Communications Infrastructure

Solutions Guide

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POWER**WISE**
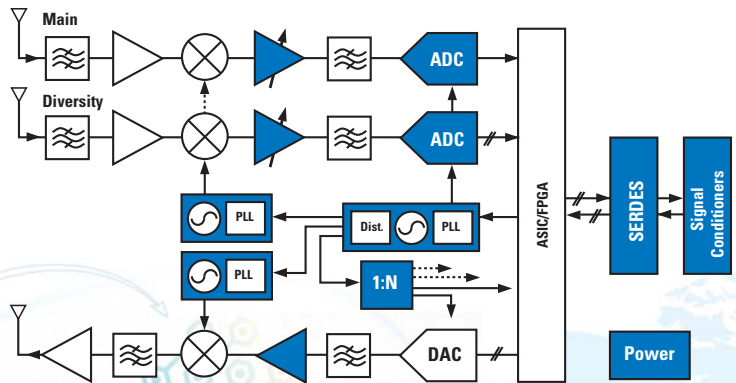
National Semiconductor

Communications Infrastructure

National's energy-efficient products address the critical needs of communications infrastructure systems—wireless basestations, wired data centers, and merchant power supply applications—by combining high performance solutions with easy-to-use online design tools and comprehensive reference designs.

National's Energy-Efficient Products:

- Reduce cost by increasing efficiency and lowering the total cost of ownership over the product's lifetime
- Reduce size by decreasing the overall footprint and minimizing the heat generated by power losses
- Provide reliability by protecting overall system health

Wired and Data Center Applications

As data load and power demands continue to increase, National's products, tools, and reference designs can power more energy-efficient, highly reliable, cost-efficient data centers.
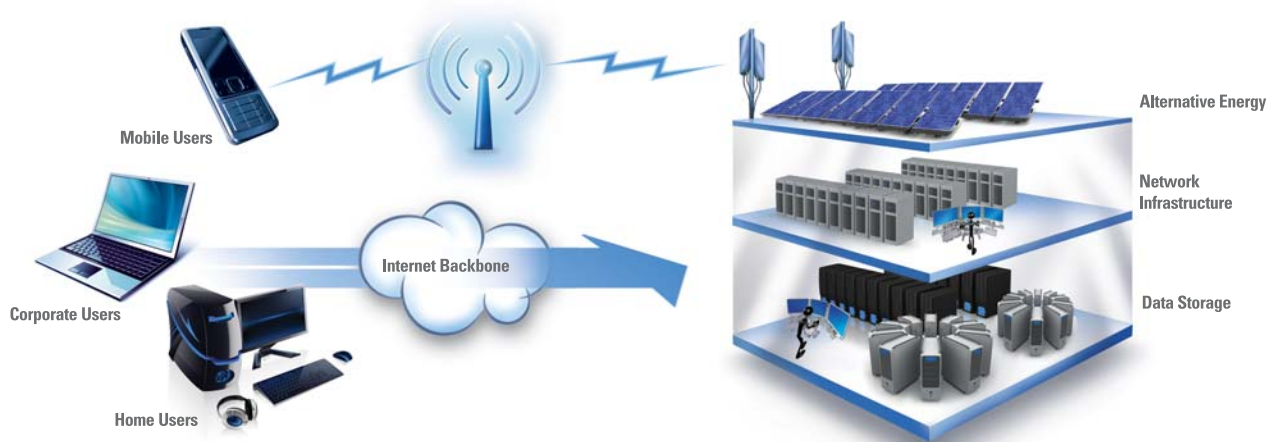
Wireless Basestation Applications

To address wireless basestation performance, monitoring, and capacity challenges, National offers energy-efficient, flexible, integrated system-level infrastructure solutions designed to meet evolving multicarrier/multistandard demands.

Merchant Power Solutions

With a great use of more complex power supply topologies in smaller form factors, National's diverse portfolio of power management solutions are designed to maximize power density and end-to-end power chain efficiency.

To download the latest reference designs and design-in a product using the WEBENCH® Designer online design tool, visit: **national.com/comms**

Mobile Users

Corporate Users

Home Users

Internet Backbone

Alternative Energy

Network Infrastructure

Data Storage

Contents

Wired and Data Center Applications

Energy consumption by servers and data centers more than doubled over the past eight years; in the U.S., data centers consumed 61 billion kWh of energy in 2006.[1] Based on current trends, energy consumption in data centers will continue to grow 12% year-on-year, posing a serious threat to the health of our global ecosystem. IT and facilities professionals must address issues of cost and human-influenced environmental impacts of a given business operation by taking actions to reduce power consumption in existing and new installations.

Computing power density increase

|	Traditional Server	High-Density Blade Server
Power per rack	2-3 kW/rack	20 kW/rack
Power per floor space	30-40 W/sqf	700-800 W/sqf
Cooling needs: chilled airflow	200-300 CFM	3000 CFM

Source: Gartner 2006

[1] Fact Sheet on National Data Center Energy Efficiency Information Program, U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA), March 19, 2009.

Data Center Efficiency

Data Center Energy	61B kWh
CO_2 Footprint	31B kg
# Households	5.7M
# Cars	8M

Data center challenges include dramatic increases in data load power consumption worldwide—computation, network equipment, and storage—along with power conversion efficiency from AC-to-DC to point of load.

4.4 MW to Data Load

12 MW

Data Center

Cooling 37% Data Load 36%

Power Chain 27%

Net Efficiency = 36%
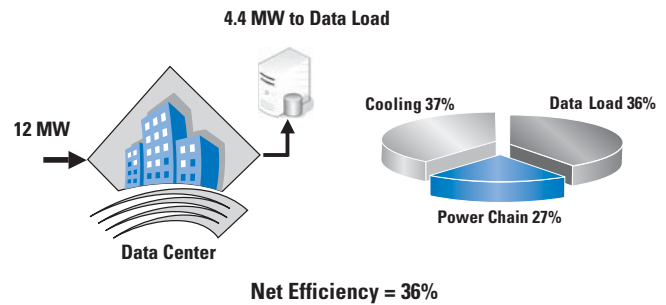
High Speed Interface Technology

Challenges:
Driven by the proliferation of social networking and cloud computing applications, the interface bandwidth speed for data center systems is doubling every three years. The physical reach requirements, however, remain the same with a greater emphasis on low power consumption as the demand for reliable, energy efficient operations increases.

Solutions:
Building on a foundation of low-power BiCMOS process technologies, National's PowerWise® signal conditioning solutions extend the reach of high speed serial signals further with the least amount of additive jitter. With the industry's lowest power to data rate ratio—16 mW/Gbps compared to typical solutions at 20 mW/Gbps—National's signal conditioning solutions lower data center interface power requirements by 25%.

The system aware features like SAS/SATA OOB (out-of-band) signal detection and rate adaptive signal conditioning for PCIe enable complex heterogeneous interconnects for server, storage, and switch applications. Compliance testing for industry standards as well as third party controllers guarantees interoperability in end system implementations.

Data Center High Speed Interfaces
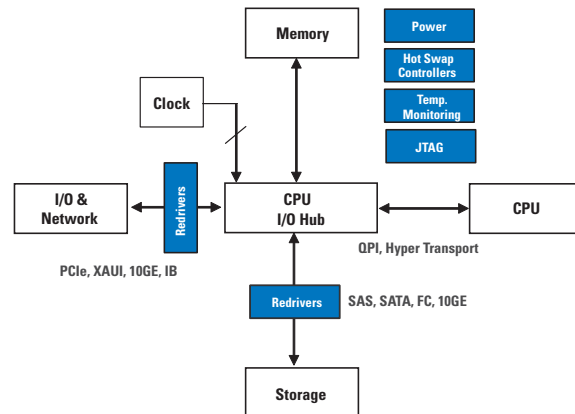
Product	Function
DS50PCI401	2.5 to 5.0 Gbps 4-Lane PCI express transceiver
DS64BR401	6.4 Gbps quad lane signal conditioning repeater
DS80EP100	5 to 12.5 Gbps power-saver equalizer
DS50EV401	2.5 to 5.0 Gbps quad PCI express equalizer
DS25CP104A	3.125 Gbps 4x4 LVDS Crosspoint Switch

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Wired and Data Center Applications

Adaptive Voltage Scaling Technology

Challenges:

The exponential increase of data load computing and data center energy consumption must be met with energy-efficient and energy saving solutions.

Solutions:

PowerWise® Adaptive Voltage Scaling (AVS) technology optimizes supply voltage to significantly reduce energy consumption of digital processing engines, ASICs, SoCs, and FPGAs.

• Minimizes system energy consumption and improves reliability

• Offers 20% to 40% power savings over fixed-voltage implementations

• Created to enable a seamless implementation

AVS is advanced, closed-loop technology for reducing active and standby energy consumption of digital processing engines and ASICs. The use of simple, standard hardware interfaces and National's collaboration with other industry leaders ensures that this technology can be used on any CMOS process with standard design tools and flows. Additionally, it can be integrated with any operating system or application, resulting in exceptional energy efficiency.

Energy savings with PowerWise AVS
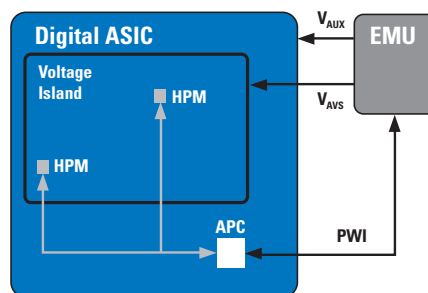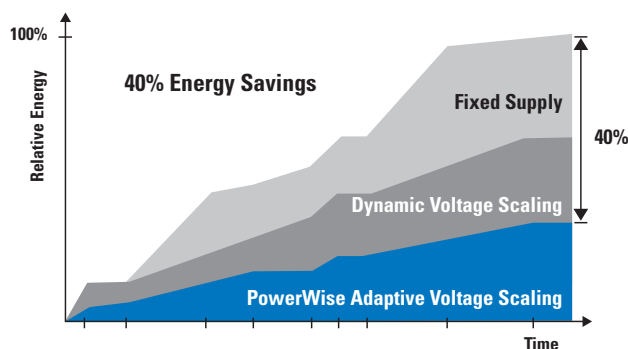
Adaptive Voltage Scaling technology minimizes system energy consumption and improves reliability by impacting both dynamic energy and static (leakage) energy consumption.

Several non-intrusive blocks are embedded into the ASIC/SoC to determine its profile. Hardware Power Monitor (HPM) is designed into the digital engine with an Advanced Power Controller (APC) to monitor the performance of the silicon based on process and temperature variation. Information is fed back to an Energy Management Unit (EMU) which then sets the voltage precisely according to the processor's needs.

AVS technology enables optimum energy management delivery to the processors, ASICs, and SoCs, which maximizes overall system energy savings. It is process and architectural independent by design. AVS typically enables 20% to 40% power savings over traditional fixed-voltage schemes across temperature range and guardbands common in processors.

National Semiconductor developed Adaptive Voltage Scaling technology specifically to address tomorrow's energy-saving requirements. It is ideally suited to high volume systems such as data centers and wireless base stations, as well as power constrained applications such as portable devices, USB powered peripherals, and consumer electronics. Anywhere that an ASIC, processor, or SoC is used, AVS can be implemented.

Wireless Basestation (BTS) Applications

With many 2G and 2.5G systems expanding and maturing, 3G systems evolving to provide higher data speeds and voice capacity, along with the continued development of 4G systems, the need for higher-performance, energy-efficient solutions is crucial.

National provides a wide range of PowerWise® high-performance, energy-efficient solutions for wireless basestations, including data converters, hardware monitors, high-speed amplifiers, timing and clocking solutions, and power management products.

Evolution of Future Technologies
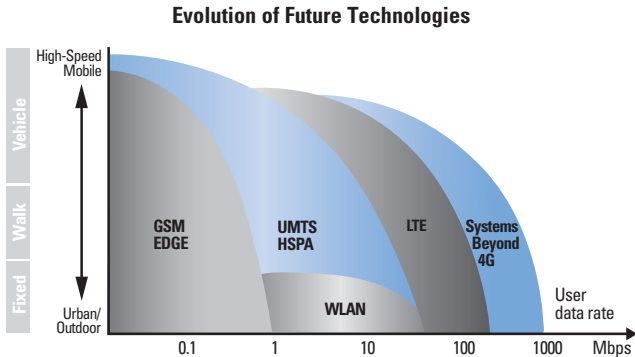
With more than three million wireless basestations installed worldwide and a typical net basestation efficiency of 5%, a key challenge is improving basestation efficiency. The RF PA subsystem consumes much of the power and typically operates at only 35% efficiency. Additionally, digital baseband ASICs' power consumption and power conversion from AC-to-DC to point-of-load present efficiency challenges.

Net Efficiency = 4.6%

Wireless Basestation Efficiency

Basestation Energy	68 B kWh
CO_2 Footprint	34B kg
# Households	6M
# Cars	8.5M

Worldwide basestation installations consume 68 billion kilowatt hours annually.

Network Energy Consumption and Monitoring

Challenges:
As energy costs continue to grow, maintaining inefficient base-station systems can require significant operational expense—not only through wasted energy but also through the additional overhead required to remove excess heat.
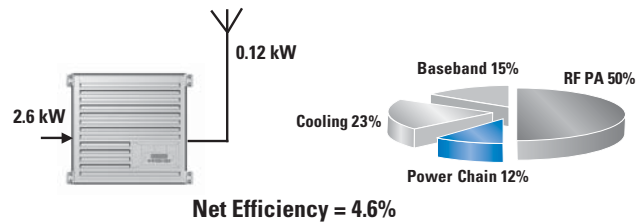
The primary energy consumption challenges in basestations are:

• RF power amplifiers (PA), which typically operate at only 35% efficiency
• AC-to-DC and DC-to-DC power chain efficiency
• Heat reduction to improve reliability

Solutions:
National's high-efficiency data communications subsystems reduce power consumption and system heat. High-efficiency DC-to-DC power supplies for the RF PA and power chain can be found in Merchant and Point of Load Applications. In addition to improving efficiency, National's system-level monitoring and control solutions protect and maintain overall system health and reliability, as well as reduce system heat and maintenance costs.

Increased Network Capacity

Challenges:
Exponential growth of wireless network subscriptions is straining system capacity. Studies show by 2013, there will be roughly 6.5 billion mobile subscriptions and more than 2.5 billion broadband subscriptions—of which more than two-thirds will be mobile. This projected growth of broadband subscriptions implies increasing demand for expanded network capacity and functionality in the near future.

Solutions:
PowerWise signal conditioning redrivers and switching devices based on SiGe process technology and advanced design techniques enable 10 Gbps data pipes with the industry's lowest mW/Gbps ratio.

National's Precision PHYTER® products provide a high bandwidth Ethernet backhaul for next-generation networks and hardware IEEE 1588 protocol implementation which provides time and frequency synchronization to maintain high-quality service.

Product	Function	Key Feature
DS64BR401	6.4 Gbps Quad Lane Redriver	33 dB input EQ gain, -12 dB output De-emphasis driver
DS80EP100	4.25 to 12.5 Gbps power-saver equalizer	Passive equalizer with 7 db effective boost
DS25CP104A	3.125 Gbps 4 X 4 crosspoint	Low jitter, equalization and pre-emphasis
DP83640	100/100 Ethernet PHY	Supports IEEE 1588

Wireless Basestation (BTS) Applications

Remote Radio Heads

Challenges:

Basestation vendors and operators must optimize basestation capacity and coverage to cost-effectively deliver rich data and mobile broadband content to their customers. To address this challenge, vendors and operators are opting for distributed basestation architectures with one Base Band Unit (BBU) serving multiple Remote Radio Heads (RRH). These RRHs present a challenge because they require high-performance serial links and introduce synchronization issues for the central basestation.

Solutions:

National's CPRI/OBSAI SerDes and precision clock conditioners combine to deliver the industry's best signal path jitter performance and data transfer flexibility for energy-efficient RRH design. The integrated, system-level functions enable seamless synchronization of the RRHs to the central basestation, along with flexibility in the deployment of various distributed RRH topologies over copper or fiber interconnects without additional components or complicated system intervention.

New Multi-Standard/BTS Demand

Challenges:

The future of basestations will require the coexistence of 2G, 3G, and 4G in the same frequency band, and will create a new demand for multi-standard/reconfigurable BTSs.

Solutions:

National offers a comprehensive multi-standard basestation solution that combines the industry's highest performance clock and timing devices with high dynamic range data converters and the best noise- and linearity-to-power variable gain amplifiers.

The ADC16DV160 is a 16-bit, 160-MSPS ADC that offers the industry's best dynamic performance in the smallest package at less than half the power of similar parts. Its large input bandwidth provides excellent dynamic performance across a large range of input frequencies, enabling high bandwidth, high sensitivity multi-carrier/multi-standard basestations.

The LMH6517 Digital Variable Gain Amplifier (DVGA) offers the industry's best dynamic performance-to-power ratio. With a gain range of -9.5 dB to 22 dB in 0.5 dB steps, the LMH6517 optimally scales the received signal to maximize the available signal path dynamic range in the presence of interfering signals.

It delivers a 5.5 dB noise figure and 44 dBm OIP3—ideal for meeting the demanding needs of new multi-carrier/multi-standard wireless basestation designs.

The LMK family of precision clock conditioners offers high-performance clock jitter cleaning, generation and distribution, and are equipped with advanced features to simplify clock architecture design. The LMK04000 family features a cascaded PLL architecture enabling sub-200 fs jitter using a simple external crystal, rivaling performance in the most expensive VCXO modules.

The LMX family of frequency synthesizers offers a broad mix of ultra-low power devices that combine integer/delta-sigma PLLs with integrated low-noise VCOs. National's frequency synthesizer family includes the LMX2531 and newly introduced LMX2541 which offers the industry's lowest noise PLL that extends to 4 GHz.

Multi-Standard Basestation Solution Products

Product	Function	Key Feature
LMK04031B	Clock jitter cleaner with cascaded PLLs	sub-200 fs RMS jitter using a simple external crystal
LMK03000C	Clock jitter cleaner with integrate VCO	400 fs RMS jitter using integrated VCO
LMK01000	1.6 GHz low-noise clock distributor	30 fs additive RMS jitter
ADC16DV160	Dual-channel, 16-bit, 160 MSPS ADC with DDR LVDS outputs	91.2 dBFS SFDR and 76.3 dBFS SNR at f_{IN} = 197 MHz with Pd = 1.3W
ADC16V130	16-bit, 130-MSPS ADC with LVDS outputs	90.6 dBFS SFDR and 76.7 dBFS SNR at f_{IN} = 160 MHz with Pd=755 mw
LMH6517	Dual 1.2 GHz digitally controlled variable gain amplifier	22 dB Max Gain, 31.5 dB gain range, 0.5 dB steps, 44 dBm OIP3, 5.5 dB noise figure, 80 mA/ch supply current
LMX2531	Low phase noise frequency synthesizer	Low VCO phase noise and spurs, -115 dBc/Hz at 100 kHz offset at 2 GHz LO
LMX2541	Ultra-low RMS noise frequency synthesizer	Ultra-low noise PLL, < 2-mrad of RMS noise with ultra-low spurs, 31.6 to 4000 MHz range

# Merchant and Point of Load Power Solutions

Challenges:

System designers are being challenged to supply more power in less space as data processing requirements for wired and wireless infrastructure equipment grows. With shrinking form factor requirements, high-power density and efficiency become critical—not only to reduce total power consumption, but also to minimize the heat generated by power losses and improve system reliability and safety.

Solutions:

National's diverse portfolio of power management solutions are designed to maximize power density and end-to-end power chain efficiency. By combining advanced process technology, chip-scale packaging, and proprietary circuitry, National has developed a range of power management solutions for reliable, high-performance, cost-effective system design.

- Higher power density solutions enable smaller form factors
  - Advanced topologies like active clamp and half-bridge converters support high-power applications
  - Integrated solutions reduce BOM count and save valuable space
  - High switching frequencies (3 MHz and more) enable fast transient response and the use of smaller components

- A wide range of high-efficiency power ICs to reduce thermal dissipation in higher power modules
  - Synchronous converters minimize switching losses
  - Point of load converters with automatic PFM to PWM switching increase light load efficiency

- Protection and performance ICs improve system robustness
  - Hot swap/in-rush current controllers with power limiting and over- and under-voltage protection provide maximum system protection and reliability
  - Low-noise, low-power low dropout (LDO) regulators preserve signal fidelity in the analog signal path

End-to-End Power Management Solutions

Data Conversion Solutions
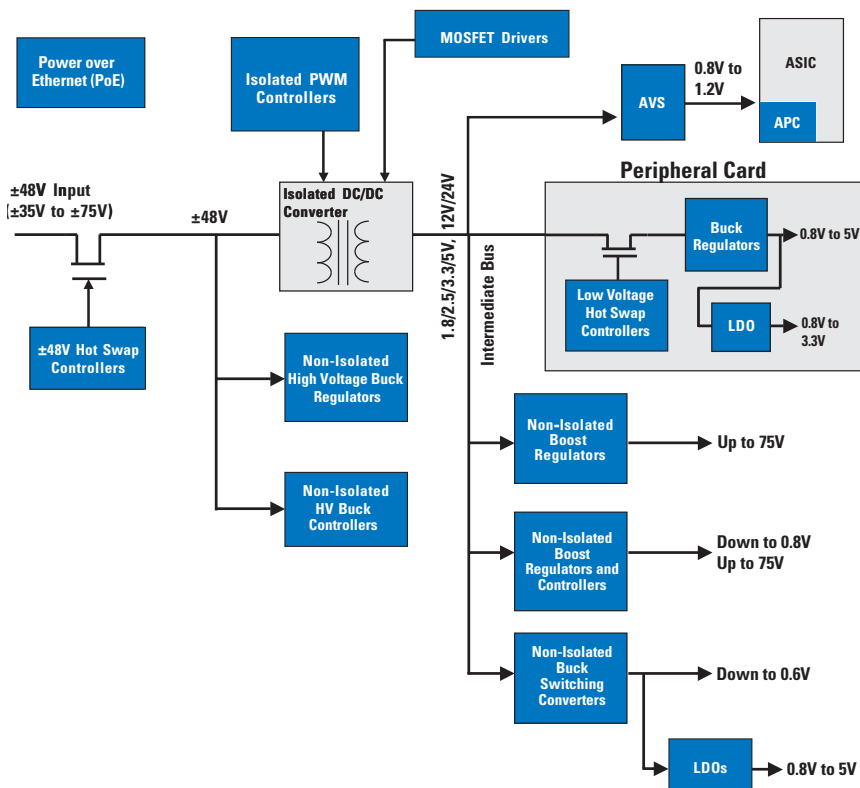
ADC16DV160 – Dual-Channel, 16-Bit, 160 MSPS A/D Converter with DDR LVDS Outputs

Features

- On-chip precision reference and sample-and-hold circuit
- Dual data rate LVDS output port
- Dual supplies: 1.8V and 3.0V operation
- Selectable input range: 2.4, 2.0, 1.5 and 1.0 Vpp
- Integer clock divider by 1 or 2
- On-chip low jitter duty-cycle stabilizer
- Power-down and sleep modes
- Output fixed pattern generation
- Output clock position adjustment
- Offset binary or 2's complement data format
- On-chip automatic calibration during power-up

Performance (typical)

- SNR
  - 78.5 dBFS (f_{IN} = 30 MHz)
  - 76.3 dBFS (f_{IN} = 197 MHz)
- SFDR
  - 95 dBFS (f_{IN} = 30 MHz)
  - 91.2 dBFS (f_{IN} = 197 MHz)
- Full power bandwidth 1.4 GHz
- Power consumption
  - Core per channel: 591 mW
  - LVDS driver: 118 mW
  - Total: 1.3W

High-IF sampling receiver subsystem board available featuring ADC16DV160, LMH6517, and LMK04031B (SP16160CH1RBKIT).

Applications

Ideal for use in multi-carrier, mult-standard basestation receivers, high IF sampling and diversity channel receivers, and communications instrumentation.

High-Speed Radio Signal Path for Wireless Basestations
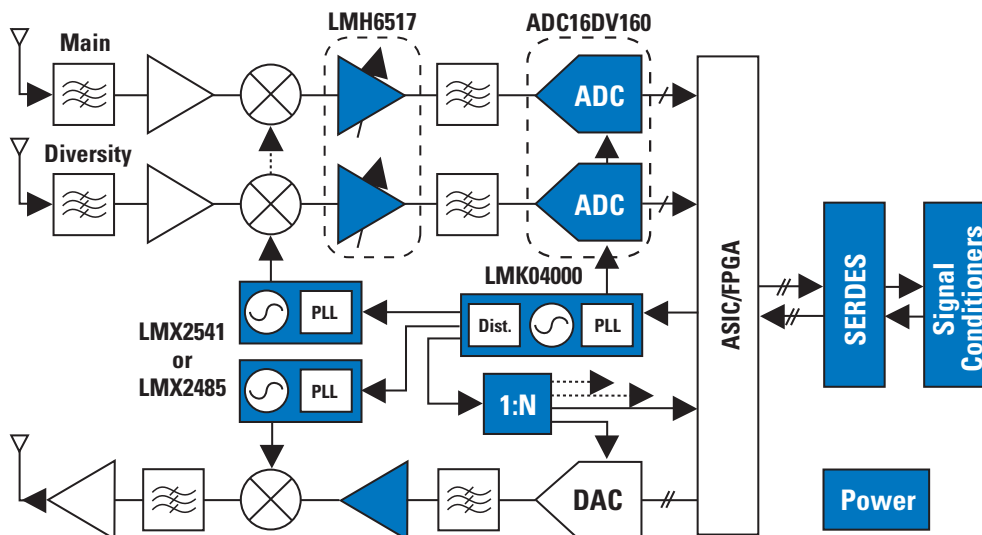
Data Conversion Solutions

ADC16V130 – 16-bit, 130 MSPS A/D Converter

Features

- 1.4 GHz full power bandwidth
- Performance:
  - 90.6 dBFS SFDR at f_{IN} = 160 MHz
  - 76.7 dBFS SNR at f_{IN} = 160 MHz
  - 101.5 dBFS worst harmonic or spur (except H2 & H3) at f_{IN} = 160 MHz
- Low power consumption: 755 mW
- Dual 3.0V/1.8V supply operation
- Parallel LVDS outputs
- Automatic on chip calibration during power-up
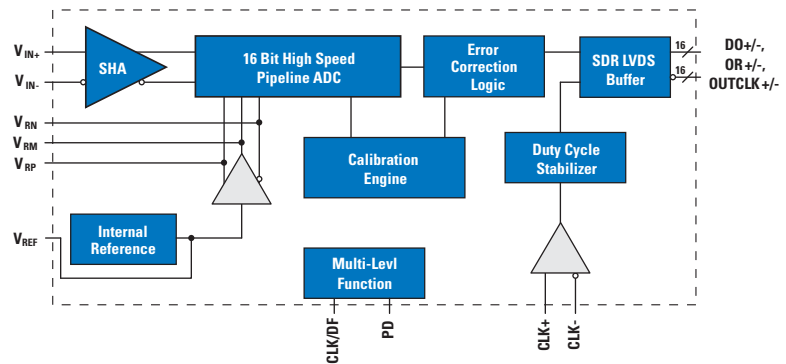
Low-IF receiver board available (SP16130CH4RB) featuring LMK04031B clock jitter cleaner.

Applications

Ideal for use in multi-carrier, mult-standard basestation receivers, high IF sampling receivers, and communications instrumentation.

SNR, SFDR, and Spur–H2/3 vs. Fin
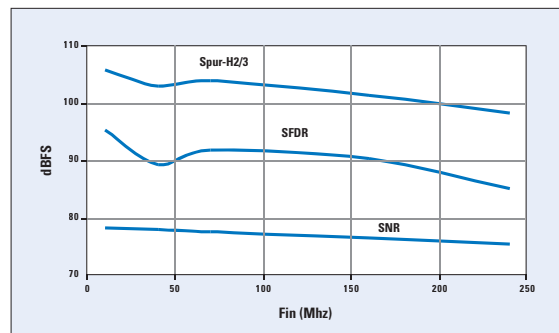
ADC10/11DV200 – Dual 10- and 11-bit, 200 MSPS Dual A/D Converters

Features

- 900 MHz full power bandwidth
- 59.9 dBFS (10-bit)/62.5 dBFS (11-bit) SNR at 70 MHz input
- 82 dBFS SFDR at 70 MHz input
- LVDS or CMOS outputs
- Low power consumption:
  - 225 mW/ch in LVDS mode at 200 MSPS
  - 140 mW/ch in CMOS mode at 170 MSPS
- Power scaling with sampling rate
- Single 1.8V power supply
- Over-range indicator
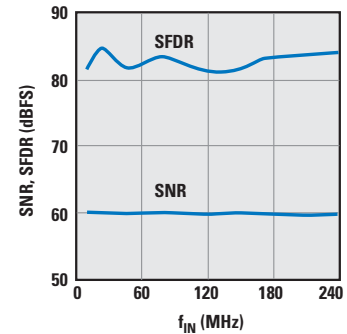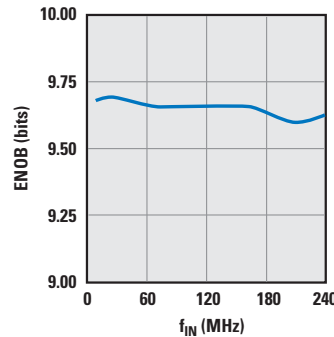
Applications

Ideal for use in predistortion (DPD), wireless communications, and communications instrumentation.

High-Speed MSPS A/D Converters

Product ID	Channels	Speed (MSPS)	Power (mW)	SNR (dB)	SFDR (dB)	Outputs	Packaging
16-bit							
ADC16DV160 [E] [P]	2	160	1300	78.5	95	LVDS	LLP-68
ADC16V130 [E] [P]	1	130	755	78.5	95.5	LVDS	LLP-64
14-Bit							
ADC14155 [E] [P]	1	155	967	71.3	87	CMOS	LLP-48
ADC14V155 [E] [P]	1	155	951	71.7	86.9	Parallel LVDS	LLP-48
ADC14DS080/105 [E] [P]	2	80/105	800/1000	74.2/73	90	Serial LVDS	LLP-60
ADC14DC080/105 [E] [P]	2	80/105	600/800	73/74	90	CMOS	LLP-60
ADC14C080/105 [E] [P]	1	80/105	300/400	74.2/74	90	CMOS	LLP-32
ADC14L040 [E] [P]	1	40	235	73	90	CMOS	LQFP-32
ADC14L020 [E] [P]	1	20	150	74	93	CMOS	LQFP-32
12-Bit							
ADC12C170 [E] [P]	1	170	715	67.2	85.4	CMOS	LLP-48
ADC12V170 [E] [P]	1	170	781	67.2	85.8	Parallel LVDS	LLP-48
ADC12C105 [E] [P]	1	105	400	71	90	CMOS	LLP-32
ADC12DS080/105 [E] [P]	2	80/105	800/1000	71	88	Serial LVDS	LLP-60
ADC12DC080/105 [E]	2	80/105	600/800	71.5/71	90	CMOS	LLP-60
ADC12C080 [E] [P]	1	80	300	71.2	90	CMOS	LLP-32
ADC12DL080 [E] [P]	2	80	447	69	82	CMOS	TQFP-64
ADC12L080 [E]	1	80	425	66	80	CMOS	LQFP-32
ADC12L066	1	66	357	66	80	CMOS	LQFP-32
ADC12QS065 [E]	4	65	800	69	83	Serial LVDS	LLP-60
ADC12DL065 [E] [P]	2	65	360	69	86	CMOS	TQFP-64
ADC12L063	1	62	354	66	78	CMOS	LQFP-32
ADC12EU050 [E] [P]	8	50	384	69.3	77	Serial LVDS	LLP-68
ADC12DL040 [E] [P]	2	40	210	69	85	CMOS	TQFP-64
ADC12D040 [E]	2	40	600	68	80	CMOS	TQFP-64
ADC12040 [E]	1	40	340	69.5	84	CMOS	LQFP-32
ADC12020	1	20	185	70	86	CMOS	LQFP-32
11-Bit							
ADC11DV200 [E] [P]	2	200	450	62.5	82	CMOS or LVDS	LLP-60
ADC11C170 [E]	1	170	715	65.1	85.4	CMOS	LLP-48
ADC11C125 [E]	1	125	608	65.5	88.2	CMOS	LLP-48
ADC11DL066	2	66	686	64	80	CMOS	TQFP-64
ADC11L066	1	66	357	65	78	CMOS	LQFP-32
10-Bit							
ADC10DV200 [E]	2	200	450	59.9	82	CMOS or LVDS	LLP-60
ADC10080 [E] [P]	1	80	78.6	59.5	79	CMOS	TSSOP-28
ADC10DL065 [P]	2	65	370	61	85	CMOS	TQFP-64
ADC10065 [P]	1	65	68.4	59.6	80	CMOS	TSSOP-28
ADC10D040	2	40	267	60	72	CMOS	TQFP-48
ADC10040 [P]	1	40	55.5	59.6	80	CMOS	TSSOP-28
ADC10D020 [P]	2	20	150	59	75	CMOS	TQFP-48

[P] PowerWise® product   [E] Evaluation board

Data Conversion Solutions
Ultra-High-Speed ADCs

ADC10D1000/1500 – 10-Bit, Dual 1.0/1.5 GSPS or Single 2.0/3.0 GSPS A/D Converter

Features

- World-class accuracy and dynamic performance
- Lowest available power consumption
- Internally terminated, buffered, differential analog inputs
- Selectable dual-edge sampling mode; the I- and Q-channels sample one input at twice the sampling clock rate
- Test patterns at output for system debug
- 1:1 non-demuxed or 1:2 demuxed LVDS outputs
- AutoSync feature for multi-chip systems
- Integrated tuneable L-C filter on the clock input to filter wideband clock jitter
- Single 1.9V power supply

Performance (typ) ADC10D1000 / ADC10D1500

- ENOB 9.1/9.0 bits
- SNR 57/56.8 dB
- SFDR 70/68 dBc
- Full power bandwidth 2.8/3.1 GHz
- DNL ±0.25/±0.25 LSB
- Power consumption
  - Single channel enabled 1.6/1.9W
  - Dual channels enabled 2.8/3.6W
  - Power-down mode 6/6 mW

Applications
Ideal for use in wideband communications and communications infrastructure.
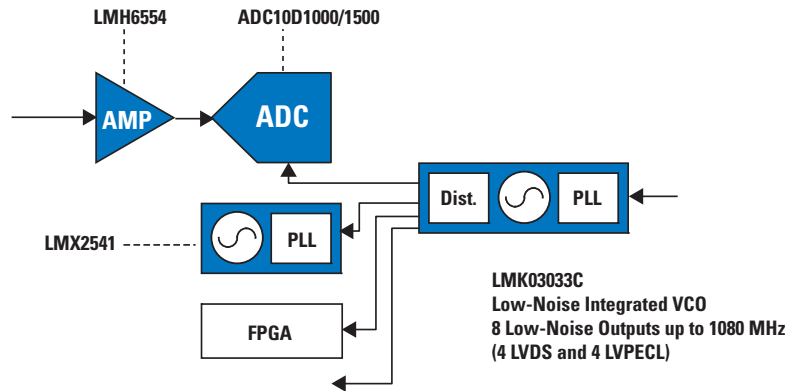
Typical ADC10D1000 performance

Data Conversion Solutions
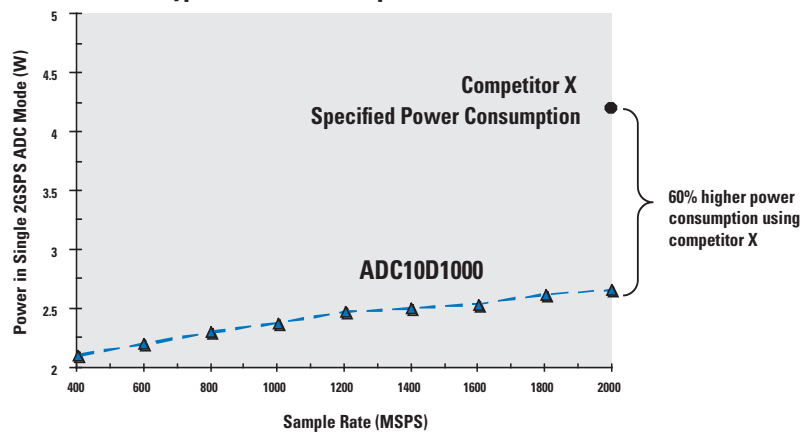
ADC08D1520 – 8-Bit, Dual 1.5 GSPS or Single 3.0 GSPS A/D Converter

Features

- Single +1.9V ±0.1V operation
- Interleave mode for 2x sample rate
- Multiple ADC synchronization capability
- Adjustment of input full-scale range, clock phase, and offset
- Choice of SDR or DDR output clocking
- 1:1 or 1:2 selectable output demux
- Second DCLK output
- Duty cycle corrected sample clock
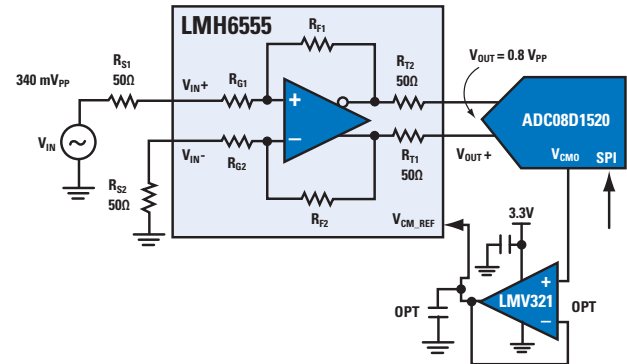
Applications

Ideal for use in Direct RF down conversion, satellite set-top boxes, and communications systems.

Ultra-High-Speed 8- and 10-bit ADCs

Product ID	Resolution	Speed (MSPS)	Supply Voltage (V)	Power (mW)	SFDR (dB)	THD (dB)	ENOB (bit)	SNR (dB)	Packaging
Ultra-High-Speed 10-bit ADCs									
ADC10D1000 E 🌀	10-bit dual	1000/2000	1.9	2770	70	-67	9.1	57	TEPBGA-292
ADC10D1500 E 🌀	10-bit dual	1500/3000	1.9	3590	68	-65	9	56.8	TEPBGA-292
Ultra-High-Speed 8-bit ADCs									
ADC08500 E 🌀	8-bit	500	1.9	800	55	-55	7.5	47.5	eLQFP-128
ADC081000 🌀	8-bit	1000	1.9	1450	59	-57	7.5	48	eLQFP-128
ADC081500 🌀	8-bit	1500	1.9	1200	56	-54.5	7.4	47	eLQFP-128
ADC083000 E 🌀	8-bit	3000	1.9	1800	57	-57	7.25	45.4	eLQFP-128
ADC08B3000 E 🌀	8-bit	3000	1.9	1800	57.5	-55	7.25	45.6	eLQFP-128
ADC08D500 E 🌀	8-bit dual	1000	1.9	1400	55	-55	7.5	48	eLQFP-128
ADC08D1000 E 🌀	8-bit dual	1000/2000	1.9	1600	55	-55	7.4	47	eLQFP-128
ADC08D1020 E 🌀	8-bit dual	1000/2000	1.9	1700	58	-58	7.4	46.8	eLQFP-128
ADC08D1500 E 🌀	8-bit dual	1500/3000	1.9	1800	56	-54.5	7.4	47	eLQFP-128
ADC08D1520 E 🌀	8-bit dual	1500/3000	1.9	2000	58	-58	7.4	46.8	eLQFP-128

🌀 PowerWise® product   E Evaluation board

Low Power ADC Solutions
Lowest Power, Broad Family

Product ID	Res (bits)	# Mux Inputs	Pin and Function Comp. Family	Max Speed Range (kSPS)	Supply Voltage (V)	Op. Power (typ) at 3.6V and Max Sample Rate (mW)	Static Performance (Typ)		Dynamic Characteristics (Typ)		I/O	Temp Range (°C)	Packaging
							INL (LSB)	DNL (LSB)	ENOB (bits)	SINAD (dB)			
Analog-to-Digital Converters													
ADC081S021 E,W	8	1		50 to 200	2.7 to 5.25	1.3	+0.45, -0.3	+0.45, -0.3	7.9	49.5	SPI	-40 to 85	SOT-23, LLP-6
ADC081S051 E,W	8	1		200 to 500	2.7 to 5.25	1.6	+0.06, -0.04	+0.06, -0.05	7.9	49.5	SPI	-40 to 85	SOT-23, LLP-6
ADC081S101 E,W	8	1		500 to 1000	2.7 to 5.25	2.0	±0.05	±0.07	7.9	49.7	SPI	-40 to 85	SOT-23, LLP-6
ADC101S021 E,W	10	1		50 to 200	2.7 to 5.25	2.3	+0.14, -0.13	+0.16, -0.09	9.9	61.5	SPI	-40 to 85	SOT-23, LLP-6
ADC101S051 E,W	10	1		200 to 500	2.7 to 5.25	2.7	+0.15, -0.09	+0.15, -0.11	9.9	61.5	SPI	-40 to 85	SOT-23, LLP-6
ADC101S101 E,W	10	1		500 to 1000	2.7 to 5.25	2.0	±0.2	+0.3, -0.2	9.9	61.7	SPI	-40 to 85	SOT-23, LLP-6
ADC121S021 E,W	12	1		50 to 200	2.7 to 5.25	1.5	+0.45, -0.4	+0.45, -0.25	11.7	72	SPI	-40 to 85	SOT-23, LLP-6
ADC121S051 E,W	12	1		200 to 500	2.7 to 5.25	1.7	+0.45, -0.4	+0.5, -0.25	11.6	72	SPI	-40 to 85	SOT-23, LLP-6
ADC121S101 E,W	12	1		500 to 1000	2.7 to 5.25	2.0	±0.4	+0.5, -0.3	11.7	72	SPI	-40 to 125	SOT-23, LLP-6
ADC082S021 E,W	8	2		50 to 200	2.7 to 5.25	1.6	±0.04	±0.04	7.9	49.6	SPI	-40 to 85	MSOP-8
ADC082S051 E,W	8	2		200 to 500	2.7 to 5.25	2.2	+0.12, -0.06	±0.09	7.9	49.5	SPI	-40 to 85	MSOP-8
ADC082S101 E,W	8	2		500 to 1000	2.7 to 5.25	3.2	±0.13	±0.10	7.9	49.6	SPI	-40 to 85	MSOP-8
ADC102S021 E,W	10	2		50 to 200	2.7 to 5.25	1.9	±0.13	±0.13	9.9	61.8	SPI	-40 to 85	MSOP-8
ADC102S051 E,W	10	2		200 to 500	2.7 to 5.25	2.7	+0.2, -0.1	±0.13	10.0	61.7	SPI	-40 to 85	MSOP-8
ADC102S101 E,W	10	2		500 to 1000	2.7 to 5.25	3.9	+0.4, -0.1	+0.26, -0.16	9.9	61.6	SPI	-40 to 85	MSOP-8
ADC122S021 E,W	12	2		50 to 200	2.7 to 5.25	2.2	±0.35	+0.4, -0.2	11.7	72	SPI	-40 to 85	MSOP-8
ADC122S051 E,W	12	2		200 to 500	2.7 to 5.25	3.0	±0.5	+0.7, -0.4	11.7	72	SPI	-40 to 85	MSOP-8
ADC122S101 E,W	12	2		500 to 1000	2.7 to 5.25	4.3	±0.64	+0.9, -0.6	11.7	72	SPI	-40 to 85	MSOP-8
ADC084S021 E,W	8	4		50 to 200	2.7 to 5.25	1.6	±0.04	±0.04	7.9	49.6	SPI	-40 to 85	MSOP-10
ADC084S051 E,W	8	4		200 to 500	2.7 to 5.25	2.2	+0.12, -0.06	±0.09	7.9	49.5	SPI	-40 to 85	MSOP-10
ADC084S101 E,W	8	4		500 to 1000	2.7 to 5.25	3.2	±0.13	±0.10	7.9	49.6	SPI	-40 to 85	MSOP-10
ADC104S021 E,W	10	4		50 to 200	2.7 to 5.25	1.9	±0.13	±0.13	9.9	61.8	SPI	-40 to 85	MSOP-10
ADC104S051 E,W	10	4		200 to 500	2.7 to 5.25	2.7	+0.2, -0.1	±0.13	10.0	61.7	SPI	-40 to 85	MSOP-10
ADC104S101 E,W	10	4		500 to 1000	2.7 to 5.25	3.9	+0.4, -0.1	+0.26, -0.16	9.9	61.6	SPI	-40 to 85	MSOP-10
ADC124S021 E,W	12	4		50 to 200	2.7 to 5.25	2.2	±0.35	+0.4, -0.2	11.7	72	SPI	-40 to 85	MSOP-10
ADC124S051 E,W	12	4		200 to 500	2.7 to 5.25	3.0	±0.5	+0.7, -0.4	11.7	72	SPI	-40 to 85	MSOP-10
ADC124S101 E,W	12	4		500 to 1000	2.7 to 5.25	4.3	±0.64	+0.9, -0.6	11.7	72	SPI	-40 to 85	MSOP-10
ADC088S022 E,W	8	8		50 to 200	2.7 to 5.25	0.9	±0.04	±0.04	7.9	49.5	SPI	-40 to 105	TSSOP-16
ADC088S052 E,W	8	8		200 to 500	2.7 to 5.25	1.2	±0.05	±0.06	7.9	49.6	SPI	-40 to 105	TSSOP-16
ADC088S102 E,W	8	8		500 to 1000	2.7 to 5.25	1.8	±0.05	±0.06	7.9	49.6	SPI	-40 to 105	TSSOP-16
ADC108S022 E,W	10	8		50 to 200	2.7 to 5.25	1.1	±0.10	±0.1	10.0	61.8	SPI	-40 to 105	TSSOP-16
ADC108S052 E,W	10	8		200 to 500	2.7 to 5.25	1.5	±0.10	±0.2	10.0	61.8	SPI	-40 to 105	TSSOP-16
ADC108S102 E,W	10	8		500 to 1000	2.7 to 5.25	2.1	±0.20	±0.2	10.0	61.8	SPI	-40 to 105	TSSOP-16
ADC128S022 E,W	12	8		50 to 200	2.7 to 5.25	1.2	±0.4	-0.3, +0.5	11.8	73	SPI	-40 to 105	TSSOP-16
ADC128S052 E,W	12	8		200 to 500	2.7 to 5.25	1.6	±0.4	-0.4, +0.6	11.8	73	SPI	-40 to 105	TSSOP-16
ADC128S102 E,W	12	8		500 to 1000	2.7 to 5.25	2.3	±0.5	-0.4, +0.7	11.8	73	SPI	-40 to 105	TSSOP-16
Differential-Input SPI A/D Converters													
ADC121S625 E,W	12	1		50 to 200	4.5 to 5.5	2.25 (at 5V)	+0.5/-0.3	±0.4	11.8	72.5	Serial (SPI)	-40 to 85	MSOP-8
ADC121S655 E,W	12	1		200 to 500	4.5 to 5.5	9.0	±0.6	±0.4	11.7	72.2	Serial (SPI)	-40 to 105	MSOP-8
ADC121S705 E,W	12	1		500 to 1000	4.5 to 5.5	11.5	±0.6	±0.4	11.7	72.2	Serial (SPI)	-40 to 105	MSOP-8
ADC122S625 E,W,*	12	2		50 to 200	4.5 to 5.5	8.6 (at 5V)	±1.0	±0.95	11.25	69.5	Serial (SPI)	-40 to 105	MSOP-10
ADC122S655 E,W,*	12	2		200 to 500	4.5 to 5.5	11.1 (at 5V)	±1.0	±0.95	11.25	69.5	Serial (SPI)	-40 to 105	MSOP-10
ADC122S706 E,*	12	2	—	500 to 1000	2.7 to 5.5	20.0	±0.5	±0.4	11.8	72.5	Serial (SPI)	-40 to 105	TSSOP-14
ADC141S626 E,W	14	1		50 to 250	2.7 to 5.5	4.8	±0.5	±0.5	13.7	84.2	Serial (SPI)	-40 to 85	MSOP-10
ADC161S626 E,W	16	1		50 to 250	4.5 to 5.5	5.8 (at 5V)	±0.8	±0.5/±0.8	14.3	89	Serial (SPI)	-40 to 85	MSOP-10

* Simultaneous Sampling   PowerWise product   E Evaluation board   W WEBENCH enabled

Digital-to-Analog Converters

Product ID	Res (bits)	# Mux Inputs	Pin and Function Comp. Family	Typ Settling Time (µsec)	Supply Voltage (V)	Typ Current Consumption (µA)		Static Performance (Typ)		Reference	I/O Type[1]	Packaging
						3.6V	5.5V	INL (LSB)	DNL (LSB)			
DAC081S101 E 🌀	8	1		3	2.7 to 5.5	175	260	+0.16, -0.12	+0.04, -0.02	From supply	Serial (SPI)	MSOP-8, TSOT-6
DAC101S101 E 🌀	10	1		5	2.7 to 5.5	175	260	±0.6	+0.15, -0.05	From supply	Serial (SPI)	MSOP-8, TSOT-6
DAC121S101 E 🌀	12	1		8	2.7 to 5.5	175	260	±2.6	+0.25, -0.15	From supply	Serial (SPI)	MSOP-8, TSOT-6
DAC082S085 E 🌀	8	2		3	2.7 to 5.5	210	320	±0.14	+0.04, -0.02	External	Serial (SPI)	MSOP-10, LLP-10
DAC102S085 E 🌀	10	2		4.5	2.7 to 5.5	210	320	±0.7	+0.08. -0.03	External	Serial (SPI)	MSOP-10, LLP-10
DAC122S085 E 🌀	12	2		6	2.7 to 5.5	210	320	±2.4	+0.2, -0.1	External	Serial (SPI)	MSOP-10, LLP-10
DAC084S085 E 🌀	8	4		3	2.7 to 5.5	350	500	±0.14	+0.04, -0.02	External	Serial (SPI)	MSOP-10, LLP-10
DAC104S085 E 🌀	10	4		4.5	2.7 to 5.5	350	500	±0.7	+0.08, -0.03	External	Serial (SPI)	MSOP-10, LLP-10
DAC124S085 E 🌀	12	4		6	2.7 to 5.5	360	480	±2.4	+0.2, -0.1	External	Serial (SPI)	MSOP-10, LLP-10
DAC088S085 E 🌀	8	8		3	2.7 to 5.5	650	970	±0.125	±0.03	Dual External	Serial (SPI)	TSSOP-16, LLP-16
DAC108S085 E 🌀	10	8		4.5	2.7 to 5.5	650	970	±0.5	+0.08, -0.04	Dual External	Serial (SPI)	TSSOP-16, LLP-16
DAC128S085 E 🌀	12	8		6	2.7 to 5.5	650	970	±2.0	+0.15, -0.09	Dual External	Serial (SPI)	TSSOP-16, LLP-16

Single-Ended Input I²C Compatible A/D Converters with Multiple Addresses and Alarm Option

Product ID	Res (bits)	Inputs	Pin and Function Compatible	Speed Range (kSPS)	Supply Voltage Range(V)	Typ Power (mW)		INL (LSB)	Temp Range (°C)	Alarm	Packaging
						3V	5V				
ADC081C021 E W 🌀	8	1		5.5 to 189	2.7 to 5.5	0.26	0.78	±0.2	-40 to 105	✔	TSOT-6, MSOP-8
ADC101C021 E W 🌀	10	1		5.5 to 189	2.7 to 5.5	0.26	0.78	±0.5	-40 to 105	✔	TSOT-6, MSOP-8
ADC121C021 E W 🌀	12	1		5.56 to 189	2.7 to 5.5	0.26	0.78	±0.5	-40 to 105	✔	TSOT-6, MSOP-8
ADC081C027 E W 🌀	8	1		5.5 to 189	2.7 to 5.5	0.26	0.78	±0.5	-40 to 105	—	TSOT-6
ADC101C027 E W 🌀	10	1		5.5 to 189	2.7 to 5.5	0.26	0.78	±0.5	-40 to 105	—	TSOT-6
ADC121C027 E W 🌀	12	1		5.56 to 189	2.7 to 5.5	0.26	0.78	±0.5	-40 to 105	—	TSOT-6
NEW! ADC128D818 E 🌀	12	8	—	0.01	3.0 to 5.5	2.01*	4.0*	±0.4 (3.3V)	-40 to 125	✔	TSSOP-16

Single-Ended Input I²C Compatible Digital-to-Analog Converters

Product ID	Res (bits)	Inputs	Pin and Function Compatible	Speed Range (kSPS)	Supply Voltage Range(V)	Typ Power (mW)		Static Performance (Typ)		ENOB (bits) Typ	Temp Range (°C)	Packaging
						3V	5V	INL (LSB)	DNL (LSB)			
DAC081C081 E 🌀	8	1		6	2.7 to 5.5	0.38	0.73	±0.1	±0.08	Supply	-40 to 125	MSOP-8
DAC101C081 E 🌀	10	1		6	2.7 to 5.5	0.38	0.73	+0.21, -0.16	+0.25, -0.16	Supply	-40 to 125	MSOP-8
DAC121C081 E 🌀	12	1		6	2.7 to 5.5	0.38	0.73	+2.2, -1.5	+0.18, -0.12	Supply	-40 to 125	MSOP-8
DAC081C085 E 🌀	8	1		6	2.7 to 5.5	0.38	0.73	±0.1	±0.08	External	-40 to 125	MSOP-10
DAC101C085 E 🌀	10	1		6	2.7 to 5.5	0.38	0.73	+0.21, -0.16	+0.25, -0.16	External	-40 to 125	MSOP-10
DAC121C085 E 🌀	12	1		6	2.7 to 5.5	0.38	0.73	+2.2, -1.5	+0.18, -0.12	External	-40 to 125	TSSOP-14

[1] SPI/QSPI/DSP compatible   * 3.6V 5.5V   🌀 PowerWise® product   E Evaluation board   W WEBENCH enabled

Precision Signal Path Applications
Monitoring and Control Solutions for Communications Systems

Wireless Basestation
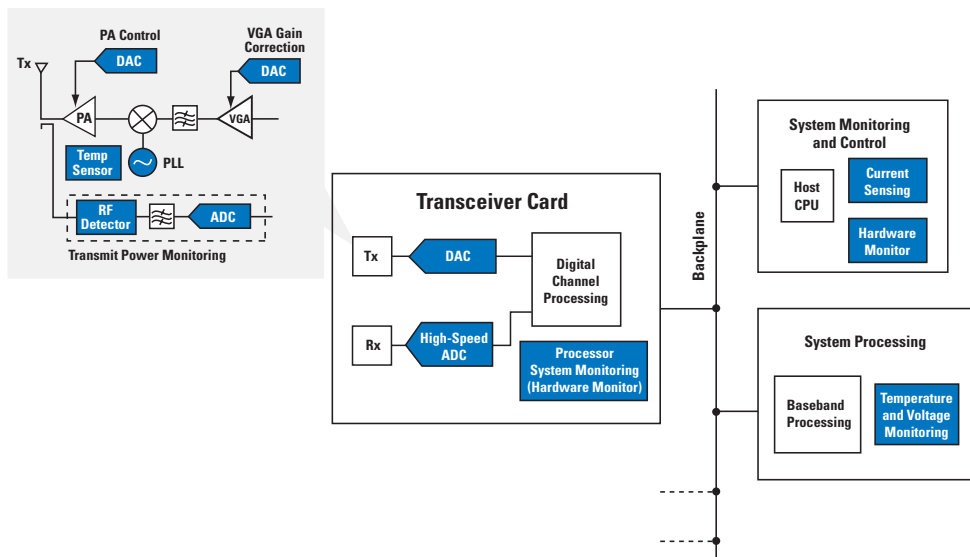
Optical Networks

RSSI (Receive Signal Strength Indicator) in Channelized Communication

LM96080 – System Hardware Monitor with 2-Wire Serial Interface

Features

- Local temperature setting
- 7 positive voltage inputs with 10-bit resolution
- 2 programmable fan-speed monitoring inputs
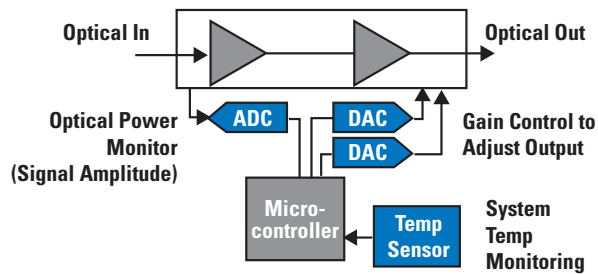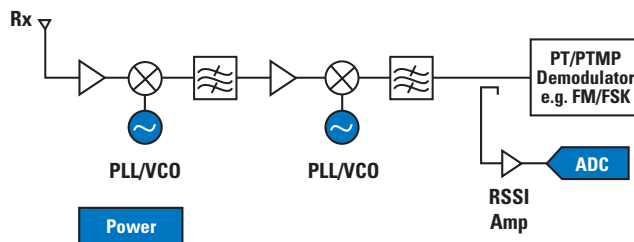- 2.5 mV LSB and 2.56V input range
- Chassis intrusion detector
- WATCHDOG comparison of all monitored values
- I²C serial bus interface compatibility
- Shutdown mode to minimize power consumption
- Software- and pin-compatible with LM80

Applications

Ideal for use in communications infrastructure, system thermal, and hardware monitoring for servers, electronic test equipment and instrumentation, as well as office electronics.
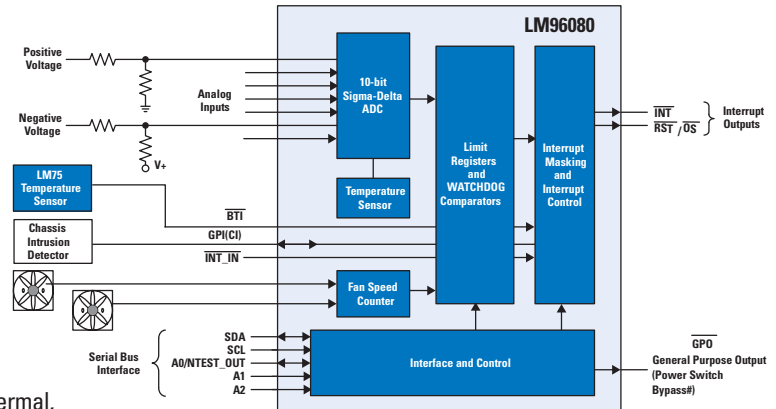
Selected Temperature Sensors

Product ID	Description	Temperature Range (°C)	Accuracy	Scale Factor / Resolution	Supply Voltage (V)	Supply Current	Packaging
Analog							
LM94022 E	1.5V analog temperature sensor with 4 selectable gains and class-AB output	-50° to 150°	± 1.5°C (20°C to 40°C)	-5.5 to -13.6 mV/°C	1.5 to 5.5	5.4 µA	SC-70
Digital							
LM73 E	11- to 14-bit, 2-wire local digital temperature sensor	-40° to 150°	± 1.0°C (-10°C to 80°C)	0.03125°C/LSB	2.7 to 5.5	320 µA	SOT23-6
LM75A E	9-bit digital temperature sensor and thermal watchdog with two-wire interface	-55° to 125°	± 2.0°C (-25°C to 100°C)	0.5°C/LSB	3.0 to 5.5	250 µA	MSOP-8, SOIC-8
Remote Diode							
LM95214 E	11-bit quad remote diode temperature sensor with SMBus interface, 3 Tcrit	-40° to 140°	±1.1°C (TA = 25°C to 85°C, TD = 60°C to 100°C)	0.03125°C/LSB	3.0 to 3.6	570 µA	LLP-14
Temperature Switches							
LM26LV E	1.6 V factory preset temperature switch and temperature sensor	-50° to 150°	± 2.2°C (0°C to 150°C)	—	1.6 to 5.5	8 µA	LLP-6
LM57 E	2.4V user programmable temperature switch and temperature sensor	-50° to 150°	±1.5, ±2.3 (-50°C to 150°C)	—	2.4 to 5.5	24 µA	LLP-8
Hardware Monitors							
LM96080 E	10-bit ADC, 7 channels, local temp, fan TACH inputs, 2 wire I/F	-40° to 125°	± 3.0°C (-40°C to 125°C)	0.0625°C/LSB	3.0 to 5.5	0.3 mA	TSSOP-24
LM87 E	Dual remote diodes, DAC output, TACH inputs	-40° to 125°	± 3.0°C (TA = 60°C to 125°C)	1°C/LSB	2.8 to 3.8	0.7 mA	TSSOP-24
LM96194	4 TruTherm® RDTS, 4 fan monitors, 2 fan controls, 8 voltage monitors	-40° to 85°	± 3°C (TA = 0°C to 85°C TD = 0°C to 100°C)	0.5°C/LSB	3.0 to 3.6	1.6 mA	LLP-48
LM96163 E	TruTherm remote clocks and integrated fan control	-40° to 140°	±0.75°C (TA = ±25°C to 85°C TD = 50°C to 105°C)	0.125°C/LSB	3.0 to 3.6	4.56 mA	LLP-10
ADC128D818 E	12-bit ADC, 8 single-ended or 4 pseudo-differential channels, local temp, 2 wire I/F	-40° to +125°	± 3.0°C (-40°C to 125°C)	0.0625°C/LSB	3.0V to 5.5	0.56 mA	TSSOP-16

PowerWise® product   E Evaluation board

# RF Detectors and High-Speed Comparator Solutions

LMH2110 – 6 GHz Logarithmic RMS RF Power Detector

Features

- 40 dB linear-in-dB power detection range
- >30 dB dynamic range, 1900 MHz, n=50
  - ±0.3 dB Log Conformance error
  - ±0.3 dB variation over temperature
  - 0.05 dB (typ) output variation due to modulation, WCDMA
- Shutdown pin
- Multi-band operation from 50 MHz to 6 GHz

Applications
Ideal for use in the transmit power control loop of 3G HSUPA(+)and LTE handset design.

LMH2110 Performance
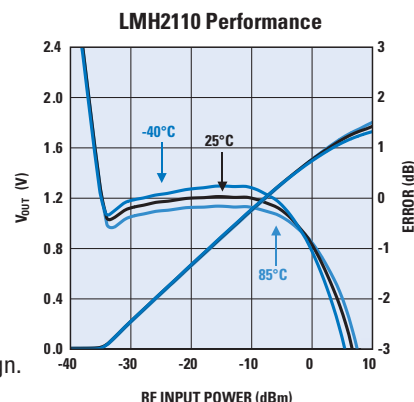
RF Detectors

Product ID	Application	Channels	Supply Voltage Range (V)	Dynamic Range (dB)	Frequency Range (MHz)	Packaging
LMV221 E	CDMA, WCDMA, GSM, GPRS	1	2.7 to 3.3	40	50 to 3500	LLP-6
LMV225/6/8 E	CDMA, WCDMA, GSM, EDGE, GPRS, TDMA	1	2.7 to 5	>30	450 to 2000	micro SMD-4, LLP-6
LMV232 E	3G, UMTS, WCDMA, CDMA2000, LAN, GPS	2	2.5 to 3.3	20	50 to 2000	micro SMD-8
LMH2100 E	CDMA, WCDMA, GSM, GPRS	1	2.7 to 3.3	40	50 to 4000	micro SMD-6
LMH2110 E	LTE, UMTS, WCDMA, CDMA2000, GSM/EDGE	1	2.7 to 5	40	50 to 6000	micro SMD-6

LMV7231 – Hex Window Comparator with 1.5% Precision and 400 mV Reference

- 6-channel window comparator monitors multiple power supplies
- High accuracy 400 mV internal reference
- Threshold accuracy ±1.5% (max)
- Wide supply voltage range +2.2V to +5.5V
- Internal hysteresis 6 mV
- Propagation delay 7 μs
- Supply current 7 μA per channel

Applications
Ideal for use in power supply voltage detection, battery monitoring, and relay driving.
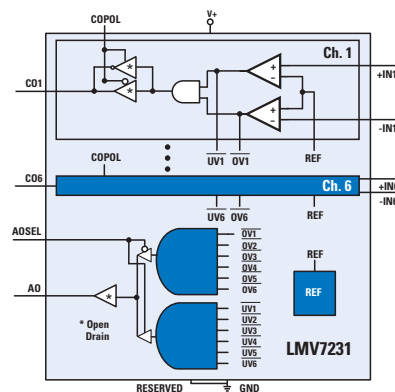
Comparators

Product ID	Application	I_{CC} (mA/ch)	V_{CC} (V)	t_{PD} (ns)	Toggle Rate (Mbps)	Packaging
LMH7322 E	Dual high-speed comparator with LVDS/RSPECL outputs	22.6	2.7 to 12	0.7	4000	LLP-24
LMH7324 E	Quad high-speed comparator with LVDS/RSPECL outputs	22.6	5 to 12	0.7	4000	LLP-32
LMH7220	High-speed comparator with LVDS outputs	6.8	2.7 to 12	2.9	1080	TSOT-23
LMV7219	High-speed comparator with TTL outputs	1.1	2.7 to 5	7	—	SOT-23
LMV7231 E	Hardware monitor, low-power hex comparator	7 μA	2.2 to 5.5	7 μs	—	LLP-24
LMP7300 E	Precision comparator and reference	10 μA	2.7 to 12	10 μs	—	SOIC-8, MSOP-8

PowerWise® product   E Evaluation board

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LMH6629 – 8 GHz Gain Bandwidth Ultra Low Noise Amplifier

Features

- 8 GHz gain bandwidth
- 0.65 nV√Hz input noise voltage
- 25˚C 250 uV input offset voltage max
- 1200 V/µs slew rate
- -90/-91 dBc HD2/HD3 at 0.5 Mhz
- 3 to 5V supply voltage range
- ≥4/≥10 selectable min gain
- 15 mA typical supply current

Applications

Ideal for use in basestation amplifiers, wide band active filters, and transimpedance amplifiers.
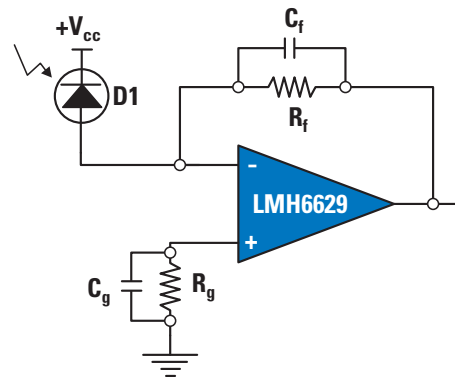
LMH6517 – Low-Power, Low-Noise IF and Baseband Dual 16-bit ADC Driver with Digitally-Controlled Gain

Features

- Differential 200Ω input
- 44 dBm OIP3 at 200 MHz
- 5.5 dB noise figure
- 1.2 GHz bandwidth
- Digital attenuator: 0 to 31.5 dB, 0.5 dB steps
- 22 dB maximum gain
- Differential output
- Serial Interface and Parallel (SPI)
- Dual channel
- 80 mA/ch I_{CC} at 5V supply
- 3.15V to 5.25V operation

Applications

Ideal for use in cellular basestations and IF sampling receivers.
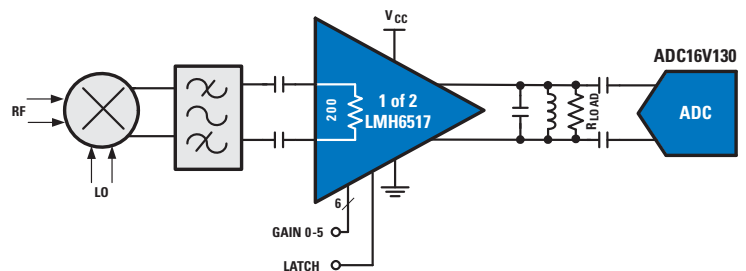
Amplifier Solutions
Select Amplifier Products

Variable Gain Amplifiers

Product ID	Type	Max Gain/Gain Step Size (dB)	BW, Unity Gain (MHz)	I_{CC} (mA/ch)	OIP3 (dBm)	Noise Figure (dB)	Packaging
LMH6514[E]	Digital variable gain amplifier	32/6	600	107	39 at 70 Mhz	8.3	LLP-16
LMH6515[E]	Digital variable gain amplifier	26/1	600	107	40 at 70 Mhz	8.3	LLP-16
LMH6517	Dual digital variable gain amplifier	22/0.5	1200	80	44 at 200 MHz	5.5	LLP-32

High-Speed Amplifiers

Product ID	Type	Slew Rate (V/μs, $A_V = 1$)	Small Signal Band-width (MHz, $A_V = 1$)	I_{CC}(mA/ch)	2nd/3rd HD ($R_L = 100$)	Voltage Noise (nV/$\sqrt{Hz}$)	Packaging
LMH6714[E]	Single, wideband, op amp	1800[2]	400[2]	5.6	-58/-70 at 20 MHz	3.4	SOIC-8, SOT23-5
LMH6321	100 MHz buffer with 300 mA output	1800	110	15	-70/-70 at 100 MHz	2.8	PSOP-8, TO-263
LMH6550[E]	Single differential I/O amplifier	3000	400	20	-78/-88 at 20 MHz	6	SOIC-8, MSOP-8
LMH6551[E]	Single differential I/O amplifier	2400	370	12.5	-94/-96 at 5 MHz	6	SOIC-8, MSOP-8
LMH6552[E]	Single differential I/O CFB amplifier	2500	1.5 GHz	20.4	-92/-93 at 20 MHz	0.9	SOIC-8, LLP-8
LMH6553[E]	Single differential I/O CFB amplifier	2300	900	29.1	-79/-90 at 20 MHz	1.2	PSOP-8, LLP-8
LMH6554[E]	Single differential I/O CFB amplifier	6200	2.8 GHz	52	-79/-70 at 250 MHz	0.9	LLP-14
LMH6555[E]	1.2 GHz differential I/O amplifier	1500	1.2 GHz	130	-64/-66 at 150 MHz	1.4	LLP-16
LMH6601[E,W]	2.4 to 5.5V CMOS op amp	260	250	9.6	-61/-64 at 10 MHz	7	SC70-6
LMH6609[W]	Single, op amp	1400[2]	900	7	-63/-57 at 20 MHz	3.1	SOT23-5, SOIC-8
LMH6611[E,W]	Single RRO op amp	460	365	3.3	-64/-66 at 10 MHz	10	TSOT23-6
LMH6618/9[E,W]	Single/Dual RRIO op amp	57	140	1.35	-74/-73 at 1 MHz	10	TSOT23-6, SOIC-8
LMH6622[E,W]	Dual, op amp	85[2]	160[2]	4.3	-90/-94 at 1 MHz	1.6	SOIC-8, MSOP-8
LMH6624[E,W]	Single, op amp	350[1]	95[1]	12	-63/-80 at 10 MHz	0.92	SOT23-5, SOIC-8
LMH6626[E,W]	Dual, op amp	320[1]	85[1]	12	-63/-80 at 10 MHz	1	SOIC-8, MSOP-8
LMH6628[E,W]	Dual, op amp	550[2]	300	9	-65/-74 at 10 MHz	2	SOIC-8
(NEW!) LMH6629[E]	Single, ultra low noise op amp	1200[3]	800[3]	15	-90/-91 at 0.5 MHz	0.65	LLP-8
LMH6702[E,W]	Single, op amp	3100[2]	1.7 GHz[2]	12.5	-63/-72 at 60 MHz	1.8	SOT23-5, SOIC-8
LMH6703[E]	Single, op amp	4500[2]	1.2 GHz[2]	11	-69/-90 at 20 MHz	2.3	SOT23-5, SOIC-8
LMH6715[E,W]	Dual, wideband, op amp	1300[2]	400[2]	5.8	-60/-75 at 20 MHz	3.4	SOIC-8
LMH6720[E,W]	Single, wideband, op amp w/disable	1800[2]	400[2]	5.6	-58/-70 at 20 MHz	3.4	SOIC-8, SOT23-5

Precision Amplifiers

Product ID	Description	I_{CC}/Ch (mA)	V_{OS} (mV) Max.	GBW (MHz)	Noise (nV/$\sqrt{Hz}$)	Packaging
LMP7701/2/4[W]	Single/Dual/Quad CMOS input, RRIO amplifier	0.7	0.2	2.5	9	SOT23-5, MSOP-8, TSSOP-14
LMP7711/12[W]	17MHz, CMOS input amplifier	1.15	0.15	17	5.8	SOT23-6, MSOP-10
LMP7731	Low noise 2.9 nV/√Hz, RRIO amplifier	2.0	0.5	21	3.3	SOT23-5
LM6211[W]	Low noise 17 MHz, 24V amplifier	1.05	2.5	20	5.5	SOT23-5
LMV841/2/4[E]	Single /dual/quad precision amplifiers	1.0	0.5	4.5	20	SC-70 , SOIC-8, MSOP-8, SOIC-14, TSSOP-14
LPV531	Micropower CMOS input amplifier	5 to 425 μA	1.0	0.7 to 4.6	20	TSOT23-5
LPV521[E]	Nanopower 1.8V, CMOS input amplifier	0.4	1.0	6.2 kHz	272	SC-70
(NEW!) LMP8645[E]	High voltage current sense variable gain amplifier	0.6	1.0	0.85	120	TSOT-6

[1] $A_V = +20$ [2] $A_V = +2$ [3] $A_V = +10$ PowerWise product   [E] Evaluation board   [W] WEBENCH enabled

LMK Clock Conditioner Family
Jitter Cleaning + Multiplication + Distribution
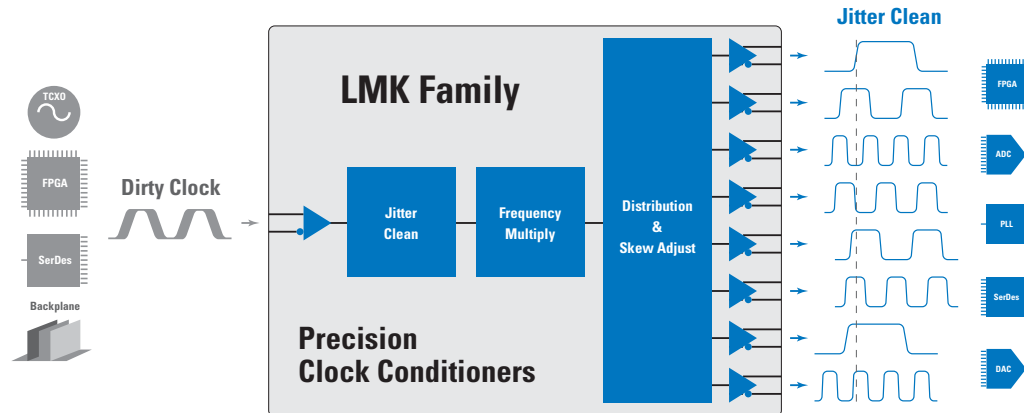
LMK Clock Conditioner Family

| Product ID	Outputs			Architecture	Output Clock Range (MHz)	VCO Frequency Range (MHz)	RMS Jitter (ps) *
	LVPECL	LVDS	LVCMOS				
LMK01000ISQ E	5	3	0	2:8 Clock Distribution	1 to 1600	NA	0.03 (additive)
LMK01010ISQ E	0	8	0		1 to 1600	NA	0.03 (additive)
LMK01020ISQ E	8	0	0		1 to 1600	NA	0.03 (additive)
LMK02000ISQ E	5	3	0	PLL + Clock Distribution (needs external VCXO)	1 to 800	NA	0.02 (+VCXO)
LMK02002ISQ E	4	0	0		1 to 860	NA	0.2 (+VCXO)
LMK03000CSQ E	5	3	0	PLL + VCO + Clock Distribution	1 to 648	1185 to 1296	0.4
LMK03000ISQ W	5	3	0		1 to 648	1185 to 1296	0.8
LMK03000DISQ	5	3	0		1 to 648	1185 to 1296	1.2
LMK03001CISQ E	5	3	0		1 to 785	1470 to 1570	0.4
LMK03001ISQ W	5	3	0		1 to 785	1470 to 1570	0.8
LMK03001DISQ	5	3	0		1 to 785	1470 to 1570	1.2
LMK03002CISQ E	4	0	0		1 to 860	1566 to 1724	0.4
LMK03002ISQ	4	0	0		1 to 860	1566 to 1724	0.8
LMK03033CISQ E	4	4	0		1 to 1080	1843 to 2160	0.5
LMK03033ISQ	4	4	0		1 to 1080	1843 to 2160	0.8
LMK03200ISQ E	5	3	0		1 to 1080	1185 to 1296	0.8
LMK04000BISQ E	3	0	4	Cascaded PLLs + VCO + Clock Distribution (PLL1 requires external Crystal or VCXO)	1 to 648	1185 to 1296	0.15/0.2 (+VCXO/Crystal)
LMK04001BISQ E	3	0	4		1 to 785	1430 to 1570	0.15/0.2 (+VCXO/Crystal)
LMK04011BISQ E	5	0	0		1 to 785	1430 to 1570	0.15/0.2 (+VCXO/Crystal)
LMK04031BISQ E	2	2	2		1 to 785	1430 to 1570	0.15/0.2 (+VCXO/Crystal)
LMK04002BISQ E	3	0	4		1 to 875	1600 to 1750	0.15/0.2 (+VCXO/Crystal)
LMK04033BISQ E	2	2	2		1 to 1080	1840 to 2160	0.15/0.2 (+VCXO/Crystal)

*Integrated from 10 kHz to 20 MHz   PowerWise product   E Evaluation board

LMK Clock Conditioner Family
Performance

Superior Phase Noise Performance
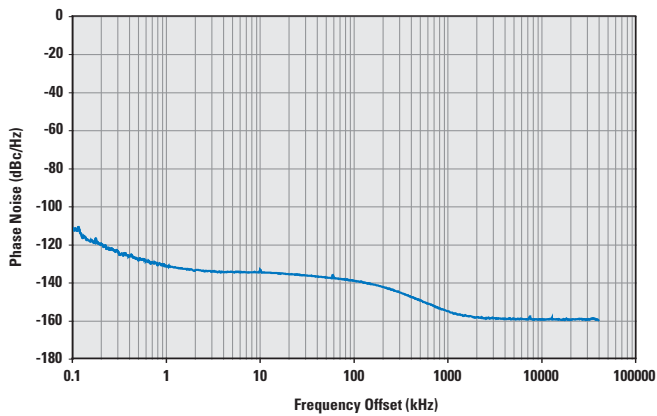
LMK04031B LVCMOS Output Phase Noise at 122.88 MHz
using a Crystek VCXO
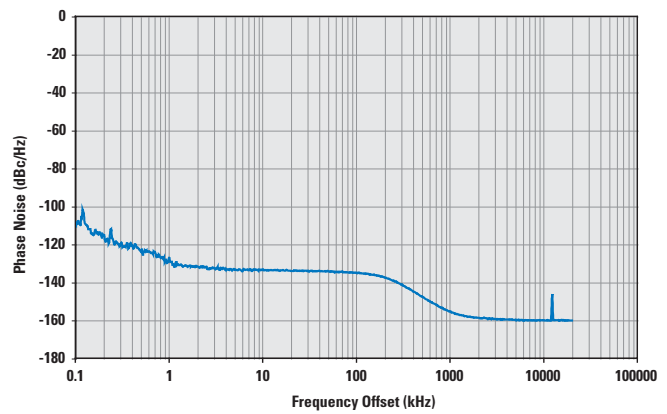
LMK04031B LVCMOS Output Phase Noise at 122.88 MHz using a
low-cost Vectron Crystal

National's Clock Design Tool

Easy-to-use and feature-rich design tool for simple and quick clock subsystem design and analysis

Features

- Easy design parameter entry
- LMK part selection and configuration
- PLL and loop filter customization
- Input clock and VCXO phase noise entry
- Phase noise and jitter simulations and plotting

Updated to support LMX2531 and LMX2541 part
selection and design.
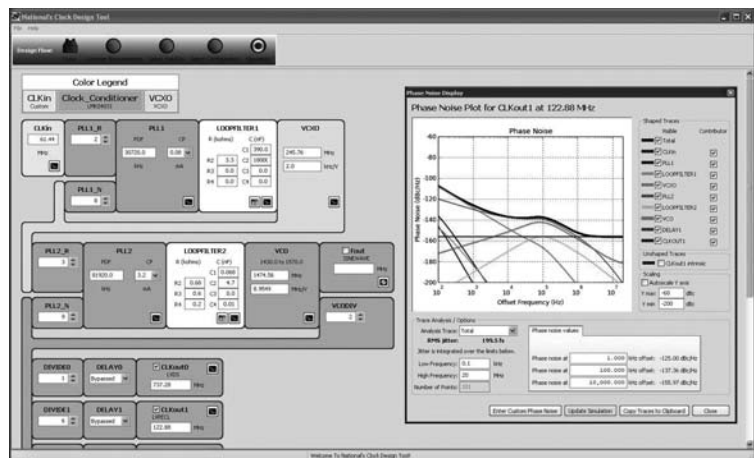
To test the Clock Design Tool, visit **national.com/timing**.

High-Performance Frequency Synthesizer Solutions

LMX2541 – Ultra-Low-Noise PLLatinum® Frequency Synthesizer with Integrated VCO

The LMX2541 family is the industry's lowest noise integrated frequency synthesizer. Featuring the world's lowest noise Phase-Locked Loop (PLL), the LMX2541 provides less than 2 milli-radians (mrad) root-mean-square (RMS) noise at 2.1 GHz and 3.5 mrad RMS noise at 3.5 GHz, outperforming the nearest competitor by 10 dB in both in-band PLL noise and spurious performance.

When paired with the LMK04000 clock jitter cleaner, the LMX2541 significantly improves system error vector magnitude (EVM), resulting in enhanced receiver sensitivity and transmitter spectral purity.

LMK04000 Clock Jitter Cleaner

LMX2541 RF Synthesizer

LMX2541 vs. Competition, Phase Noise and Spurious, Fvco = 3.08025 GHz

Features

- Fully integrated, ultra-low noise VCO
- Normalized PLL phase noise of -225 dBc/Hz
- VCO output divider, 1 to 63 (odd and even)
- Phase detector frequency up to 104 MHz
- Wide frequency range of 31.6 MHz to 4 GHz
- External VCO mode (internal VCO powered down)
- Partially integrated loop filter components
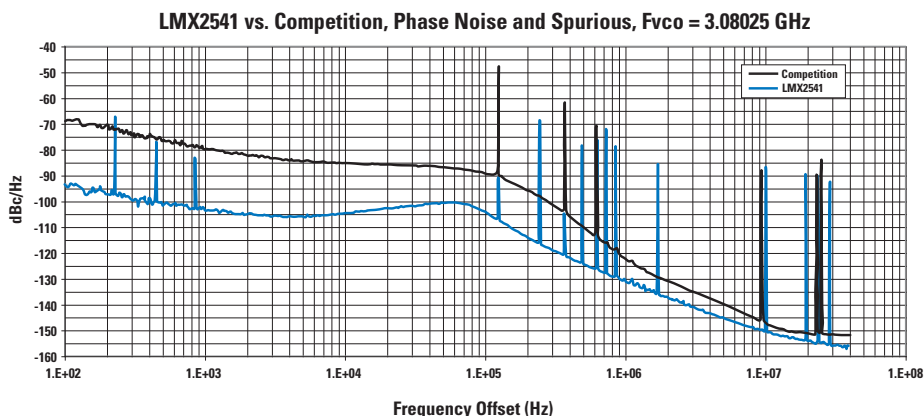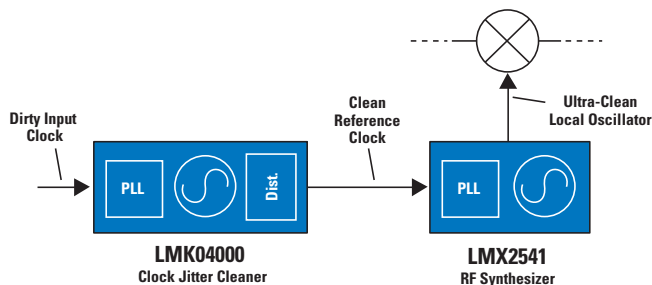- Supports crystal oscillator based reference clock input

Applications
Ideal for use in next-generation basestation radio transceivers such as UMTS, LTE, and WiMAX.

Design Tools and Resources
- EasyPLL WEBENCH® design tool
- Clock design tool
- PLL Codeloader evaluation software
- LMX PLLatinum PLL/VCO evaluation boards
- *PLL Performance, Simulation, and Design handbook*, 4th edition
- Clock Conditioner owner's manual
- Application notes
- Online seminars

Visit **national.com/timing** for more information.

Product ID	VCO Frequency Range (MHz)	Total Device Frequency Range Using Divider Output (MHz)	
		Min	Max
LMX2541SQ2060E E, W	1990 to 2240	31.58	2240
LMX2541SQ2380E E, W	2200 to 2530	34.92	2530
LMX2541SQ2690E E, W	2490 to 2865	39.52	2865
LMX2541SQ3030E E, W	2810 to 3230	44.60	3230
LMX2541SQ3320E E, W	3130 to 3600	49.68	3600
LMX2541SQ3740E E, W	3480 to 4000	55.23	4000

PowerWise product   E Evaluation board   W WEBENCH enabled

High-Performance PLLatinum® Family of PLL Products

High-Performance PLLatinum Family of PLL Products

Product ID	Main Operating Frequency Range (GHz)	Aux. Operating Frequency Range (MHz)	Main Normalized Phase Noise (dBc/Hz)	Supply Current (mA)	Supply Voltage (V)	Packaging
Dual-Integer PLLs						
LMX2434 E,W	1.0 to 5.0	500 to 2500	-219	7.0	2.35 to 2.75	TSSOP-20
LMX2433 E,W	0.5 to 3.6	250 to 1700	-219	5.2	2.25 to 2.75	TSSOP-20
LMX2430 E,W	0.25 to 3.0	100 to 800	-219	4.2	2.25 to 2.75	TSSOP-20
Fractional-N PLLs						
LMX2487 E,W	3.0 to 6.0	250 to 3000	-209	8.2	2.5 to 3.6	LLP-24
LMX2487E W	3.0 to 7.5	250 to 3000	-209	8.2	2.5 to 3.6	LLP-24
LMX2486 E,W	1.0 to 4.5	250 to 3000	-210	8.3	2.5 to 3.6	LLP-24
LMX2485 E,W	0.5 to 3.0	75 to 800	-209	5	2.5 to 3.6	LLP-24
LMX2485E E,W	0.05 to 3.0	75 to 800	-209	5	2.5 to 3.6	LLP-24

LMX2531 PLLatinum Family of High-Performance, Low-Power Synthesizer Systems

Product ID	Max PLL Freq (MHz)	Min PLL Freq (MHz)	Max Aux PLL Freq (MHz)	Min Aux PLL Freq (MHz)	Normalized PLL Phase Noise (dBc/Hz)	VCO Phase Noise, 100 kHz Offset (dBc/Hz)	Supply Current (mA)
LMX2531LQ1146E E,W	1184	1106	592	553	-212	-121	34
LMX2531LQ1226E E,W	1268	1184	634	592	-212	-121	34
LMX2531LQ1312E E,W	1360	1268	680	634	-212	-121	34
LMX2531LQ1415E E,W	1470	1360	735	680	-212	-121	34
LMX2531LQ1500E E,W	1510	1499	—	—	-212	-121	34
LMX2531LQ1515E E,W	1580	1450	790	725	-212	-122	34
LMX2531LQ1650E E,W	1700	1590	850	795	-212	-118	34
LMX2531LQ1700E E,W	1770	1662	885	831	-212	-117	34
LMX2531LQ1742 E,W	1866	1760	933	880	-212	-117	34
LMX2531LQ1778E E,W	1840	1726	920	863	-212	-117	34
LMX2531LQ1910E E,W	2028	1834	1014	917	-212	-115	34
LMX2531LQ2080E E,W	2274	1904	1137	952	-212	-113	34
LMX2531LQ2265E E,W	2400	2178	1200	1089	-212	-113	38
LMX2531LQ2570E E,W	2790	2336	1395	1168	-212	-112	38
LMX2531LQ2820E E,W	2925	2710	1462	1355	-212	-111	38
LMX2531LQ3010E E,W	3132	2910	1566	1455	-212	-110	38

PowerWise product   E Evaluation board   W WEBENCH enabled

World's Most Robust Serial Interface Solutions

Base Station

Remote Radio Heads (RRHs)

CPRI SerDes
SCAN25100

Backplane SerDes

Baseband Module

RE Module

Transport Module

Ethernet

Ethernet

To Backhaul

Combiner/ Distributor

BBB

RE Module

RE Module

CPRI SerDes

CPRI SerDes

Ethernet

Ethernet

Control Module

Ethernet Solutions
DP83640 (IEEE1588 supported)
DP83848 (Single)
DP83849 (Dual)

Backplane SerDes
DS32ELX0421/0124
SCAN928028/6260
DS92LV18
DS90UR241
DS90UR124

CPRI SerDes
SCAN25100
SCAN12100

DS32EL(X)0421/DS32EL(X)0124 – 3.125 Gbps FPGA-Link Ser/Des

Features

- Wide serial data rate 1.25 to 3.125 Gbps
- On-chip advanced signal conditioning (de-emphasis, equalization)
- Supports – CAT-5e/6/7, FR-4, coax (50Ω, 75Ω)
- Low power – auto standby and configurable sleep modes
- FPGA-friendly interface – 5-bit DDR LVDS data
- ELX version features – retimed output and redundant I/O
- Sample FPGA IP for Ser/Des interfacing included

Applications

Ideal for use in high speed communication serial links across FR-4 and balanced cables and fiber optic cables.

Typical Application Circuit

FPGA

System Logic

LVDS Interface

Ctrl

DS32ELX0421

LVDS Interface

Parallel to Serial

PLL

Control

3.125 Gbps Data Payload

20m CAT6 Cable

80 inch FR-4 Backplane

DS32ELX0124

Serial to Parallel

LVDS Interface

PLL

Control

No reference clock required

FPGA

LVDS Interface

System Logic

Ctrl
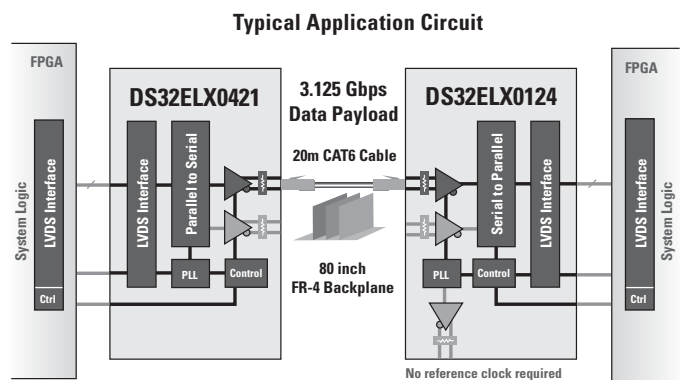
Serializers and Deserializers
Backplane, Cable, and Radio Interface

Family	Embedded Clock	Signal Conditioning	Embedded DC-Balance	Product ID		Parallel Width	Parallel I/O	Min Freq (MHz)	Max Freq (MHz)	Mux Ratio
				Serializer	Deserializer					
FPGA-Link	✔	Advanced Rx EQ, Tx Driver Redundant I/Os Retimed Serial Output	✔	DS32EL0421	DS32EL0124	5	LVDS	125	312.5	ANY:1
			✔	DS32ELX0421	DS32ELX0124	5	LVDS	125	312.5	ANY:1
8-bit/10-bit SerDes	✔	Moderate Rx EQ, Tx Driver	✔	SCAN25100 ᴱ	SCAN25100	10	LVCMOS	30.72	122.88	10:1
Channel-Link II	✔	Moderate Rx EQ, Tx Driver	— (NEW!)	DS92LV3241	DS92LV3242	32	LVCMOS	20	85	32:4
			— (NEW!)	DS92LV3221	DS92LV3222	32	LVCMOS	20	50	32:2
Channel-Link	—	Limited Rx EQ, Tx Driver	—	DS90CR217 ᴱ	DS90CR218A ᴱ	21	LVCMOS	20/12	85	21:3
			—	DS90CR287 ᴱ	DS90CR288A ᴱ	28	LVCMOS	20	85	28:4
			✔	DS90CR483A ᴱ	DS90CR484A ᴱ	48	LVCMOS	33	112	48:8
			✔	DS90CR485 ᴱ	DS90CR486 ᴱ	48	LVCMOS	66	133	48:8
Bus LVDS SerDes	—	—	—	DS92LV1021A ᴱ	DS92LV1212A ᴱ	10	LVCMOS	16	40	10:1
			—	SCAN921025H ᴱ	SCAN921226H ᴱ	10	LVCMOS	20	80	10:1
			—	SCAN928028 ᴱ	SCAN926260 ᴱ	nx10	LVCMOS	25/16	66	10:1
			—	DS92LV16 ᴱ	DS92LV16	16	LVCMOS	25	80	16:1
			—	DS92LV18 ᴱ	DS92LV18	18	LVCMOS	15	66	18:1

ᴱ Evaluation board

LVDS and CML Repeaters, Equalizers
Signal Conditioning — Extend Your Reach

National offers an array of signal conditioning solutions, covering data rates from DC to 10 Gbps and topologies ranging from point-to-point to 32 multidrop loads.

LVDS is the most widespread high-speed signaling technology and generally requires the least amount of power while supporting data rates from DC to 3.125 Gbps.

CML supports data rates as high as 10 Gbps while generally maintaining the lowest jitter.

Signal conditioning using equalization and pre-emphasis (for CML, de-emphasis) enables both technologies to significantly extend cable and backplane reach by compensating for media loss.

B-LVDS and M-LVDS are lower-speed technologies that use controlled edge rates to improve signal integrity when driving multiple loads in multidrop or multipoint configurations.

National's Signal Conditioners
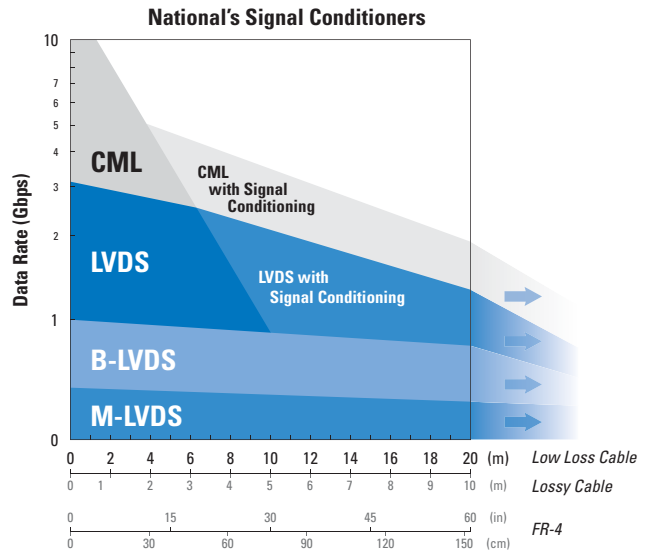
DS50PCI401 – PCIe Standards-Approved Gen-1 and Gen-2 Quad Transceiver

Features

- PCI-SIG approved for PCIe Gen-1 and Gen-2 applications
- Signal conditioning on receive (26 dB equalization) and transmit (12 dB de-emphasis)
- Auto rate detect and adjustment of signal-conditioning
- Gen-1 (2.5 Gbps)
- Gen-2 (5 Gbps)

- IDLE and receiver detect, beacon signal pass through
- Low power–100 mW/Channel, per-channel power-down option
- 0.10 UI residual DJ at 5 Gbps over 42" FR-4
- 10 x 5.5 mm flow-through LLP-54

Applications
Extends the reach of high-speed PCIe signals across lossy backplane and cable ICs in communications systems.

Server Backplane Running PCI Express
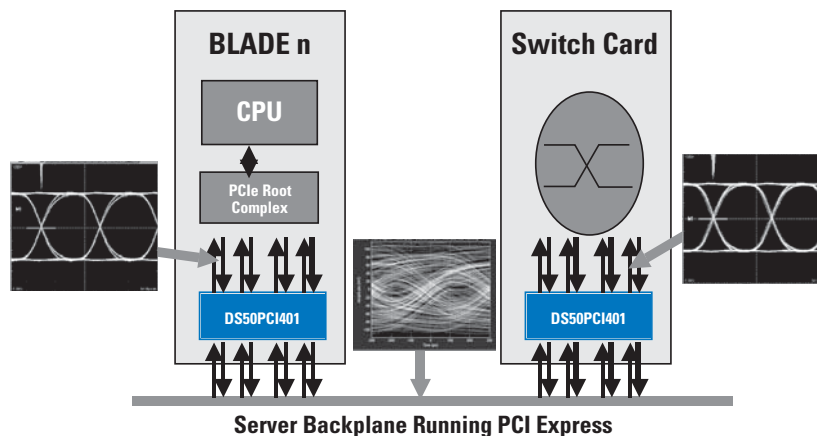
Signal Conditioners
PCIe, SAS, SATA, CPRI, Infiniband

DS64BR401 – Quad Bi-Directional Transceiver with Equalization and De-Emphasis

Features

- 6.4 Gbps quad lane (8 channels) signal conditioning repeater
- Signal conditioning on receive (33 dB equalization) and transmit (-12 dB de-emphasis)
- Automatic SAS/SATA OOB management
- Low power – 95 mW/Channel, per-channel power-down option
- 0.25 UI residual DJ at 6.4 Gbps over 40" FR-4
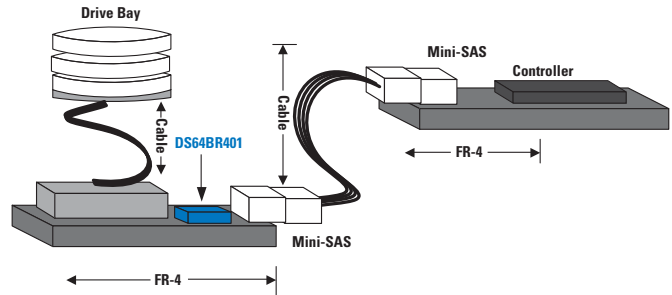
Applications

Ideal for use in SAS, SATA, RXAUI, Infiband, CPRI, and other high speed interconnects.

Protocol Aware Signal Conditioners								
Product ID	**Channels**	**Protocol**	**Max Speed/ Ch (Gbps)**	**Input SigCon (Max dB)**	**Output SigCon (Max dB)**	**Power/ Ch (mW)**	**Packaging**	**Control Interface**
DS50PCI401 ᴱ ⚡	8	PCIe	5.0	26	-12	95	LLP-54	Pin or SMBus
DS50EV401 ᴱ	8	PCIe	8.0	20	—	223	LLP-48	Pin
DS64BR401 ᴱ ⚡	8	SAS/SATA	6.4	33	-12	95	LLP-54	Pin or SMBus

Protocol Agnostic Signal Conditioners								
Product ID	**Channels**	**I/O Compatibility**	**Max Speed/ Ch (Gbps)**	**Input SigCon (Max dB)**	**Output SigCon (Max dB)**	**Power (mW)**	**Packaging**	**Configuration**
DS80EP100 ᴱ ⚡	1	LVDS/LVPECL/CML	12.5	7.0	—	0	LLP-6	Fixed
DS64EV400 ᴱ ⚡	4	LVDS/LVPECL/CML	10	24	—	90	LLP-48	Pin or SMBus
DS50EV401 ᴱ	8	LVDS/LVPECL/CML	8.0	20	—	223	LLP-48	Pin
DS38EP100 ᴱ ⚡	1	LVDS/LVPECL/CML	5.0	7.0	—	0	LLP-6	Fixed
DS42BR400 ᴱ ⚡	8	CML	4.2	5.0	-9.0	163	LLP-60	Fixed EQ, Pin DE
DS32EV400 ᴱ ⚡	4	LVDS/LVPECL/CML	3.2	4.0	—	90	LLP-48	Pin or SMBus
DS25BR440	4	LVDS/LVPECL/CML	3.125	5.0	+6.0	134	LLP-40	Pin
DS25BR400 ᴱ ⚡	8	CML	2.5	5.0	-9.0	163	LLP-60	Fixed EQ, Pin DE
DS25BR100 ᴱ ⚡	1	LVDS/LVPECL/CML	3.125	8.0	+6.0	115	LLP-8	Pin
DS15EA101 ᴱ	1	0.8V Diff. IN	1.5	35	—	210	LLP-16	Adaptive
DS15BA101 ᴱ	1	LVDS/LVPECL/CML	1.5	—	—	150	LLP-8	Fixed

Protocol Agnostic Buffers, Stub-hiders								
Product ID	**Channels**	**I/O Compatibility**	**Max Speed/ Ch (Gbps)**	**Input SigCon**	**Output SigCon**	**Power (mw)**	**Packaging**	**Configuration**
DS90LV004	4	LVDS/LVPECL/CML	1.5	—	6.0	96	TQFP-48	Pin PE
SCAN90004 ᴱ	4	LVDS/LVPECL/CML	1.5	—	6.0	96	TQFP-48	Pin PE
DS90LV001 ᴱ	1	LVDS/LVPECL/CML	0.8	—	—	155	LLP-8/SOIC-8 Narrow	None
DS90LV804	4	LVDS/LVPECL/CML	0.8	—	—	96	LLP-32	None
DS92001	1	LVDS/LVPECL/CML	0.4	—	—	165	LLP-8/SOIC-8 Narrow	None

⚡ PowerWise® product   ᴱ Evaluation board

DS25CP104A – PowerWise® LVDS 4 x 4 Crosspoint Switch
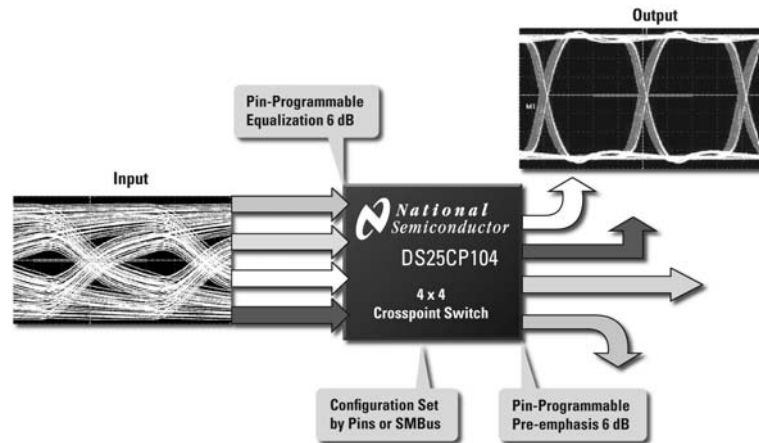
Features

- 3.125 Gbps maximum data rate
- 6 dB equalization, 6 dB pre-emphasis compensates for lossy cables, backplanes
- Crosspoint configurable using external pins or SMBus
- Maximum total jitter 35 ps

- 518 mW typ power consumption
- Additional configurations available
  - DS25CP102 : 3.125 Gbps 2 x 2
  - DS10CP154A : 1.5 Gbps 2 x 2

Applications
Multiplex between high-speed signals to implement high availability, redundant channels in communications systems.

DS42MB200 – Dual-Channel, 4.25 Gbps Redundancy Switch

Features

- 2:1 multiplexer and 1:2 fan-out
- 1 to 4.25 Gbps fully differential data paths
- Fixed input equalization
- Programmable output pre-emphasis
- Independent switch and line side pre-emphasis controls
- Programmable switch-side loopback mode
- On-chip terminations
- For AC-coupled CML interfaces

Applications
Ideal for use in high-speed, backplane applications requiring redundancy and signal conditioning.
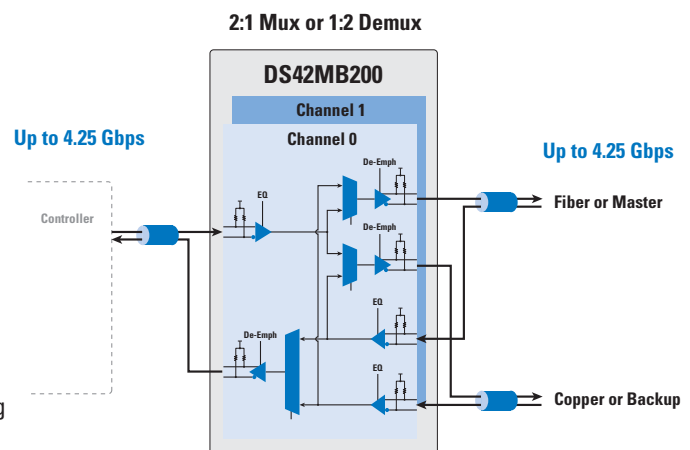
LVDS and CML Crosspoints, Mux-Buffers, Fan-Outs

Crosspoint Switch								
Product ID	Switch Size	Control Interface	Max Speed/Ch (Gbps)	Input SigCon (Max dB)	Output SigCon (Max dB)	Power (mW)	Packaging	Comments
DS25CP104A [E] ⚡	4 x 4	Pin or SMBus	3.125	EQ	Pre-E	518	LLP-40	—
DS25CP102 [E] ⚡	2 x 2	Pin selectable	3.125	EQ	Pre-E	254	LLP-16	Available in AEC-Q
DS25CP152 ⚡	2 x 2	Pin selectable	3.125	—	—	211	LLP-16	Available in AEC-Q
DS10CP154A [E] ⚡	4 x 4	Pin or SMBus	1.5	—	—	380	LLP-40	—
DS10CP152 [E]	2 x 2	Pin selectable	1.5	—	—	191	SOIC-16 Narrrow	Available in AEC-Q
SCAN90CP02 [E]	2 x 2	Pin selectable	1.5	—	Pre-E	140	LLP-28, LQFP-32	JTAG
DS90CP22 [E]	2 x 2	Pin selectable	0.8	—	—	330	TSSOP-16, SOIC-16 Narrow	—

Mux-Buffer (2:1 Redundancy Switch)								
Product ID	Mux Ratio	Ports	Max Speed/Ch (Gbps)	Input SigCon (Max dB)	Output SigCon (Max dB)	Power (mW)	Packaging	Comments
DS42MB200	2:1 & 1:2	2	4.25	EQ	Pre-E	1000	LLP-48	Loopback
DS42MB100	2:1 & 1:2	1	4.25	EQ	Pre-E	450	LLP-36	Loopback
DS25MB200	2:1 & 1:2	2	2.5	EQ	Pre-E	1000	LLP-48	Loopback
DS25MB100 [E]	2:1 & 1:2	1	2.5	EQ	Pre-E	450	LLP-36	Loopback
DS15MB200	2:1 & 1:2	2	1.5	—	Pre-E	743	LLP-48	15 kV ESD
SCAN15MB200 [E]	2:1 & 1:2	2	1.5	—	Pre-E	743	LLP-48	15 kV ESD, JTAG

Fan-Outs (1:n Repeater)								
Product ID	Mux Ratio	Input Channel	Max Speed/Ch (Gbps)	Input SigCon (Max dB)	Output SigCon (Max dB)	Power (mW)	Packaging	Comments
DS25BR204 [E]	1 to 4	2	3.125	EQ	Pre-E	495	LLP-40	LVDS/LVPECL/ CML to LVDS
DS10BR254	1 to 4	2	1.5	EQ	—	373	LLP-40	LVDS/LVPECL/ CML to LVDS
DS90LV110AT	1 to 10	1	0.4	—	—	413	TSSOP-28	LVDS/LVPECL/ CML to LVDS
DS91M124 [E]	1 to 4	1	0.25	—	—	215	SOIC-16	LVCMOS to M-LVDS
DS91M125 [E]	1 to 4	1	0.25	—	—	221	SOIC-16	LVDS to M-LVDS
DS92CK16	1 to 6	1	0.25	—	—	66	TSSOP-24	Clock distribution

⚡ PowerWise® product   [E] Evaluation board

LVDS, M-LVDS, B-LVDS Drivers, Receivers, Transceivers
Extend Your Reach, Translate Your Signals

LVDS is the most common differential signaling interface. The low power consumption, minimal EMI, and excellent noise immunity are features that have made LVDS the interface of choice for many applications. In addition, the LVDS wide-input common mode makes LVDS devices easy to interoperate with other differential signaling technologies.

Two versions of LVDS have been optimized for multipoint—Bus LVDS (B-LVDS) and Multipoint LVDS (M-LVDS). B-LVDS shares many of the characteristics of LVDS but has much higher current drive (10 mA typ) and controlled (slower) edge rates. B-LVDS is designed specifically for driving multiple loads and in a well-designed backplane can support up to 32 loads. M-LVDS includes all of the desirable attributes for multidrop including increased drive, slow controlled edges, tighter input thresholds, and a wider common mode. M-LVDS is capable of driving 32 loads at speeds up to 250 Mbps.

National LVDS/M-LVDS/B-LVDS devices can be used for data and clock distribution.

DS91C176 and DS91D176 – Single Channel M-LVDS Transceivers

Features

- Meets TIA/EIA-899 M-LVDS standard
- Capable of driving 32 M-LVDS loads
- Controlled 1.8 ns (typ) edge rates tolerant to stubs
- Wide - 1.4V to 3.8V input common mode for increased noise immunity
- DS91D176 has type-2 receiver input
- DS91C176 has type-2 100 mV offset fail-safe support
- Up to 200 Mbps operation
- Industrial temperature range
- Single 3.3V supply
- Pin-for-pin compatible replacement for TI SN65MLVDS200, 201, 204, 206

Applications
Ideal for use in server backplane implementations.

DS91C176 Typical Performance
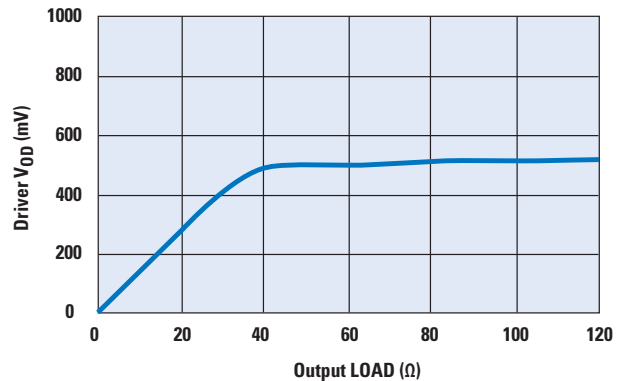
DS91D176 Driving 50 MHz Clock on ATCA backplane – 13 Loads – 1/2-inch Stubs – Rx slot 7, Tx slot 14

LVDS, M-LVDS, B-LVDS

LVDS Drivers, Receivers, Transceivers

Product ID	Function	Ports	Max Speed/ Ch (Gbps)	IN Signal	OUT Signal	Power (mW)	Packaging	Comments
DS90LV017A	Line driver	1	600	LVTTL	LVDS	17	SOIC-8	>8 kV ESD
DS90LV027A	Line driver	2	600	LVTTL	LVDS	27	SOIC-8	Available in AEC-Q
DS90LT012A	Receiver	1	400	LVDS	LVTTL	18	SOT23-5	Available in AEC-Q
DS90LV011A	Line driver	1	400	LVTTL	LVDS	17	SOT23-5	Available in AEC-Q
DS90LV018A	Receiver	1	400	LVDS	LVTTL	18	SOIC-8	>7 kV ESD
DS90LV028A	Receiver	2	400	LVDS	LVTTL	18	SOIC-8/LLP-8	Available in AEC-Q
DS90LV047A	Line driver	4	400	LVTTL	LVDS	14	SOIC-16	Ganged enable
DS90LV048A	Receiver	4	400	LVDS	LVTTL	30	SOIC-16/TSSOP-16	Ganged enable
DS90LV049	Driver+receiver	2+2	400	LVTTL/LVDS	LVTTL/LVDS	70	TSSOP-16	Dual pair, available in AEC-Q
DS90C031B	Line driver	4	155	TTL	LVDS	20	SOIC-16/TSSOP-16	Robust inputs
DS90C032B	Receiver	4	155	LVDS	TTL	18	SOIC-16	Power off high Z, failsafe
DS36C200	Transceiver	2	100	TTL/LVDS	TTL/LVDS	55	SOIC-14	IEEE 1394 compatible
DS90LV019	Driver/receiver pair	1+1	100	TTL/LVTTL/LVDS	TTL/LVTTL/LVDS	45	SOIC-14/TSSOP-14	3.3V or 5V operation

M-LVDS, B-LVDS Drivers, Receivers, Transceivers

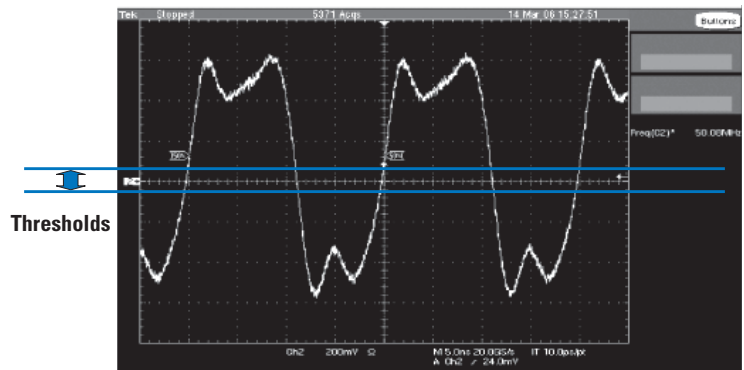| Product ID	Function	Ports	Max Speed/ Ch (Gbps)	IN Signal	OUT Signal	Power (mW)	Packaging	Comments
DS91M040 [E]	M-LVDS transceiver	4	250	LVTTL/M-LVDS	LVTTL/M-LVDS	221	LLP-32	Failsafe, '176 pinout
DS91M047 [E]	M-LVDS line driver	4	250	LVCMOS	M-LVDS	215	SOIC-16	Failsafe, '180 pinout
DS91M124 [E]	M-LVDS repeater	1:4	250	LVCMOS	MLVDS	215	SOIC-16	
DS91M125 [E]	M-LVDS repeater	1:4	250	LVDS	M-LVDS	221	SOIC-16	
DS91C176 [E]	M-LVDS transceiver	1	200	LVTTL/M-LVDS	LVTTL/M-LVDS	66	SOIC-8	Failsafe
DS91C180	M-LVDS driver/receiver pair	1+1	200	LVTTL/M-LVDS	LVTTL/M-LVDS	56	SOIC-14	8 kV ESD
DS91D176	M-LVDS transceiver	1	200	LVTTL/M-LVDS	LVTTL/M-LVDS	66	SOIC-8	
DS91D180	M-LVDS driver/receiver pair	1+1	200	LVTTL/M-LVDS	LVTTL/M-LVDS	66	SOIC-14	8 kV ESD
DS92LV040A	B-LVDS transceiver	4	155	LVTTL/LVDS	LVTTL/LVDS	231	LLP-44	
DS92LV010A	B-LVDS transceiver	1	100	LVTTL/LVDS	LVTTL/LVDS	53	SOIC-8	
DS92LV090A	B-LVDS transceiver	9	100	LVTTL/LVDS	LVTTL/LVDS	429	LQFP-64	Low skew
SCAN92LV090	B-LVDS transceiver	9	100	LVTTL/LVDS	LVTTL/LVDS	429	FBGA-64/ LQFP-64	Low skew

[E] Evaluation board

Ethentic...

Ethernet Backhaul and IEEE 1588 Solutions
High-Speed Ethernet Connectivity, Single Port Solutions

DP83640 – Precision PHYTER® – IEEE 1588 Precision Time Protocol Transceiver

- Enable IEEE 1588 with any MAC based microcontroller, FPGA or ASIC
- Node synchronization accuracy to <10 nS
- Replace E1/T1 lines and expensive GPS clocks
- Synchronized clock output
- Synchronous Ethernet support
- IEEE 802.3 compliant
- Industry's lowest deterministic latency
- Cable health diagnostic support
- 100 BASE-FX Fiber Interface
- Reference clock output to MAC

See Power-over-Ethernet (PoE) solutions on page 41.

Applications
Ideal for use in Ethernet/IP implementations, telecommunications equipment, real-time networking, and backhaul solutions.

Wireless Basestation Timing Sync over Ethernet Backhaul
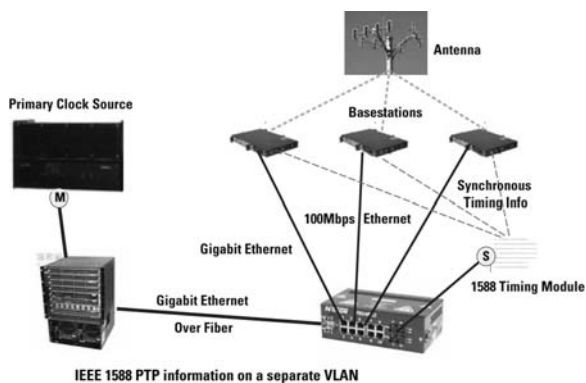
Product ID	DP83640	DP83848I/E	DP83848YB	DP83848M/T/H	DP83848J/K
IEEE 1588 v1 & v2 hardware support	•				
Fiber Support	•				
Temp Range (°C)	-40 to 85	-40 to 85	-40 to 125	0 to 70 -40 to 85 -40 to 125	0 to 70 -40 to 85
Interface	MII/RMII	MII/RMII/SNI	MII/RMII/SNI	MII/RMII	MII/RMII
Power	280 mW	265 mW	265 mW	265 mW	265 mW
UNH Interoperability Testing	•	•	•	•	•
Auto-MDIX	•	•	•	•	•
Deterministic Delay	•	•	•	•	•
Low Latency	•	•	•	•	•
LEDs	3	3	3	1	2
Interrupt Pin	•	•	•		
Cable Health Diagnostics	•				
System Diagnostics	•	•	•	•	•
IEEE 1149.1 (JTAG)	•	•	•		
Software Utility Support	•	•	•	•	•
Error-Free Operation (m typ)	150	150	150	137	137
Supply Voltage (V)	3.3	3.3	3.3	3.3	3.3
Package	LQFP-48	LQFP-48	LQFP-48	LLP-40	LLP-40
ESD HBM/CDE (kV)	8.0 / 2.0	4.0 / 2.0	4.0 / 2.0	4.0 / 2.0	4.0 / 2.0

Ethernet Backhaul and IEEE 1588 Solutions
High-Speed Ethernet Connectivity, Dual Port Solutions
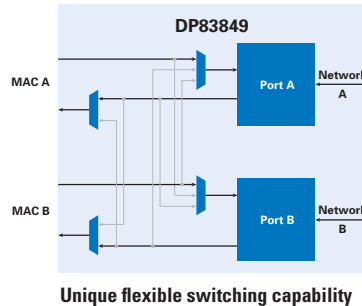
DP83849 – Dual PHYTER® 10/100 Ethernet PHY

Features

- Flexible port switching and chaining
  - MII port assignment
  - MDI chaining
- Industry's lowest deterministic latency
- Enhanced cable diagnostics
- IEEE 802.3 compliant
- Two fully independent 10/100 ports
  - Selectable 100Base-Tx/100Base-Fx
  - MII/RMII/SNI
- Controlled I/O during power up
- Built-in Self-Test (Packet BIST)

See Power-over-Ethernet (PoE) solutions on page 41.

Applications

Ideal for use in wireless remote basestations, industrial networking, and general embedded applications.

Unique flexible switching capability

Enhanced cable diagnostics

Product ID	DP83849C E	DP83849I E	DP83849ID E	DP83849IF E
Fiber Support			•	•
Flexible Port Switching		•		•
Temp Range (°C)	0 to 70	-40 to 85	-40 to 85	-40 to 85
Interface	MII/RMII	MII/RMII	MII/RMII	MII/RMII
Power	300 mW / Port	300 mW / Port	300 mW / Port	300 mW / Port
UNH Interoperability Testing	•	•	•	•
Auto-MDIX	•	•	•	•
Deterministic Delay	•	•	•	•
Low Latency	•	•	•	•
LEDs	3	3	3	3
Interrupt Pin	•	•	•	•
Cable Health Diagnostics	•	•	•	•
System Diagnostics	•	•	•	•
IEEE 1149.1 (JTAG)		•	•	•
Software Utility Support	•	•	•	•
Error-Free Operation (m typ)	137	137	137	137
Supply Voltage (V)	3.3	3.3	3.3	3.3
Package	TQFP-80	TQFP-80	TQFP-80	TQFP-80
ESD HBM/CDE (kV)	4.0 / 2.0	4.0 / 2.0	4.0 / 2.0	4.0 / 2.0

E Evaluation board

Other Useful DP83849 Configurations

Failover operation

Fiber-copper converter (MAC-less)

300m repeater-extender (MAC-less)
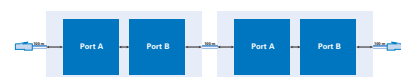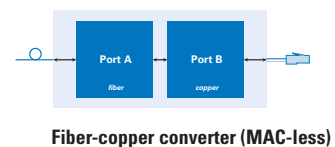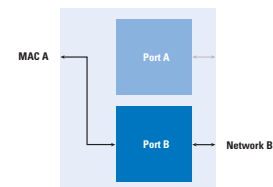
JTAG Solutions
More Than Board Test

Many modern communication systems incorporate IEEE 1149.1 JTAG test bus infrastructure for board debug, manufacturing test, remote test, and system diagnostics. National's SCANSTA family of solutions further extends the capabilities of a JTAG infrastructure. With the growing popularity of FPGAs, JTAG is now also used for programming and creating highly flexible and scalable communication systems. The use of National's JTAG devices in this additional application is detailed in two application notes. Visit **national.com/appnotes** to find both AN-1340 (Xilinx FPGAs) and AN-1327 (Altera FPGAs).

Quickly target and reprogram FPGAs and Flash and emulate and debug processor and DSP code

Monitor critical analog voltages

Baseband Card

Reconfigure FPGAs

Reconfigure FPGAs

Emulate and Debug Processor & DSP Code

JTAG0

JTAG1

JTAG(n)

Microcontroller or FPGA with JTAG

Data

Address

R/W

Program Flash Memory

SCANSTA111/112

JTAG Port

Address

R/W

Radio Card

Analog IC

Analog IC

Analog IC

Probe0

Probe1

Probe(n)

SCANSTA476

Mux

A to D Converter

JTAG Port

SCAN Registers

IEEE 1149.1 JTAG Bus

Backhaul or Control Card

JTAG Port

Dual Port Memory

Parallel Interface

Processor or Microcontroller

SCANSTA101
JTAG Master

Memory

Backhaul Link

Vectors

```
0 1 1 0 0 0 1 0 1 1 0 0 0 1
1 0 0 0 1 1 0 1 0 0 0 1 1 0
0 0 1 1 0 1 0 0 0 1 1 0 1 0
1 0 1 0 1 1 1 1 0 1 0 1 1 1
1 1 0 1 1 0 0 1 1 0 1 1 0 0
1 1 0 0 1 0 1 1 1 0 0 1 0 1
1 1 1 0 0 0 1 0 1 1 1 0 0 1
1 0 0 0 1 1 0 1 0 0 0 1 1 0
1 0 1 0 1 1 1 0 1 0 1 0 1 1
1 1 0 1 1 0 0 1 1 0 1 1 1 0
0 0 1 1 0 1 0 0 1 1 1 1 0 1
1 1 1 0 0 1 0 1 1 1 0 0 1 0
```

Test, Program, Emulate, Diagnose

Remotely manage, diagnose, and reconfigure systems

Visit **national.com/scan** for detailed information about implementing JTAG solutions.

national.com/comms

35

JTAG System Product Solutions

Remote Diagnostic and Reconfiguration Solutions

### SCANSTA476 – 8 Channel IEEE 1149.1 Analog Voltage Monitor

Features

- 8 selectable full-scale (0 to V_{DD}) analog input channels
- Typical 2 mV typ accuracy at max V_{DD}
- Single 2.7V to 5.5V supply operation
- Analog full-scale input range 0V to V_{DD}
- IEEE 1149.1 (JTAG) compliant interface
- Very low power operation
- Industrial -40°C to +85°C temperature range

Applications

Ideal for use in communications systems, including servers, telecom systems, and real-time signal monitoring.
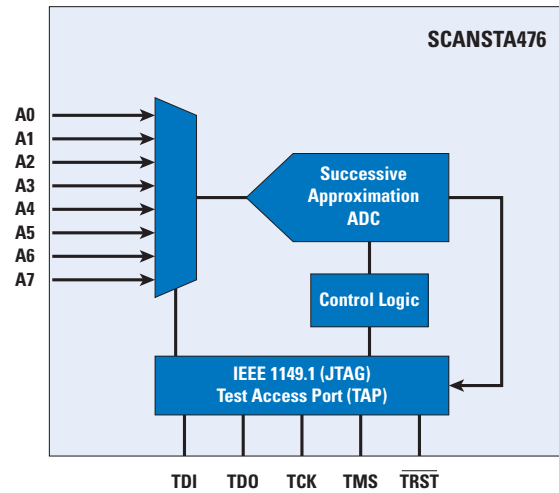
JTAG System Management Products

Product ID	Description	Supply Voltage (V)	Features	Packaging
SCANSTA111 [E]	3-port multidrop IEEE 1149.1 JTAG bus multiplexer	3.3	7 address inputs, 3 local scan ports, transparent mode	TSSOP-48, BGA-49
SCANSTA112 [E]	7-port multidrop IEEE 1149.1 JTAG bus multiplexer	3.3	8 address inputs, 7 local scan ports, transparent mode, stitcher mode	TQFP-100, BGA-100
SCANSTA101 [E]	IEEE 1149.1 JTAG system test master	3.3	Parallel 16-bit interface to IEEE 1149.1 master device	BGA-49
SCANSTA476 [E]	8-input IEEE 1149.1 JTAG analog voltage monitor	2.7 to 5.5	8 selectable analog 0-V_{DD} input channels, 2 mV typ accuracy	LLP-16

[E] Evaluation board

Power Solutions for Networking Infrastructure

Networking Infrastructure Power Solutions

Wired and wireless infrastructure equipment continue to demand higher power density, higher efficiency, and increased reliability. To address these demands, National's diverse portfolio of power management solutions optimize efficiency through the entire power chain—from the AC main power supply down to point-of-load. Each of National's power products are designed for best-in-class performance with advance process technology, chip-scale packaging, and proprietary circuitry. The full range of power management solutions enables reliable, high-performance, cost-effective system design.

Product	Features	Benefits
SIMPLE SWITCHER® Power Modules	Single DAP package with exposed leads	Easy prototyping and manufacturing
	Low EMI	Complies with EN55022 (CISPR22) Class B Radiated EMI standard
Adaptive Voltage Scaling	Optimizes supply voltages adaptively over process and temperature variations	Maximizes system level energy savings
POE Controllers	Integrated PD controller and PWM controller	Allows user to integrate power conversion, robustness, and handle fault situations more effectively
	V_{IN} range up to 100V	Eliminates additional bias regulation and protection circuitry
Hot Swap Controllers	Current and Power limiting, over-voltage and under voltage protection	Maximum system protection to improve system robustness
	Multiple voltage options	Complete system coverage
Isolated PWM Controllers	Integrated bias regulators and high voltage drivers	Enables higher power density and smaller module form factors
	Support for multiple switching topologies, including Active Clamp, 1/2-bridge, full-bridge, push, pull, and Cascade	Design flexibility to support designs from <100W to more than 500W
MOSFET Gate Drivers	High voltage, high current support	Higher power density
Non-Isolated Controllers and Regulators	Wide operating voltage range	Flexibility for use in multiple applications
	Integrated synchronous FETs	Smaller form factors, higher efficiency and reduced bill of materials
Low Dropout Regulators	Low noise	Perserve signal fidelity in analog signal path
	Low dropout	Higher efficiency

SIMPLE SWITCHER® Power Modules

SIMPLE SWITCHER® Power Modules

National's new SIMPLE SWITCHER power modules optimize system efficiency, increase power density, and deliver robust system performance in a compact solution designed for space-constrained conditions. They feature an innovative new package with best-in-class EMI and thermal performance. Each module series is pin-to-pin compatible for faster time to market.

These energy-efficient power modules, combined with easy-to-use online design tools, address the specific needs of wired data centers and wireless basestation applications.
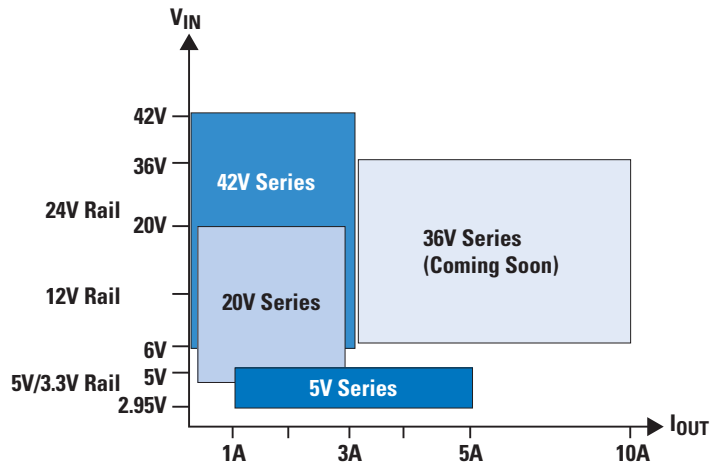

Highly Integrated Solution in Easy-to-Use Package

The new power modules integrate control circuitry, synchronous MOSFETs, a shielded inductor, and small passives in an easy-to-use package. This reduces development time by removing many design and layout challenges, such as choosing the right inductor, selecting the switching frequency, and optimizing the switch node for thermal and EMI performance.

Benefits of this innovative package include:

- Single DAP and standard IC leads in a convenient size and lead pitch
- Compatible with pick-and-place manufacturing used for TO-263
- Easy to hand solder for quick prototyping
- Fully RoHS compliant
- Pin-to-pin compatibility and identical footprint for different load currents within each module series

Similar to TO-263 package
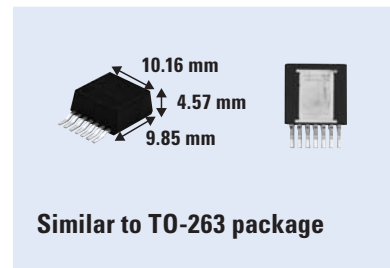
Low EMI

The modules are ideal for noise-sensitive applications and feature patent-pending packaging technology with a shielded inductor and internal capacitors optimized for excellent EMI performance. The power modules pass the EN55022 Class B radiated EMI standards.

For more information about the entire line of energy-efficient SIMPLE SWITCHER products, visit **national.com/switcher**.

SIMPLE SWITCHER® Power Modules

Best-in-Class Thermal Performance

The new SIMPLE SWITCHER power modules offer outstanding thermal performance with very low system heat generation. Each of the modules are versatile in a wide range of temperature environments—even successfully operating at very high ambient temperatures, which eliminates the need for airflow and external heat sinks and reduces design cost and complexity.

Features

- Supports common 3.3V, 5V, 12V, 24V, and 36V input rails
- Output voltage down to 0.8V
- Load currents from 1A to 5A
- Peak efficiency up to 96%
- ±2% maximum output tolerance over full line and load condition
- External soft-start
- Precision-enabled
- Pre-biased load capability
- Integrated protection features: current limit, OVP, UVLO, and thermal shutdown
- -40°C to 125°C operating junction temperature range
- Fully enabled for WEBENCH® Power Designer

Applications

Ideal for use in point-of-load conversion from the 3.3V and 5V input rail and telecommunications and broadband networking equipment.
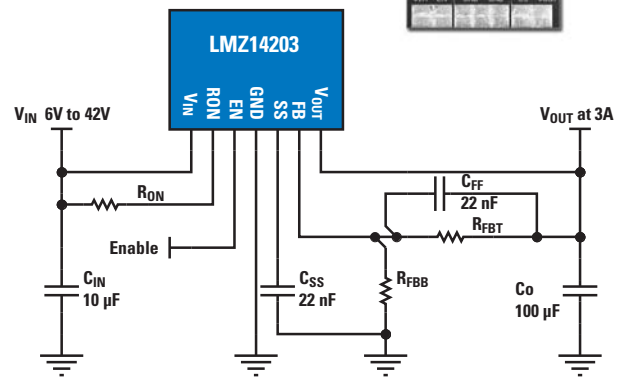
SIMPLE SWITCHER Power Modules

Series	Product ID	Output Current (A)	Input Min Voltage (V)	Input Max Voltage (V)	Output Min (V)	Output Max (V)	Freq (kHz)	Packaging
5V	LMZ10503 W	3	2.95	5.5	0.8	5	1000	TZA-7
	LMZ10504 E,W	4	2.95	5.5	0.8	5	1000	TZA-7
	LMZ10505 W	5	2.95	5.5	0.8	5	1000	TZA-7
20V	LMZ12001 W	1	4.5	20	0.8	6	1000 max	TZA-7
	LMZ12002 W	2	4.5	20	0.8	6	1000 max	TZA-7
	LMZ12003 E,W	3	4.5	20	0.8	6	1000 max	TZA-7
42V	LMZ14201 W	1	6	42	0.8	6	1000 max	TZA-7
	LMZ14202 W	2	6	42	0.8	6	1000 max	TZA-7
	LMZ14203 E,W	3	6	42	0.8	6	1000 max	TZA-7

PowerWise® product   E Evaluation board   W WEBENCH enabled

PowerWise® Adaptive Voltage Scaling (AVS)

PowerWise® AVS technology is a real-time, continuous, closed-loop power management technology. AVS technology enables optimum energy management delivery to processors, ASICs, and SoCs by optimizing supply voltages adaptively over process and temperature variations in order to maximize system-level energy savings.

## LM10500 – 5A Integrated AVS Energy Management Unit

- Closed-loop Adaptive Voltage Scaling (AVS)
- 40% typical power saving compared to fixed voltage scheme
- AVS V_{OUT} range: 0.6V to 1.0V or 0.72V to 1.2V
- V_{OUT} range (resistor feedback): 0.6V to 5V
- PWI 1.0/PWI 2.0 compatible
- 1% output voltage accuracy
- 300 kHz to 1.5 MHz switching frequency
- Frequency synchronization
- Cycle-by-cycle current limiting
- Internal soft-start to reduce in-rush current
- Power GOOD/PWROK

Applications
Ideal for use in server, network, and storage ASICS, as well as set top box processors.

AVS technology is suited to power-constrained applications such as portable devices, USB-powered peripherals, consumer electronics, and high-volume systems including data centers and cellular basestations. Anywhere an ASIC, processor, or SoC is used, designers can implement AVS.

For more information about high-current AVS Energy Management Units, visit **national.com/avs**.
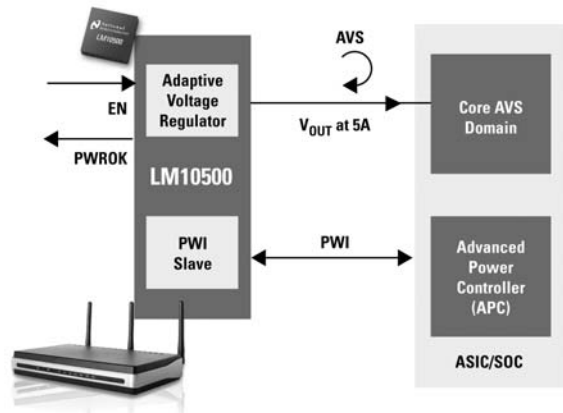
LM10500 Typical Power Savings with AVS
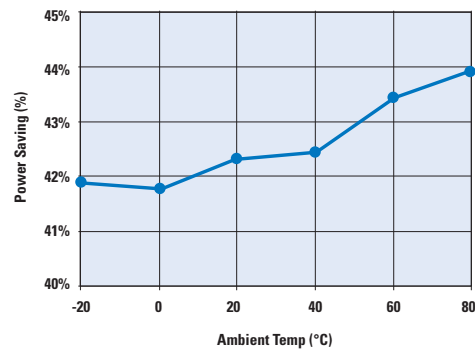
AVS Energy Management Unit

Product ID	Input Min Voltage (V)	Input Max Voltage (V)	Output Min Voltage (V)	Output Max Voltage (V)	Output Current (A)	Frequency Range (kHz)	Packaging
LM10500 E 🔁	3	18	0.6	5	5	300 kHz to 1.5 MHz	LLP-28

🔁 PowerWise® product   E Evaluation board

LM5073 – 100V Power-over-Ethernet PD Interface with Auxiliary Support

Features

- Fully compliant IEEE 802.3af PD interface
- Versatile auxiliary power options, including flexible interface to AC adaptor
  ◦ 13V minimum front auxiliary power range
 ◦ 9V minimum rear auxiliary power range
- Programmable DC current limit up to 800 mA
- Complimentary open drain outputs allow flexible DC-DC regulator selection

See Ethernet Backhaul and IEEE 1588 Solutions on pages 33 and 34.

Applications

Ideal for use in VoIP telephony, wireless access points, gate access control (card readers), Bluetooth access points, surveillance cameras, and building control.
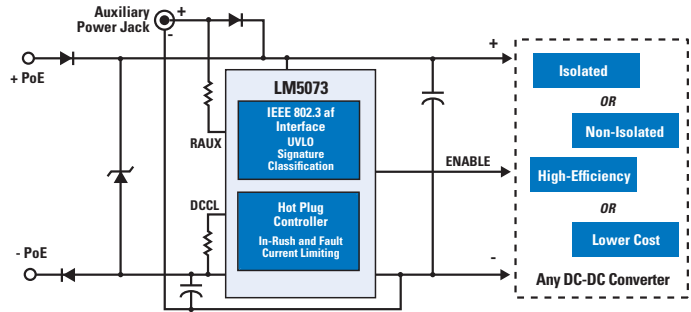
To Optimize for:	Pair LM5073 with:
High efficiency	LM5025/26/27 active clamp PWM controller
Low cost	LM5020 flyback controller
Non-Isolated and/or Ease of Design – Regulator with Integrated MOSFET	LM557x SIMPLE SWITCHER® regulator
Isolated	LM5015 2-switch forward flyback regulator

Power-over-Ethernet Powered Device Interface

Product ID	Input Max Voltage (V)	Input Min Voltage (V)	Hot Swap FET RDS(ON) Typ (Ω)	Integrated DC-DC Controller	Output Power (W)	Auxiliary Support	Reference Accuracy (+/-)	Current Draw with AUX Winding (typ)	Packaging
LM5070 E* ⚛	60	1.8	1	✔	13	48V Front only	2	0.7	LLP-16, TSSOP-16
LM5071 E ⚛	75	1.8	1	✔	13	48V Front only	2	0.7	TSSOP-16
LM5072 E* ⚛	100	9	0.7	✔	25	Fully configurable front/rear	2	0.7	eTSSOP-16
LM5073 E ⚛	100	9	0.7	—	25	Fully configurable front/rear	—	—	TSSOP-14

* Reference Design available   ⚛ PowerWise® product   E Evaluation board

Visit **national.com/refdesigns** to see the Reference Designs and other design tools available for Power-over-Ethernet solutions.

Hot Swap/In-Rush Current Controllers

LM(2)506x – Hot Swap/In-Rush Current Limit Controllers with Current and Power Limiting

Features

- Adjustable in-rush current limit and circuit breaker protect system from over-current/short-circuit events and module insertion/removal from live power sources
- Adjustable power limit sets maximum power dissipation in the external pass device
  - Ensures MOSFET stays in Safe Operating Area (SOA)
  - Reduces MOSFET size
- Adjustable features for design flexibility:
  - Input UVLO/OVLO and hysteresis
  - Multifunction timer to prevent nuisance trips
- Internal high-side charge pump and gate driver for external N-channel MOSFET
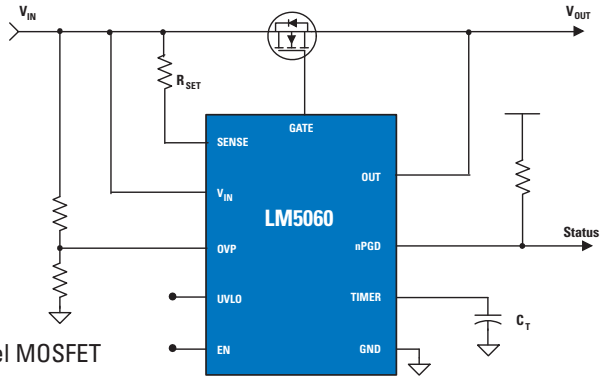

Applications
Ideal for use in server backplane and basestation power distribution systems.

Power Limiting Protects External Pass Device for Improved System Reliability

To ensure system reliability, any MOSFET must operate within its SOA in order to avoid FET failure. National's LM(2)506x hot swap controllers provide both current and power limiting to dynamically adjust the current limit at large V_{DS} and ensure the MOSFET stays in the SOA at all conditions—maximizing long-term system reliability and robustness.

Conventional Hot Swap: Current Limit Only
MOSFET Out of SOA at Large V_{DS}
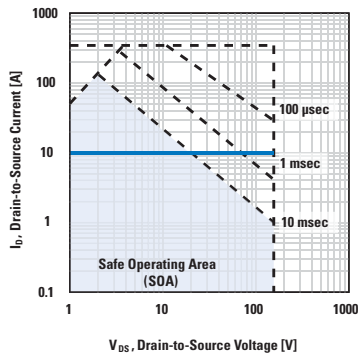
LM(2)506x: Current Limit *and* Power Limit
Optimal Circuit and MOSFET Protection for All V_{DS}
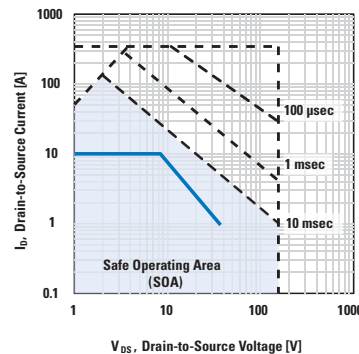
Hot Swap/In-Rush Current Controllers

Product ID	V_{IN} Range	Power Good	Adjustable UVLO	Adjustable OVLO	Active In-Rush Current Limiting	Active Current Limiting	Active Power Limiting	Fault Latch-Off / Auto Retry	Packaging
LM5067[E]	-9V to -80V	V_{DS}	✔	✔	✔	✔	✔	✔	MSOP-10, LLP-10
LM5069[E]	+9 to +100V	V_{DS}	✔	✔	✔	✔	✔	✔	MSOP-10
LM25061[E]	+2.9V to +16V	V_{OUT} (adj.)	✔	—	✔	✔	✔	✔	MSOP-10
LM25069[E]	+2.9V to +16V	V_{DS}	✔	✔	✔	✔	✔	✔	MSOP-10
LM5060[E]	+5.5V to +65V	V_{DS}	✔	✔	✔	✔	✔	Latch-Off	MSOP-10

[E] Evaluation board

High-Voltage Isolated PWM Controllers

National offers controllers for isolated solutions that maximize power density and efficiency for a range of merchant power module applications.

| Power Module Form Factor	Power Level	Ideal Topologies	National's Solutions
1/2 Brick	> 500W	Interleaved Forward or Cascade	LM5034, LM5041
1/4 Brick	300W – 400W	Cascade or Half-Bridge	LM5041, LM5035, LM5039
1/8 Brick	100W – 150W	Active Clamp Forward or Half-Bridge	LM5025, LM5026, LM5027, LM5035, LM5039
1/16 Brick	< 100W	Active Clamp Forward	LM5025, LM5026, LM5027

LM5035C – High-Voltage Isolated PWM Controller w/5V Gate Drive

Features
- 5V outputs on SR1, SR2 for use with digital isolators
- No Soft-Stop of PWM in UVLO mode
- Higher Current (40 mA) start-up regulator
- Programmable synchronous rectifier deadtimes
- High current 2A half-bridge gate drivers
- High Input Voltage 105V start-up regulator
- Voltage mode control with feed-forward
- Dual-mode over-current protection

Applications
Ideal for use in power module manufacturing and compatible with digital isolators.
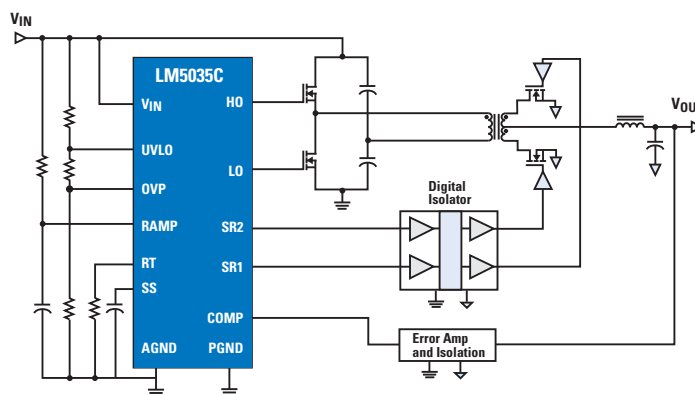
Isolated Controllers

Product ID	Topologies	Input Max Voltage (V)	Input Min Voltage (V)	Gate Drive Current (A)	Frequency Max (kHz)	PWM Mode*	Packaging	Other Features
LM25037 E	Push-pull, 1/2-bridge, full-bridge	75	5.5	1.2	2000	V/C	TSSOP-16	Alternating outputs
LM5021	AC/DC, Flyback, Forward	30	8	1	1000	C	MSOP-8, MDIP-8	Ultra low start-up current
LM5022 E	Flyback, Forward, Buck or Boost	65	6	1	2000	C	MSOP-10	Precision reference
LM5020 E	Flyback, Forward, Boost	100	13	1	1000	C	LLP-10, MSOP-10	Max duty cycle limiting
LM5030 E	Push-pull, 1/2-bridge, full-bridge	100	15	1.5	1000	C	TSSOP-20	Dual-mode current limit
LM5033 E	Push-pull, 1/2-bridge, full-bridge	100	15	1.5	1000	V	LLP-10, MSOP-10	Dual alternating drivers
LM5041/A/B E	Current/voltage-fed push-pull or bridge	100	15	1.5	1000	C	LLP-16, TSSOP-16	For cascaded topologies
LM5025/A/B/C E	Forward active clamp	105	13	3/1	1000	V	LLP-16, TSSOP-16	Programmable deadtime/overlap
LM5026 E	Forward active clamp	105	13	3/1	1000	C	LLP-16, TSSOP-16	Programmable deadtime/overlap
LM5032	Dual independent or interleaved	105	13	2.5	1000	C	TSSOP-16	Hiccup mode current limit
LM5034 E	Dual interleaved forward active clamp	105	13	2.5/1.5	1000	C	TSSOP-20	Reset transistor driver
LM5035/A/B/C E	1/2-bridge	105	13	2	1000	V/C	LLP-24, eTSSOP-20	Sync rectification for high efficiency
LM5037 E	Push-pull, 1/2-bridge, full-bridge	105	13	1.2	2000	V	TSSOP-16	Alternating outputs
LM5027 E	Forward active clamp	105	13	2/1/3	1000	V	eTSSOP-20	3A sync rectifier driver
LM5039 E	1/2-bridge	105	13	2	1000	V/C	LLP-24, eTSSOP-20	Average, Cycle-Cycle, and Hiccup mode current limit

* V = Voltage mode   C= Current mode   PowerWise product   E Evaluation board

MOSFET Drivers

LM510x – Family of High-Speed FET Drivers
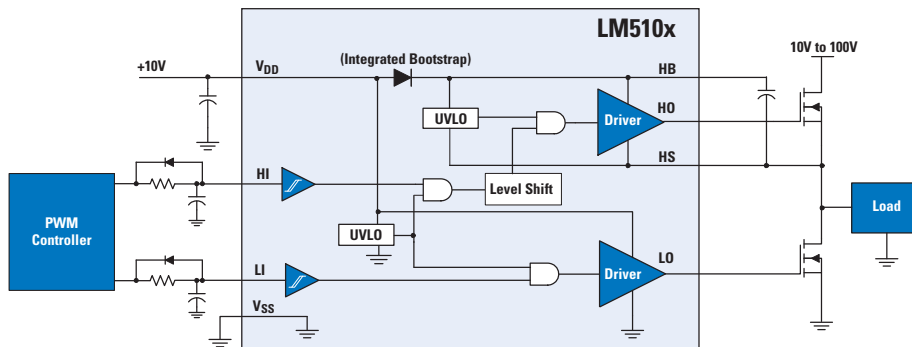
LM5100A and LM5101A are available in Power SOIC (PSOP) packages for maximum thermal performance.

MOSFET Drivers

Product ID	Topology	Input Max Voltage (V)	Supply Min (V)	Supply Max (V)	Peak Sink Current (A)	Peak Source Current (A)	Bottom Driver Prop Delay (nS)	Top Driver Prop Delay (nS)	Pulse Width Min	Input Control Type	Packaging
LM5100C	Synchronous buck, bridge	100	7.5	14	1	1	25	25	50	Dual, independent	SO-8
LM5101C	Synchronous buck, bridge	100	7.5	14	1	1	25	25	50	Dual, independent	LLP-10, SO-8
LM5109B	Buck, bridge	100	7.5	14	1	1	25	25	50	Dual, independent	LLP-8, SO-8
LM5107	Buck, bridge	100	7.5	14	1.4	1.3	25	25	50	Dual, independent	LLP-8, SO-8
LM5106	Synchronous buck, bridge	100	7.5	14	1.8	1.2	32	32	50	Single PWM	MSOP-10, LLP-10
LM5100B	Synchronous buck, bridge	100	7.5	14	2	2	25	25	50	Dual, independent	LLP-10, SO-8
LM5101B	Synchronous buck, bridge	100	7.5	14	2	2	25	25	50	Dual, independent	SO-8
LM5102	Synchronous buck, bridge	100	7.5	14	2	2	35	35	50	Dual, independent	MSOP-8
LM5104	Synchronous buck, bridge	100	7.5	14	2	2	35	35	50	Single PWM	LLP-10, SO-8
LM5105	Synchronous buck	100	7.5	14	2	2	35	35	50	Single PWM	LLP-10
LM5100A	Synchronous buck, bridge	100	7.5	14	3	3	25	25	50	Dual, independent	LLP-8, SO-8, PSOP-8
LM5101A	Synchronous buck, bridge	100	7.5	14	3	3	25	25	50	Dual, independent	LLP-10, SO-8EP, PSOP-8
LM5110	Forward, push-pull, etc	N/A	3.5	14	5	2	25	25	25	Dual, independent	LLP-10, SO-8EP
LM5111	Forward, push-pull, etc	N/A	3.5	14	5	3	25	25	25	Dual, independent	SO-8
LM5112	Forward, push-pull, etc	N/A	3.5	14	7	3	25	N/A	25	Dual, independent	LLP-6

Non-Isolated High-Voltage Buck Regulators

LM25011 – High Frequency, 2A Constant On-Time Switching Regulator

Features
- Wide V_{IN} range: 6V to 42V (44V Abs max)
- Adjustable current limit up to 2A
- Maximum switching frequency: 2 MHz
- Constant On-Time switching w/feed-forward
  - Ultra-fast transient response
  - Nearly constant switching frequency
  - No compensation needed
- Programmable soft-start
- Adjustable output down to 2.5V
- Power GOOD output
- Thermal shutdown
- Precision 2% feedback reference
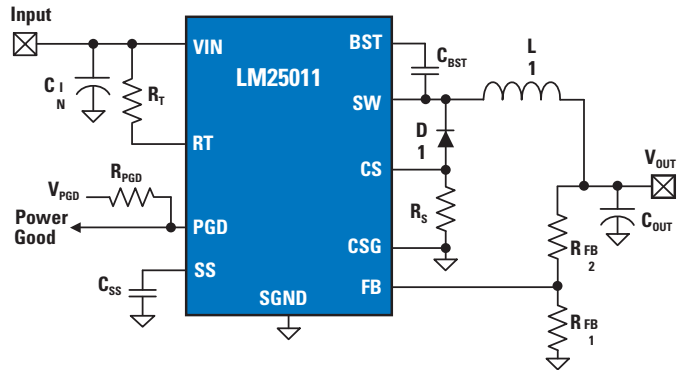
Applications
Suitable across a wide variety of point-of-load applications requiring low-cost, efficient implementations.

Non-Isolated High Voltage (>42V) Buck Regulators

Product ID	Output Current (A)	Input Min Voltage (V)	Input Max Voltage (V)	Output Min Voltage (V)	Output Max Voltage (V)	Frequency Range (kHz) & Sync Capability	Synchronous	PWM Mode	Packaging
LM5009/A [E,W]	0.15	9.5 / 6	95	2.5	85	50 to 600	—	Constant on-time	LLP-8, MSOP-8
LM5008/A [E,W]	0.35	9.5 / 6	95	2.5	75	50 to 600	—	Constant on-time	LLP-8, MSOP-8
LM22671/74 [E,W]	0.5	4.5	42	1.285	30	500 / Adj. to 1000	—	Voltage	PSOP-8
LM25007 [E,W]	0.5	9	42	2.5	37	50 to 800	—	Constant on-time	MSOP-8
LM25574 [E,W]	0.5	6	42	1.23	40	50 to 1000, Sync	—	Current	TSSOP-16
LM5007 [E,W]	0.5	9	75	2.5	73	50 to 800	—	Hysteretic	LLP-8, MSOP-8
LM5574 [E,W]	0.5	6	75	1.23	70	500, Sync	—	Current	TSSOP-16
LM3103 [E,W]	0.75	4.5	42	0.6	38	1000	✔	Constant on-time	eTSSOP-16
LM22672/75 [E,W]	1	4.5	42	1.285	30	500 / Adj. to 1000	—	Voltage	PSOP-8
LM5010/A [E,W]	1	8 / 6	75	2.5	70	50 to 1000	—	Hysteretic	LLP-10, eTSSOP-14
LM25575 [E,W]	1.5	6	42	1.23	40	50 to 1000, Sync	—	Current	eTSSOP-16
LM5575 [E,W]	1.5	6	75	1.23	70	500, Sync	—	Current	eTSSOP-16
LM22680 [E,W]	2	4.5	42	1.285	30	500	—	Voltage	PSOP-8
LM25011 [E]	2	6	42	2.51	40	Adj to 2000	—	Constant on-time	eMSOP-10
LM25005 [E,W]	2.5	7	42	1.23	40	500, Sync	—	Current mode	TSSOP-20
LM3102 [E,W]	2.5	4.5	42	0.8	38	1000	✔	Constant on-time	eTSSOP-20
LM5005 [E,W]	2.5	7	75	1.23	70	500, Sync	—	Current mode	TSSOP-20
LM22670/73/76 [E,W]	3	4.5	42	1.285	30	200 to 1000	—	Voltage	TO-263 THIN, PSOP-8
LM25576 [E,W]	3	6	42	1.23	40	50 to 1000, Sync	—	Current	eTSSOP-20
LM5576 [E,W]	3	6	75	1.23	70	500, Sync	—	Current	eTSSOP-20
LM22677/78/79 [E,W]	5	4.5	42	1.285	30	500 to 1000 adj	—	Voltage	TO-263 THIN

PowerWise product   [E] Evaluation board   [W] WEBENCH enabled

Non-Isolated High-Voltage Buck Controllers

## LM315x SIMPLE SWITCHER® Controllers

Designed to support higher current applications, the LM315x SIMPLE SWITCHER controllers are National's newest addition to its popular brand of switching solutions.

Features

- Input voltage ranging from 6V to 42V
- Output current up to 12A
- Constant On-Time control eliminates the need for complex compensation circuitry
- Patent-pending Emulated Ripple Mode allows for the use of low ESR output capacitors for reduced solution size and reduced output voltage ripple
- Synchronous architecture for added efficiency

Applications

Ideal for use in servers and networking infrastructure, wired and wireless basestations, and routers.
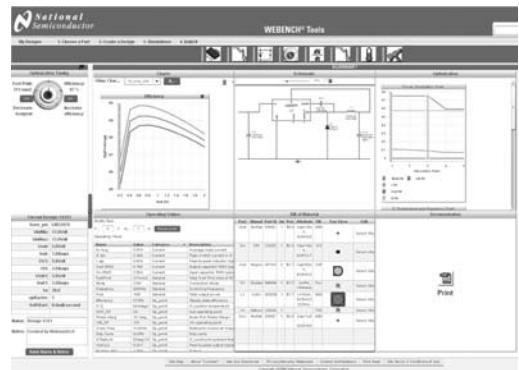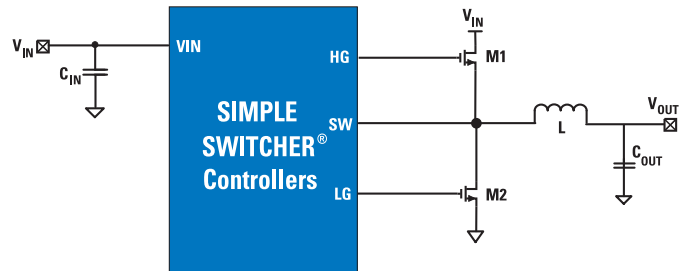
Features robust design tools, including the enhanced WEBENCH® Power Designer online tool, external component selection, new WEBENCH MOSFET selection tool, electrical and thermal simulation, and board evaluation.

Non-Isolated High Voltage (>42V) Buck Controllers

Product ID	Input Min Voltage (V)	Input Max Voltage (V)	# of Outputs	Output Min Voltage (V)	Output Max Voltage (V)	Frequency Range (kHz) & Sync Capability	Synch- ronous	PWM Mode	Packaging
LM5116 E	6	100	1	1.215	80	50 to 1000, Sync	✔	Emulated Peak Current Mode (ECM)	eTSSOP-20
LM5085 E	4.5	75	1	1.25	75	50 to 1000	—	Constant on-time	LLP-8, MSOP-8, eMSOP-8
LM5088 E,W	4.5	75	1	1.2	70	50 to 1000, Sync	—	Constant on-time	eTSSOP-16
LM5118 E,W	3	75	1	1.23	70	50 to 500, Sync	—	Emulated Peak Current Mode (ECM)	eTSSOP-20
LM5115/A E	4.5	75	1 or 2	0.75	13.5	50 to 1000, Sync	✔	Voltage/Current-injection Valley Current Mode	TSSOP-16
LM25085/A E	4.5	42	1	1.25 / 0.9	42	50 to 1000	—	Constant on-time	LLP-8, MSOP-8, eMSOP-8
LM25088 E,W	4.5	42	1	1.2	40	50 to 1000, Sync	—	Constant on-time	eTSSOP-16
LM25115/A	4.5	42	1 or 2	0.75	13.5	100 to 1000, Sync	✔	SSPR, Voltage/ Current-injection	TSSOP-16
LM25116 E	6	42	1	1.215	36	50 to 1000, Sync	✔	Emulated Peak Current Mode (ECM)	eTSSOP-20
LM3150 E,W	6	42	1	0.6	40	1000	✔	Constant on-time	TSSOP-14
LM3151/52/53 E,W	6	42	1	3.23	3.37	250, 500, 750	✔	Constant on-time	TSSOP-14

⚡ PowerWise product   E Evaluation board   W WEBENCH enabled

LM21305 – 5A, Adjustable-Frequency Synchronous Buck Regulator

Features

- Single-rail input voltage from 3V to 18V
- 0.6V to 5V VOUT range
- 1% typical output voltage accuracy
- High-efficiency switcher core
- 300 kHz to 1.5 MHz switching frequency range
- Resistor-programmable switching frequency
- Precision enable and internal soft-start

Applications

Ideal for use in point-of-load regulation from 3.3V, 5V, and 12V rails and broadband and networking solutions.
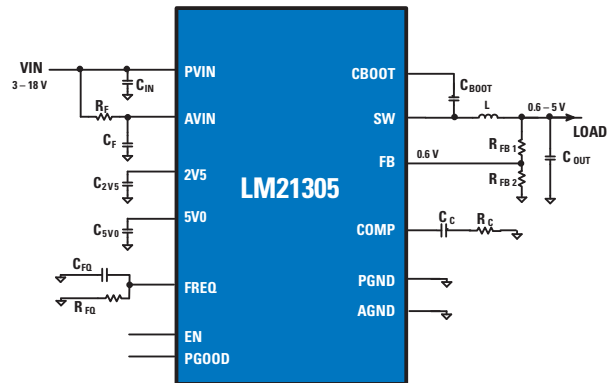
Non-Isolated PoL (<42V) Buck Regulators – Synchronous

Product ID		Output Current (A)	Input Min Voltage (V)	Input Max Voltage (V)	Output Min Voltage (V)	Output Max Voltage (V)	Frequency Range (kHz) & Sync Capability	PWM Mode	Packaging
LM3670 E,W		0.35	2.5	5.5	0.7	3.3	1000, Fixed	Voltage with input feed-forward	SOT23-5
LM3673/79 E,W		0.35	2.7	5.5	1.1	3.3	2000, Fixed	Voltage with input feed-forward	micro SMD-5
LM3671/74 E,W		0.6	2.7	5.5	1.1	3.3	2000, Fixed	Voltage with input feed-forward	SOT23-5, LLP-6
LM3676/77 E		0.6	2.9	5.5	1.1	3.3	2000, Fixed	Voltage with input feed-foward	LLP-8 , micro SMD-5
LM3691 E		1	2.3	5.5	0.75	1.8	4000, Fixed	Auto	micro SMD-6
LM3678 E		1.5	2.5	5.5	0.8	1.2	3300, Fixed	Auto	LLP-10
LM3100 E,W		1.5	4.5	36	0.8	32	Adj. to 1000	Constant on-time	eTSSOP-20
LM2852 E,W		2	2.85	5.5	0.8	3.3	500, 1500, Fixed	Voltage	TSSOP-14
LM20242 E,W		2	4.5	36	0.8	32	Adj. to 1000	Current	eTSSOP-16
LM20123 E,W		3	2.95	5.5	0.8	5	1500, Fixed	Current	eTSSOP-16
LM20133 E,W		3	2.95	5.5	0.8	5	460 to 1500, Sync	Current	eTSSOP-16
LM20143 E,W		3	2.95	5.5	0.8	5	500 to 1500	Current	eTSSOP-16
LM2853 E,W		3	3	5.5	0.8	3.3	550, Fixed	Voltage	TSSOP-14
LM20343 E,W		3	4.5	36	0.8	32	250 to 1000	Current	eTSSOP-16
LM20333 E,W		3	4.5	36	0.8	32	200 to 1500, Sync	Current	eTSSOP-16
LM20323 E,W		3	4.5	36	0.8	32	500, Fixed	Current	eTSSOP-20
LM20124 E,W		4	2.95	5.5	0.8	5	1000, Fixed	Current	eTSSOP-16
LM20134 E,W		4	2.95	5.5	0.8	5	460 to 1500, Sync	Current	eTSSOP-16
LM20144 E,W		4	2.95	5.5	0.8	5	Adj. to 1000	Current	eTSSOP-16
LM20154 E,W		4	2.95	5.5	0.8	5	1000, Fixed	Current	eTSSOP-16
LM2854 E,W		4	2.95	5.5	0.8	5	500, 1000, Fixed	Voltage	TSSOP-14
LM20125 E,W		5	2.95	5.5	0.8	5	500, Fixed	Current	eTSSOP-16
LM20145 E,W		5	2.95	5.5	0.8	5	250 to 750	Current	eTSSOP-16
LM20136 E,W		6	2.95	5.5	0.8	5	460 to 750, Sync	Current	eTSSOP-16
LM20146 E,W		6	2.95	5.5	0.8	5	250 to 750	Current	eTSSOP-16
NEW! LM21305 E		5	3.0	18	0.6	5	300 to 1500, Sync	Current	LLP-28

 PowerWise product   E Evaluation board   W WEBENCH enabled

# Non-Isolated Non-Synchronous Buck Regulators
Point of Load (POL)

LM27341/42 – 1.5A/2A, 2 MHz Wide Input Range Buck Regulator

Features
- Wide input voltage range 3V to 20 V
- Wide output voltage range 1V to 18 V
- LM27341 delivers 1.5A maximum output current
- LM27342 delivers 2A maximum output current
- High switching frequency 2 MHz
- Frequency synchronization 1.00 MHz < fSW < 2.35 MHz
- 70 nA shutdown current
- 1% reference accuracy

Applications
Ideal for use in radio power supplies, set top boxes, and DSL modems.
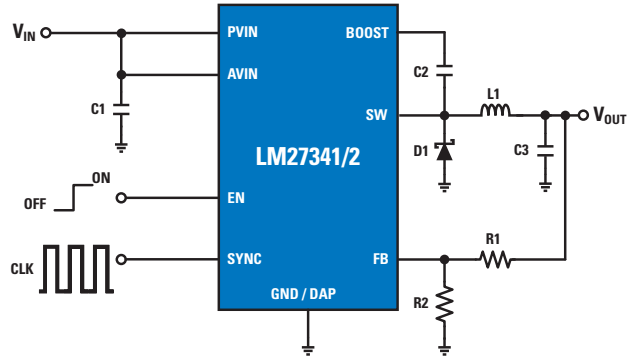
Non-Synchronous Step-Down (Buck) Switching Regulators

Product ID	Output Current (A)	Input Min Voltage (V)	Input Max Voltage (V)	Output Min Voltage (V)	Output Max Voltage (V)	Frequency Range (kHz) & Sync Capability	PWM Mode	Packaging
LM2694 [E]	0.6	8	30	2.5	24	50 to 1000	Hysteretic	LLP-10, TSSOP-14
LM34919 [E] 🦢	0.6	8	40	2.5	30	2000 (max)	Constant on-time	micro SMD-10
LM2736 [E,W]	0.75	3	18	1.25	16	550, 1600	Current	SOT23-6
LM2830 [W]	1	3	5.5	0.6	4.5	1600, 3000	Current	SOT23-5
LM2734/Z [E,W]	1	3	20	0.8	18	550, 1600 / 3,000	Current	SOT23-6
LM34930 [E] 🦢	1	8	33	2.5	30	2000 (max)	Constant on-time	micro SMD-12
LM34910 [E,W]	1.2	8	36	2.5	30	1000 (max)	Constant on-time	LLP-10
LM2695 [E]	1.25	8	30	2.5	24	50 to 800	Hysteretic	LLP-10, eTSSOP-14
LM34917A [E] 🦢	1.25	8	33	2.5	30	2000 (max)	Constant on-time	micro SMD-10
LM34914 [E]	1.25	8	40	2.5	30	1300 (max)	Constant on-time	LLP-10
LM2831 [E,W]	1.5	3	5.5	0.6	4.5	550, 1600, 3000	Current	SOT23-5
LM2738 [E]	1.5	3	18	0.8	18	550, 1600	Current	LLP-6, eMSOP-8
LM27341	1.5	3	20	1	18	2350, Sync	Current	LLP-10, eMSOP-10
LM2832 [E,W]	2	3	5.5	0.6	4.5	550, 1600, 3000	Current	LLP-6, eMSOP-8
LM27342	2	3	20	1	18	2350, Sync	Current	LLP-10, eMSOP-10
LM2833 [E]	3	3	5.5	0.6	4.5	1500, 3000	Current	LLP-10, eMSOP-10
LM2696 [E,W]	3	4.5	24	1.29	20	100 to 500	Constant on-time	TSSOP-16

🦢 PowerWise product   [E] Evaluation board   [W] WEBENCH enabled

LM27402 – Full-featured 20 V_{IN} Synchronous Buck Controller

Features
- Input voltage range of 3V to 20V
- Continuous inductor DCR current sensing
- 0.6V 1% reference (-40°C to 125°C)
- External power good indicator
- External clock synchronization
- Adjustable soft-start with external capacitor
- Sink and source current capability
- Pre-biased startup
- Power supply tracking
- Input voltage feed forward

Applications
Ideal for use in basestations, networking, and PoL modules.
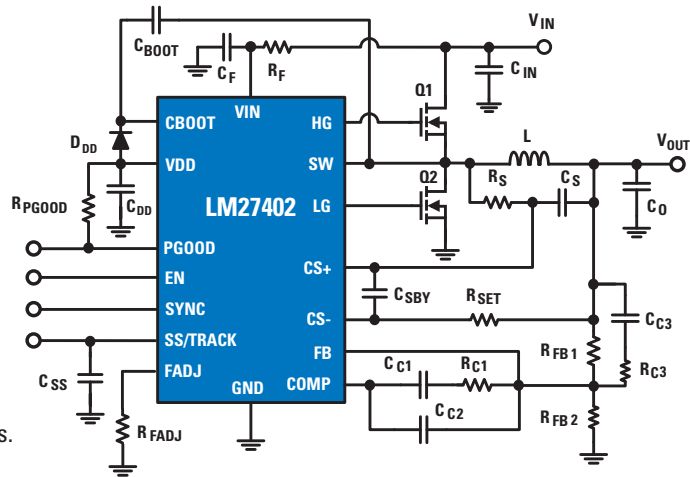
High-Current Synchronous Step-Down Switching Controllers

Product ID	Input Min Voltage (V)	Input Max Voltage (V)	Output Min Voltage (V)	Output Max Voltage (V)	Frequency Range (kHz) & Sync Capability	PWM Mode	Packaging
LM5642 E ♻	4.5	36	1.3	34.5	150 to 250, Sync	Current	TSSOP-28, eTSSOP-28
LM5642X ♻	4.5	36	1.3	34.5	200 to 500, Sync	Current	TSSOP-28, eTSSOP-28
LM3152 E,W ♻	6	33	3.3	3.3	250, 500, 750	Constant on-time	TSSOP-14
LM2642 E	4.5	30	1.3	13.5	300	Current	TSSOP-28, eTSSOP-28
LM2647 E	5.5	28	0.6	5	200 to 500	Voltage	LLP-28, TSSOP-28
NEW! LM27402 E ♻	3	20	0.6	19	200 to 1200	Voltage	LLP-16, TSSOP-16
NEW! LM3753/4 E ♻	4.5	18	0.6	3.6	200 to 1000, Sync	Voltage	LLP-32
LM3495 E ♻	2.9	18	0.6	5.5	200 to 1500, Sync	Emulated peak current mode (ECM)	TSSOP-16
LM3153 W ♻	8	18	3.3	3.3	250, 500, 750	Constant on-time	TSSOP-14
LM2737	2.2	16	0.6	5	50 to 2000	Voltage	TSSOP-14
LM2727 E	2.2	16	0.6	5	50 to 2000	Voltage	TSSOP-14
LM2742 ♻	1	16	0.6	13	50 to 2000	Voltage	TSSOP-14
LM2743 E,W ♻	1	16	0.6	13	50 to 1000	Voltage	TSSOP-14
LM1770 E,W ♻	2.8	5.5	0.8	4.5	300 to 1000	Constant on-time	SOT23-5
LM1771 E ♻	2.8	5.5	0.8	4.5	300 to 1000	Constant on-time	LLP-6, MSOP-8
LM3743 E ♻	3	5.5	0.8	4.6	300 to 1000	Voltage	MSOP-10
LM2745 E ♻	1	14	0.6	13	50 to 1000	Voltage	TSSOP-14
LM2747 E ♻	1	14	0.6	13	50 to 1000	Voltage	TSSOP-14
LM2748 ♻	1	14	0.6	13	50 to 1000	Voltage	TSSOP-14

♻ PowerWise product   E Evaluation board   W WEBENCH enabled

Dual Output Converters

LM3000 – Dual Synchronous Emulated Current-Mode Controller

Features
- V_{IN} range from 3.3V to 18.5V
- Output voltage from 0.6V to 80% of V_{IN}
- Remote differential output voltage sensing
- 1% accuracy at FB pin
- Interleaved operation reduces input capacitors
- Frequency sync/adjust from 200 kHz to 1.5 MHz
- Startup with pre-bias load
- Independent power GOOD, enable, soft-start and track
- Programmable current limit without external sense resistor
- Hiccup-mode short-circuit protection

Applications
Ideal for use in high demand networking equipment, such as routers and hubs.
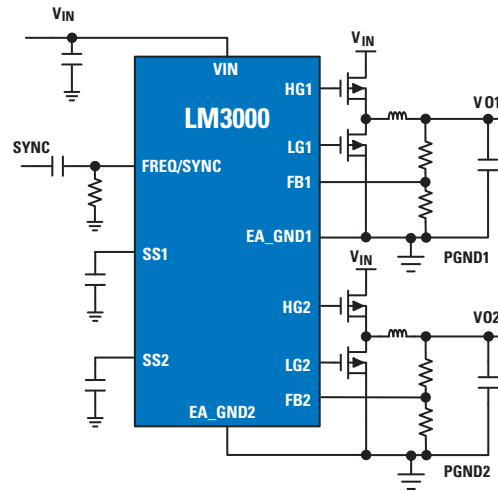
Dual Output Switching Regulators

Product ID	Input Voltage Range (V)	Frequency Range (kHz)	Output1 V_{OUT} Range (V)	Output1 I_{OUT} (A)	Output2 V_{OUT} Range (V)	Output2 I_{OUT} (A)	Soft-Start	On/Off Pin	Packaging
LM26400Y [E]	3 to 20	520 Fixed	0.6 to 16	2	0.6 to 16	2	✓	✓	eTSSOP-16, LLP-16
LM2717 [E]	4 to 20	300 to 600	3.3	2.2	1.265 to 18	3.2	✓	✓	TSSOP-24
LM3370 [E]	2.7 to 5.5	2000 Fixed	1 to 2	0.6	1.8 to 3.3	0.6	✓	✓	LLP-16, micro SMD-20

Dual Output Switching Controllers

Product ID	Input Voltage Range (V)	Frequency Range (kHz) & Sync Capability	V_{OUT} Range (V)	Packaging	Other Features
LM2647 [E]	5.5 to 28	200 to 500	0.6V to 5	LLP-28, TSSOP-28	Supports dual-channel interleaved switching, Adaptive duty cycle clamping reduces peak currents
LM2657 [E]	4.5 to 28	200 to 500	0.6V to 5	LLP-28, TSSOP-28	Supports dual-channel interleaved switching, Adaptive duty cycle clamping reduces peak currents
LM5642 [E]	4.5 to 36	150 to 500, Sync	1.3V to 32	TSSOP-28, eTSSOP-28	Configurable for single output parallel operation
LM3000 [E]	3.3 to 18.5	200 to 1500, Sync	0.6V to 80% V_{IN}	LLP-32	Features soft-start, output tracking, and output synchronization, Remote differential output voltage sensing

PowerWise product   [E] Evaluation board   [W] WEBENCH enabled

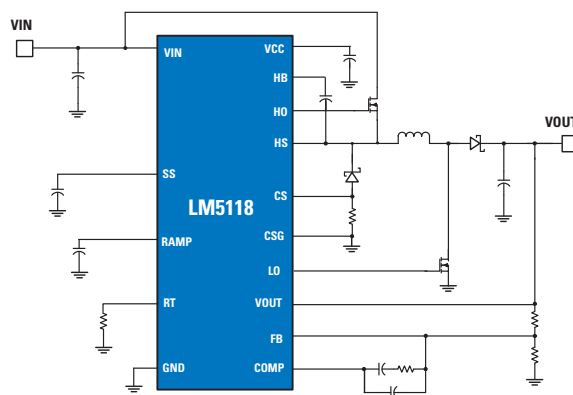# Buck-Boost Switching Regulators and Controllers

LM5118 – Wide-Voltage Range Buck-Boost Controller

Features:
- Ultra-wide input voltage range from 3V to 75V
- Emulated peak current-mode control
- Smooth transition between step-down and step-up modes
- Switching frequency programmable to 500 kHz
- Oscillator synchronization capability
- Internal high-voltage bias regulator
- Integrated high and low-side gate drivers
- 1.5% feedback reference accuracy
- Thermal shutdown

Applications
Ideal for use in telecom power converters.

Boost and Buck-Boost Switching Regulators

Product ID	Input Min Voltage (V)	Input Max Voltage (V)	Output Min Voltage (V)	Output Current (mA)	Frequency Range (kHz) & Sync Capability	PWM Mode	Topology	Packaging
LM5002	3.1	75	1.26	500	50 to 1500, Sync	Current	Boost	SO-8, LLP-8
LM3668	2.5	5.5	2.8	1000	1600 to 2700, Sync	Auto PWM/PFM	Buck-Boost	LLP-12
LM5001 E	3.1	75	1.26	1000	50 to 1500, Sync	Current	Boost	SO-8, LLP-8
LM5015 E,W	4.25	75	1.26	1200	25 to 750, Sync	Current	Two-Switch Forward	TSSOP-14
LM2611 E	2.7	14	-1.23	900, 1200	1400	CUK	Inverting	SOT23-5
LM5000 E	3.1	40	1.26	2000	300 to 1300	Current	Boost, Flyback	LLP-16, TSSOP-16

Boost and Buck-Boost Switching Controllers

| Product ID	Input Min Voltage (V)	Input Max Voltage (V)	Output Min Voltage (V)	Frequency Range (kHz) & Sync Capability	PWM Mode	Topology	Packaging
LM3478 E,W	2.95	40	1.26	1000	Current	Boost, Sepic, Flyback	MSOP-8
LM3488 W	2.95	40	1.26	1000	Current	Boost, Sepic, Flyback	MSOP-8
LM3481 E	2.97	48	1.275	1000	Current	Boost, Sepic, Flyback	MSOP-10
LM5118 E,W	3	75	1.23	50 to 500, Sync	Emulated peak current mode (ECM)	Two-Switch Buck-Boost	eTSSOP-20
LM5022 E	6	60	1.25	2000	Current	Boost, Sepic	MSOP-10
LM5021 E	8	30	1.25	1000, Sync	Current	Flyback, Forward	MSOP-8, MDIP-8
LM5020 E	13	100	1.25	1000, Sync	Current	Flyback, Inverting, Buck, Boost, Forward	MSOP-10, LLP-10

PowerWise product   E Evaluation board   W WEBENCH enabled

Low Dropout (LDO) Linear Regulators

LP5900 – Ultra-Low-Noise 150 mA Linear Regulator

Features

- Industry's lowest noise (6.5 µV$_{RMS}$) combined with 85 dB of Power Supply Ripple Rejection (PSRR) guarantees signal integrity
- 25 µA Iq minimizes current drain when system operates in low-power mode
- Elimination of bypass capacitor reduces BOM to only two ceramic 0.47 µF capacitors
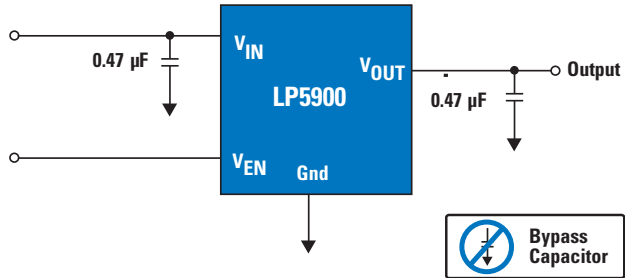
Applications
Ideal for use in wireless LAN and mobile devices.

0.47 µF | V$_{IN}$ | LP5900 | V$_{OUT}$ | Output | 0.47 µF
V$_{EN}$ | Gnd

Bypass Capacitor

Low Dropout (LDO) Linear Regulators

Product ID	Load Current (mA)	V$_{IN}$ Min (V)	V$_{IN}$ Max (V)	V$_{OUT}$ (V)	Packaging
LP8900	280	1.8	5.5	2.7 to 1.8	SMD-6
LP38511 E	800	2.25	5.5	1.8, adj down to 0.8	TO263-5
LP38851	800	1.2	5.5	0.8 to 1.8, adj	PSOP-8
LP38690	1000	3.95	10	1.25 to 9, adj	TO-252
LP38692	1000	3.75	10	1.25 to 9, adj	LLP-6
LP38512 E	1500	2.25	5.5	1.8, adj down to 0.8	TO-263, LLP-8
LP38500	1500	2.7	5.5	0.6 to 5, adj	TO-263
LP38502 E	1500	2.7	5.5	0.6 to 5, adj	TO-263
LP38852 E	1500	1.2	5.5	0.8 to 1.8, adj	TO220-7
LP38855	1500	1.38	5.5	1.2 to 1.8, adj	TO220-7
LP38858	1500	1.38	5.5	1.2 to 1.8, adj	TO220-7
LP38513 E	3000	2.25	5.5	1.8, adj down to 0.8	TO263-5
LP38501 E	3000	2.7	5.5	0.6 to 5, adj	TO-263 THIN
LP38503	3000	2.7	5.5	0.6 to 5, adj	TO-263 THIN
LP38853 E	3000	1.2	5.5	0.8 to 1.8, adj	PSOP-8
LP38856 E	3000	1.15	5.5	0.8 to 1.8, adj	TO263-7
LP38859 E	3000	1.55	5.5	1.2 to 1.8, adj	TO220-7

Low-Noise, Low-Power Linear Regulators

Product ID	Output Current (mA)	Input Max Voltage (V)	Input Min Voltage (V)	Dropout Voltage (V)	Output Voltage (V)	On/Off Pin	Quiescent Current (mA)	PSRR (dB)	Voltage Noise (rms)	Packaging
LP3995	150	6	2.5	0.06	3, 2.8, 1.9	—	0.085	60	25	micro SMD-5, LLP-6
LP3999	150	6	2.5	0.06	1.5, 2.4, 1.8, 2.5, 2.8, 3.3	—	0.085	60	30	micro SMD-5
LP5900 E	150	5.5	2.5	0.08	1.5, 2.8, 3.3	—	0.025	75	6.5	micro SMD-4
LP5990 E	200	5.5	2.2	0.15	0.8 to 3.6	—	0.03	55	60	micro SMD-4
LP3871/74	800	7	2.5	0.24	5, 1.8, 2.5, 3.3	✓	6	73	150	TO263-5, SOT223-5, TO220-5
LP3878 E	800	16	2.5	0.475	adj	✓	0.18	60	18	LLP-8, PSOP-8
LP3879	800	6	2.5	—	1.2, 1	✓	0.1	60	18	LLP-8, PSOP-8
LP3875	1500	7	2.5	0.38	1.8, 2.5, 3.3	✓	6	73	150	TO263-5, SOT223-5
LP3876	3000	7	2.5	0.8	2.5, adj	✓	6	73	150	TO263-5

PowerWise product   E Evaluation board

Wireless Basestation Solutions

Wireless basestations require highly efficient, high-power solutions. National's PowerWise® portfolio features energy-efficient solutions for data converters, high-speed amplifiers, and timing and clock applications.

Wireless Basestation Solutions

Low Intermediate Frequency Receiver	Demonstrates a low IF receiver subsystem for use in wireless infrastructure systems and frequency domain analyzers. It lowpass filters the input signal with a double-balun network and provides high dynamic range. For a 52 MHz input signal, large signal (-1 dBFS) performance is 75.8 dBFS signal-to-noise (SNR) with spurious free dynamic range (SFDR) greater than 84 dBFS. Small signal (-20 dBFS) performance is 78.0 dBFS SNR and greater than 94 dBFS SFDR.
High Intermediate Frequency Receiver	Implements a high IF receiver circuit that illustrates variable gain IF amplification and digitization in wireless infrastructure systems and frequency domain analyzers. This flexible subsystem provides excellent sensitivity for input signal frequencies up to 240 MHz. It achieves a small-signal SNR of 72 dBFS and a SFDR greater than 90 dBFS with a 169 MHz input frequency. Large signal performance yields a SNR of 68.3 dBFS and SFDR of 77 dBFS at 169 MHz.
Low Intermediate Frequency Receiver Board	Demonstrates a subsystem for quadrature direct conversion or near-zero IF receiver for signal frequencies from DC to 40 MHz. This receiver architecture is commonly used in WiMAX and WCDMA receiver systems. For a 40 MHz input signal, large-signal SNR is 73.3 dBFS and SFDR greater than 85 dBFS. Small-signal SNR is 74 dBFS and SFDR greater than 90 dBFS.

Clock Distribution Solutions

Clock Distribution on ATCA Backplane Evaluation Board	The DS91D176 is an M-LVDS evaluation board specifically targeted at ATCA clock distribution. The evaluation card includes an ATCA ADF connector and 6 M-LVDS transceivers with stub lengths ranging from 1/4 to 2 inches in length. In addition, the board includes 3 channels with trace characteristic impedances of 80, 100 and 130 Ohms. The board can act as driver or receiver. A 7th channel is also included for non-ATCA applications.
microTCA Demo	Reference Design available for clock distribution on the microTCA standard backplane.

Wired and Data Center Solutions

Powering telecom and data center servers requires special design considerations to reduce energy consumption. National addresses these design challenges and more with a portfolio of Reference Designs that include Hot Swap, Isolated High Voltage, and Power-over-Ethernet (PoE) solutions.

Hot Swap Solutions

Hot Swap Controller Evaluation Boards	National's hot swap products provide superior protection through both power and current limiting to ensure the isolating MOSFET stays in its safe operating area (SOA). This design supports negative voltage systems.

Visit **national.com/comms** to view the Hot Swap with Confidence webinar.

High-Voltage Solutions

LM25037 Evaluation Board	Demonstrates a push-pull topology that delivers 5V at 10A from an input voltage range of 16V to 32V. The LM25037 supports both current and voltage-mode control to simplify designing balanced, double-ended power converter topology, such as push-pull, half-bridge and full-bridge topologies.
LM5088-1 Evaluation Board	A wide input range buck controller featuring a frequency dither capability to reduce EMI using an emulated current-mode control for excellent transient response and reliable control for high step-down ratios. It delivers 5V at 7A from an input voltage range of 5.5V to 55V.
LM5085 Evaluation Board	Features a constant-on-time (COT) control mode and delivers 5V at 4.5A from an input voltage range of 5.5V to 55V.
Active Clamp Forward Converter Reference Design	Utilizes the LM5025 voltage-mode PWM controller to implement a high efficiency active clamp forward converter, delivering 15V at 1.5A from an input voltage range from 30V to 60V.
Isolated Two Switch DC-DC Regulator Evaluation Board	Configurable as either an isolated two-switch forward converter or flyback. It features the LM5015 regulator to support an input voltage range from 36V to 72V at an output of 5V at 2.5A.

Power-over-Ethernet (PoE) Solutions

PoE Phyter	Integrates both LM5072 PoE controller and DP83848 10/100 Mb/s Ethernet physical layer transceiver for a turnkey PoE design with an output of 3.3V at 7.3A.
LM5073-HE PoE Evaluation Board	Implements a fully compliant IEEE 802.3af PD interface with minimal power dissipation and a measured efficiency of 98.5%.
LM5072 Evaluation Board and Reference Design	An isolated, turnkey power supply design featuring a fully compliant IEEE 802.af PD interface specification that can be configured to deliver an output of 3.3V at 3A or a dual output of 5V and 3.3V, up to a combined maximum power level of 10W. Reference Design is 5V out 25W POE+ PD power supply that is fully compliant with IEEE 802.3at standard. This design converts 48 Vdc to 5 Vdc and can deliver up to 25W power.

Visit **national.com/comms** to view the Power-over-Ethernet Solutions for IEEE 802.3af-compliant Power Devices with the PoE FAQs article for design tips and answers to common questions when powering a device from standard CAT-5 Ethernet cabling.

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- Input your design requirements
- Choose a recommended part from a customized list

> Choose from only those parts that meet your specifications

Design It

- Tune your design quickly with the optimization tool to balance design objectives for efficiency and footprint
- Adjust components and use charts to make design decisions based on power dissipation, current flow, offset voltage, drift, frequency response, output-voltage ripple, efficiency, inductor-current ripple, and other electrical characteristics over the full operating range
- Exchange parts and use bill of materials graphs for easy external component selection based on efficiency, footprint, cost, or vendors

> Create your custom BOM using readily available parts
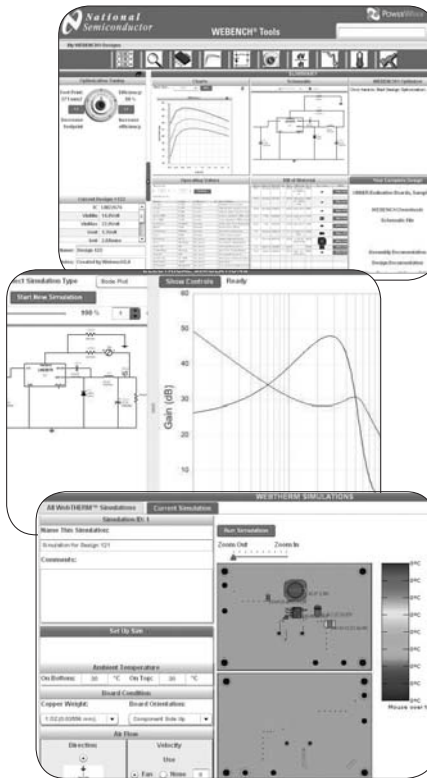
Analyze It

- Simulate your circuit and evaluate performance using electrical and thermal simulations
- Simulate electrical characteristics, choose probe points, and examine waveforms to determine performance
- Simulate thermal behavior and your circuit on a PCB in your defined environment and view color heat maps
- Overlay alternate circuits and compare results to get optimal performance

> Solve your design problems before you prototype

Build It

- Request samples and purchase parts or demo boards
- Receive your custom prototyping kit the next business day
- Download your automatically generated CAD files, assembly details, test instructions, and complete performance results

> Save weeks getting your final design into production
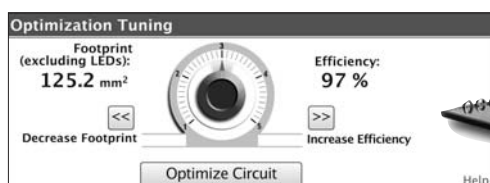
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South Portland, Maine
Greenock, Scotland

Chip Test and Assembly:
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