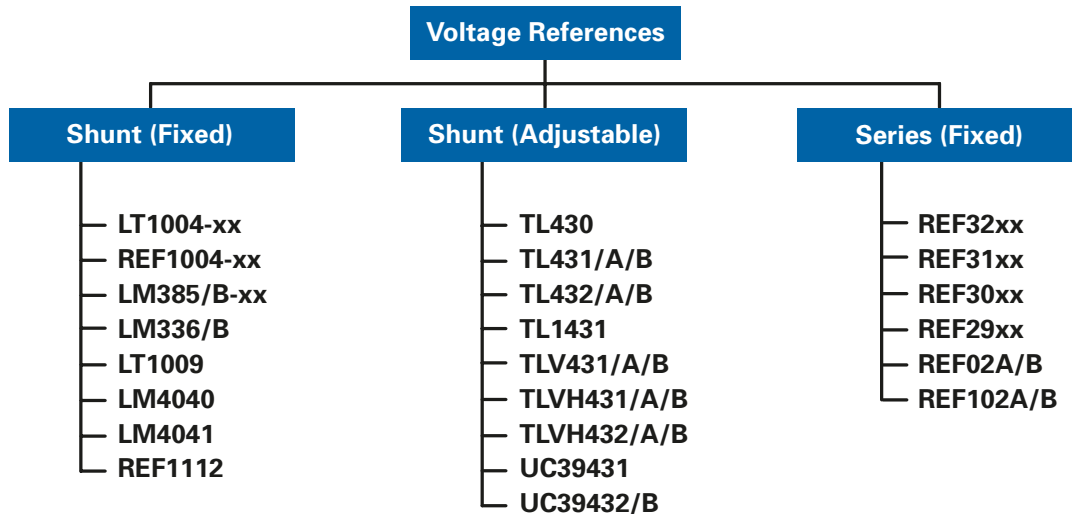
Long-Term Stability — The output of a voltage reference changes very gradually as time goes by. The greatest change occurs in the first 500 hours. This parameter can be important in high-performance applications or in applications where periodic calibration is not acceptable. TI specifies long-term stability data based on the observation of over 1000 hours at room temperature.

Output Noise — Output noise is usually specified over two frequency ranges: 0.1 Hz to 10 Hz (peak-to-peak noise) and 10 Hz to 1 kHz (RMS noise). Noise can be important because it can reduce dynamic range of the acquisition system. High-resolution data acquisition systems may experience “dither” in the LSBs solely due to reference noise. Noise can be reduced by external filtering (REF102 has noise reduction pin).

Adjustable Output — Both fixed and adjustable outputs are available. The adjustable output can be set via a resistor divider connected to a reference pin.

Packaging — Through-holes (PDIP and TO-92) and surface mount (SOIC, TSSOP, SOT-89 and SOT23) packages are available.

Voltage References Family of Products





Design Factors

Data Bus Type — There are two data bus types available: (1) address/data multiplexed and (2) parallel. With (1), the memory address lines and data lines share the same pins. With (2), the address lines and data lines are separate and the interface is the same as a static RAM. The address/data multiplexed devices have fewer pins but may require more logic to interface.

3- or 5-V Operation — The RTCs can run from a 5-V or 3-V rail.

CPU Supervisor — Some parts include a full CPU supervisor that provides:

- CPU reset (power-on and push-button).
- Power-fail interrupt.
- Watchdog timer.
- Non-volatile control for additional NVSRAM.

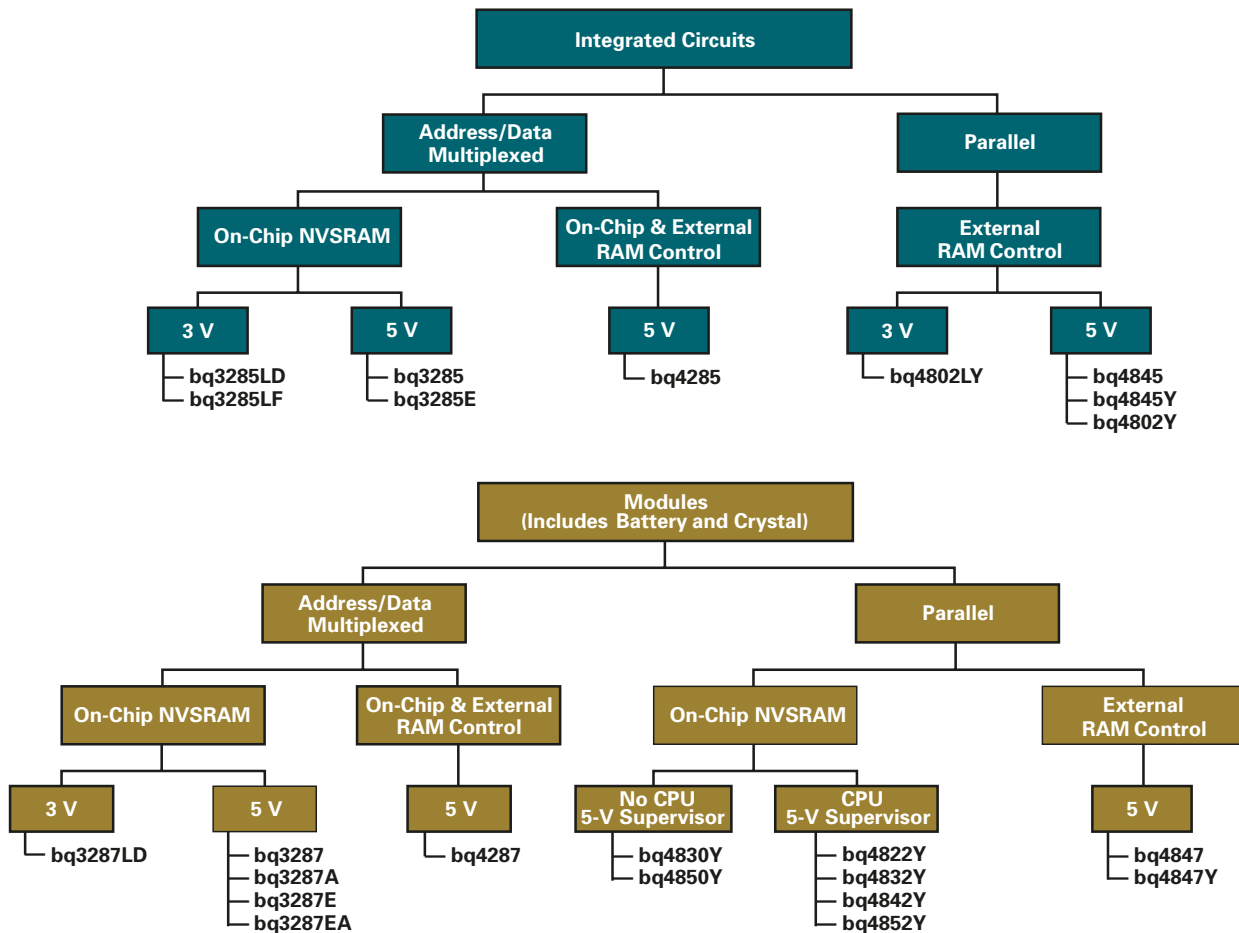
The integration of the supervisor on the RTC can reduce the component count in a design.

- Onboard NVSRAM.
- V_{CC} tolerance.
- Package type.

Features

- Real-time clock counts seconds through centuries in BCD format.
- Less than 500 nA of current consumption in battery backup mode.
- Clock accuracy (modules) better than 1 minute per month.
- Up to 512K x 8 of onboard NVSRAM.
- 3- or 5-V operation.
- Fully integrated CPU supervisor.

Real-Time Clocks Family of Products



→ Real-Time Clocks

Selection Guide

Device	V _{CC} Level (V)	V _{CC} Tolerance (%)	CPU Supervisor	Onboard NVSRAM	External NVSRAM Control	Packages	Price*
Parallel Interface							
bq4802Y	5	10	Yes	No	Yes	28-pin SOIC or TSSOP	2.50
bq4802LY	3	10	Yes	No	Yes	28-pin SOIC or TSSOP	2.50
bq4845	5	5	Yes	No	Yes	28-pin SOIC	2.50
bq4845Y	5	10	Yes	No	Yes	28-pin SOIC	2.50
bq4830Y	5	10	No	32K x 8	No	28-pin DIP Module	10.50
bq4822Y	5	10	Yes	8K x 8	No	28-pin DIP Module	9.50
bq4832Y	5	10	Yes	32K x 8	No	32-pin DIP Module	12.50
bq4842Y	5	10	Yes	128K x 8	No	32-pin DIP Module	14.50
bq4852Y	5	10	Yes	512K x 8	No	36-pin DIP Module	29.00
bq4847	5	5	Yes	No	Yes	28-pin DIP Module	4.95
bq4847Y	5	10	Yes	No	Yes	28-pin DIP Module	4.95
bq4850Y	5	10	No	512K x 8	No	32-pin DIP Module	25.00
Address/Data Multiplexed							
bq3285	5	10	No	114 bytes	No	24-pin SOIC	2.10
bq3285E	5	10	No	242 bytes	No	24-pin SOIC or SSOP	2.10
bq3285LD	3	10	No	242 bytes	No	24-pin SSOP	2.10
bq3285LF	3	10	No	240 bytes	No	24-pin SSOP	2.10
bq3287/A ¹	5	10	No	114 bytes	No	24-pin DIP Module	3.80
bq3287E/EA ¹	5	10	No	242 bytes	No	24-pin DIP Module	3.80
bq4285/E	5	10	No	114 bytes	Yes	24-pin SOIC	2.35
bq4287	5	10	No	114 bytes	Yes	24-pin DIP Module	4.30

¹The "A" versions have a RAM clear input pin.

*Suggested resale price in U.S. dollars in quantities of 1,000.

→ Non-Volatile SRAM (NVSRAM)

Design Factors

Memory Density

The densities range from 64 Kbit to 16 Mbit organized x 8.

V_{CC} Tolerance

To protect data during power-up/-down sequences, the NVSRAM automatically deselects the SRAM when its supply voltage is 5 or 10% below the nominal 5 V. The tolerance should match the characteristics of the 5-V supply. A 3.3-V supply will be available 3Q 2007.

Features

- 10-year data retention in the absence of power.
- Standard SRAM pinout and interface.
- Unlimited write cycles.
- Access times of 70 ns.
- Automatic write protection during power cycles.

Non-Volatile SRAM (NVSRAM) Family of Products

Device	Description	Price*
5% V_{CC} Tolerance		
bq4010	8K x 8 (64 Kbit)	6.50
bq4011	32K x 8 (256 Kbit)	7.50
bq4013	128K x 8 (1 Mbit)	9.50
bq4014	256K x 8 (2 Mbit)	20.00
bq4015	512K x 8 (4 Mbit)	22.00
bq4016	1024K x 8 (8 Mbit)	26.00
bq4017	2048K x 8 (16 Mbit)	50.00
10% V_{CC} Tolerance		
bq4010Y	8K x 8 (64 Kbit)	6.50
bq4011Y	32K x 8 (256 Kbit)	7.50
bq4013Y	128K x 8 (1 Mbit)	9.50
bq4014Y	256K x 8 (2 Mbit)	20.00
bq4015Y	512K x 8 (4 Mbit)	22.00
bq4016Y	1024K x 8 (8 Mbit)	26.00
bq4017Y	2048K x 8 (16 Mbit)	50.00

*Suggested resale price in U.S. dollars in quantities of 1,000.

- Internal battery isolated until initial power-up.
- 28- to 36-pin DIP.

Design Support





Seminars and Online Training

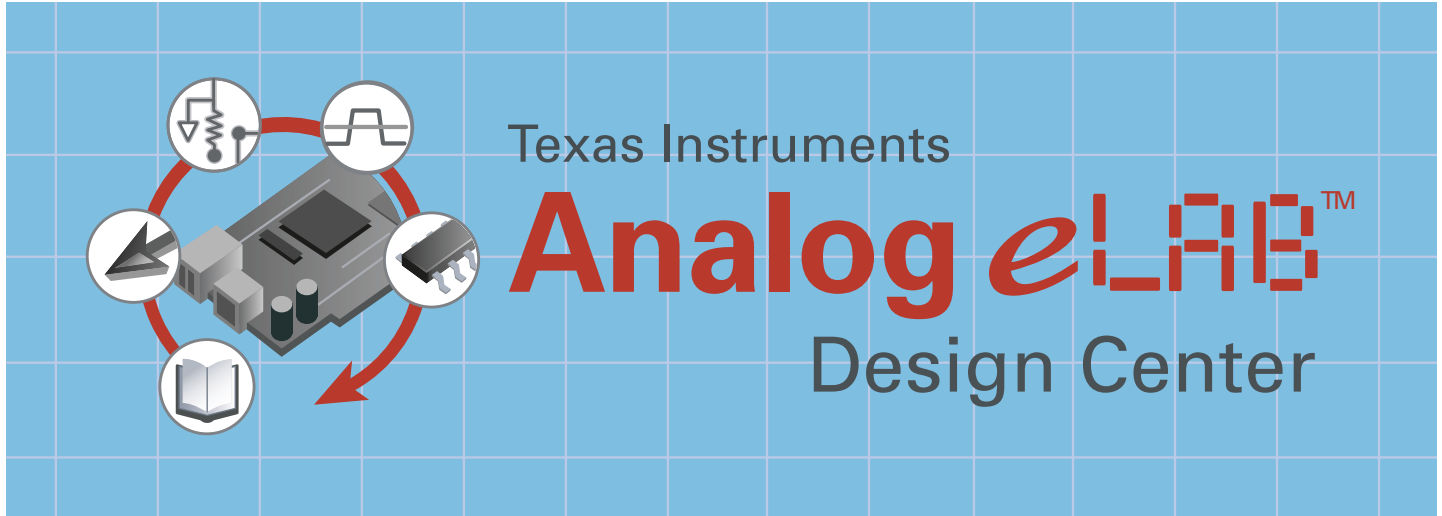
TI's popular Power Supply Design Seminar series and Portable Power Seminar series provide rich technical yet practical presentations that combine an array of advanced new power-management concepts, basic design principles and real-world applications examples. Seminar presenters are respected names in the power industry, drawing on decades of experience to discuss today's toughest design issues with innovative techniques, topologies, tools and examples.

Keep this link handy to check on dates, times and locations of the Power Seminar series at www.ti.com/training

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Training	
By Topic	<ul style="list-style-type: none"> Analog DSP Microcontrollers Applications Tools & Software
By Type	
By Date	
By Location	<ul style="list-style-type: none"> On-Line Training Webcasts Seminars Conferences 1-Day Workshops Multi-Day Workshops
	
	
	<ul style="list-style-type: none"> US & Canada Europe, Africa, & Middle East Latin America Asia

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dataconverter.ti.com for your Data Converter needs

interface.ti.com for your Interface needs

logic.ti.com for your Logic needs

www.ti.com/lprf for your Low-Power RF needs

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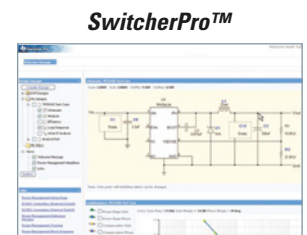
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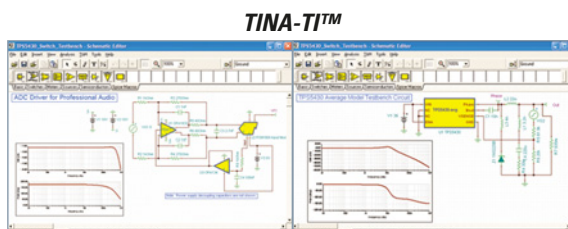
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Packaging

High-Performance Analog Packages

	Package Type	Package Designator
	Wafer Scale Package (WSP)	YEG, YEK, YEJ, YEA, YZA, YED, YNA
	Small Outline Transistor Package (SOT23)	DBY, DCN, Thin SOT, DDC
	Transistor Outline (TO236)	DBZ
	Mini Small Outline Package (MSOP)	DGK, DGS
	Small Outline No Leads (SON)	DRD, DRB, DRC
	Shrink Small Outline Package (SSOP)	DBQ, DB, DL
	Quad Flatpack No Leads (QFN)	RGS, RGY, RGT, RGV, RGY, RHC, RGA, RGP, RGW, RGY, RGE, RGU, RHD, RGL, RGD, RHB, RGF, RHA, RTA, RGN, RGZ, RGQ, RGC, RHE, RHF
	Thin Quad Flatpack (TQFP)	PBS, PJT, PFB, PAG
	Small Outline Transistor (SOT223)	DCY, DCQ
	Heat Sink Thin Quad Flatpack (HTQFP)	PHP, PAP
	Small Outline Integrated Circuit (SOIC)	D, DTH, DTC, DW, DWU

	Package Type	Package Designator
	Thin Shrink Small Outline Package (TSSOP)	PW
	Plastic Dual-In-Line Package (PDIP)	P, N, NT, NTD
	Surface Mount Header (DDPak)	KTT, KTW
	Transistor Outline (TO220)	KC
	Heat Sink Small Outline Package (HSOP)	DWP, DWD
	Power Small Outline Package (PSOP3)	DKP (slug down), DKD (slug up)
	Ball Grid Array (BGA)	



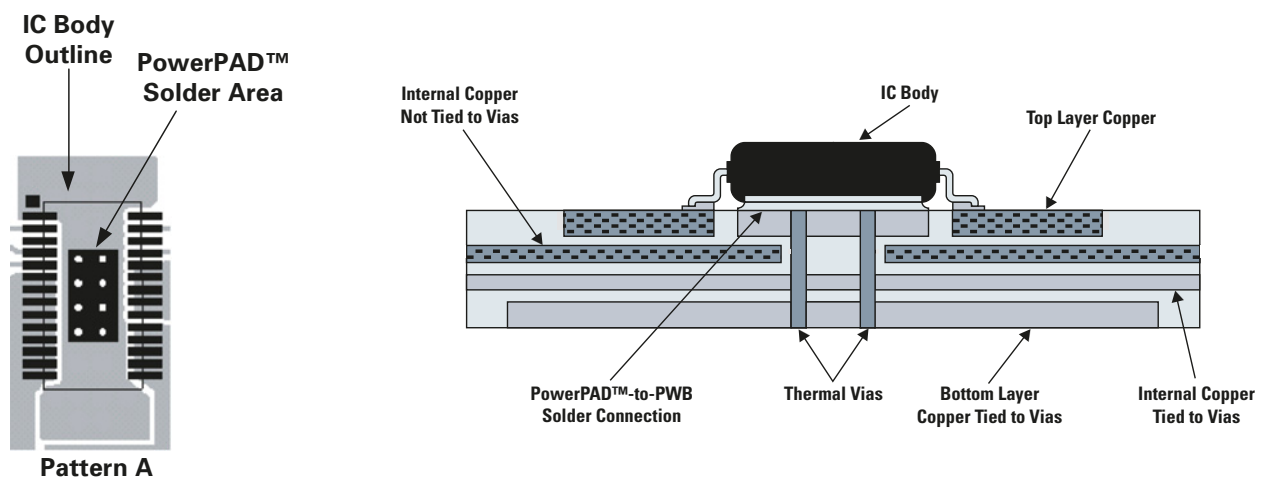
How to Connect the PowerPAD™

The PowerPAD™ should be connected to the appropriate internal signal plane as specified in the product datasheet. Depending on the electrical properties of the thermally conductive epoxy used to connect the Integrated Circuit (IC) to the lead frame, the PowerPAD may have a low impedance connection to the internal signal plane as specified in the product datasheet. Even though the PowerPAD should not be used as your primary signal connection for the IC (use the designated signal pins as specified in the product data sheet), the copper area under the pad can be connected to the specified signal plane per the product data sheet without affecting the device. Since the PowerPAD is intended to remove heat from the part, the size of the signal plane to which the thermal pad is attached within the board should be as large as needed to dissipate the heat. The via array recommendations in the documents below may vary based on layout constraints and recommendations presented in the product datasheet. The documents below should be used as a general guideline for board design while referring to the product datasheet for application specific via and land pattern requirements.

You can find additional information in the following resources.

Technical literature can be accessed online with www-s.ti.com/sc/techlit/litnumber by replacing *litnumber* with one of the literature numbers shown below in parentheses.

- Remember to check the CAD format for your package under “Symbols/Footprints,” available in all TI Product Folders
- Download the “PowerPAD Made Easy” application brief (SLMA004) in conjunction with the “PowerPAD Thermally Enhanced Package” technical brief (SLMA002)
- Specific information on QFN/SON packages is available in application reports (SLUA271 and SCBA017)
- Visit TI’s Analog & Mixed-Signal KnowledgeBase at support.ti.com/sc/knowledgebase
- Ask our experts your specific design questions via email by selecting Analog & Mixed-Signal email support in the Contact Tech Support frame at support.ti.com



PowerPAD™ package as used by the SWIFT™ product family.



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