

Communications Infrastructure

Solutions Guide

national.com/comms

2011

Data Conversion Solutions
Amplifier Solutions
Temperature Sensor Solutions
Ser/Des Solutions
LVDS Solutions
Clock and Timing Solutions
Power Management Solutions
Design Resources



 *National*
Semiconductor

National's high-density 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, reliable, cost-efficient data centers and drive higher speeds over longer, less expensive interconnects.

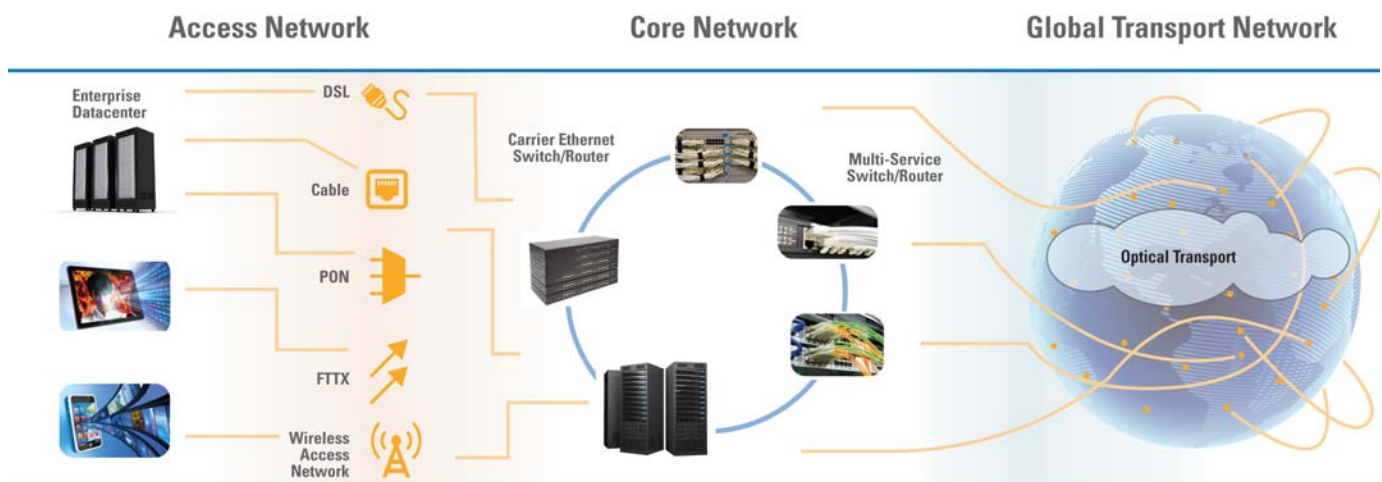
Wireless Basestation Applications

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 and Point-of-Load 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.

Visit national.com/comms to download the latest reference designs and design-in a product using online WEBENCH® Designer tools.



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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

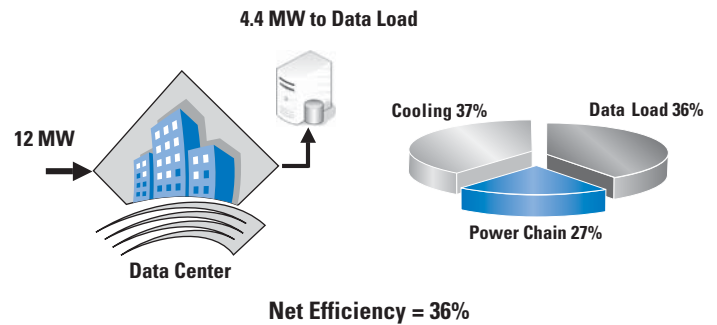
Source: Gartner 2006

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.



High-Speed Interface Technology

Challenges:

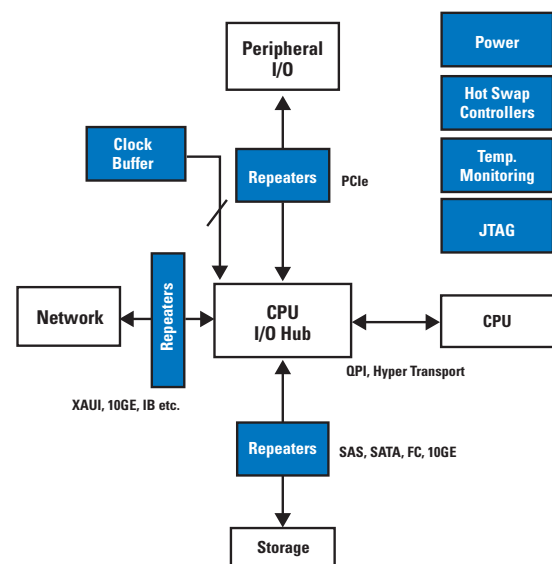
With the explosion of multimedia content on the Internet—YouTube, gaming, and cloud computing, to name a few—data centers need technology solutions that can keep up with increasing bandwidth demand. High-speed interconnect links and system capacity require upgrades at a rate never before seen. However, physical reach requirements remain the same with a greater emphasis on low power consumption as the demand increases for reliable, energy-efficient operations.

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 additive jitter and deliver the industry's lowest power to data rate ratio—5 mW/Gbps compared to typical solutions at 20 mW/Gbps.

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.

Solutions for Datacom Applications



Product	Function
DS100BR410/210/111	10 Gbps repeaters with signal conditioning
DS50PCI402	2.5 to 5.0 Gbps quad lane PCI express transceiver
DS64BR401	6.4 Gbps quad lane signal conditioning repeater
DS64MB201	6.4 Gbps dual port mux/buffer with signal conditioning
DS80EP100	5 to 12.5 Gbps power-saver equalizer

Data Center Applications

Designing Efficient Data Centers

Energy-Efficient Wired and Data Center Applications

Challenges:

The explosion of multimedia content on the Internet and distributed computing demands are driving dramatic increases in bandwidth and power requirements across data communications systems. IT and facilities professionals search for new ways to increase bandwidth and reduce power demands in new and existing installations. Equipment systems designers are tasked with increasing performance and reliability, as well as decreasing system power consumption and reducing operating expenses.

Solutions:

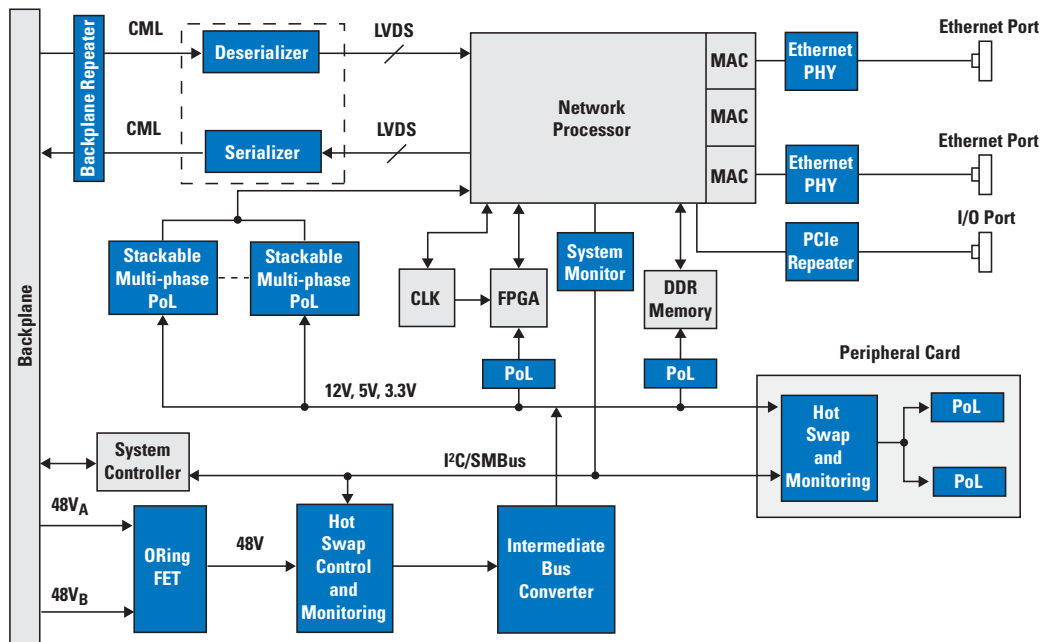
National's energy-efficient, next-generation products address the critical needs of data communications and data centers, including 48V and point-of-load power, high-speed cable/backplane extenders, and other low-power analog solutions.

High-efficiency PowerWise® point-of-load ICs, such as LM21215 and the stackable LM3753 and LM3754 reduce power consumption and thermal dissipation.

PCB protection and monitoring ICs, such as LM25066 and system monitors like the LMP92001, ADC128D818, and LMV7231 maintain system health. Signal conditioners, like the DS100BR410 embedded inside the active copper cable assemblies and backplane boards ensure signal integrity for overall system reliability.

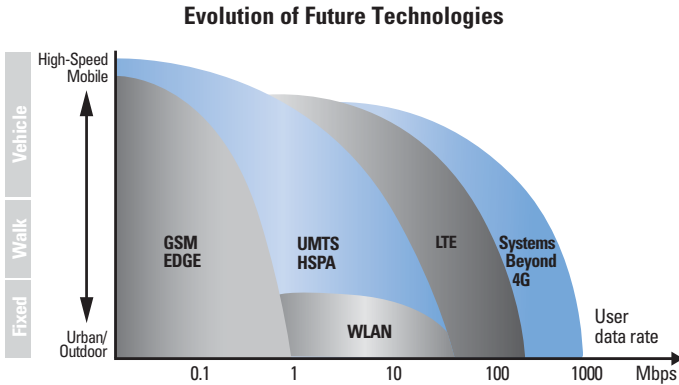
National offers integrated solutions, such as the LM5045, LM5046, and LM5066 to help reduce design complexity and time-to-market while enabling smaller form factors and lower system costs.

Data Center Equipment Diagram



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.



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.

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.

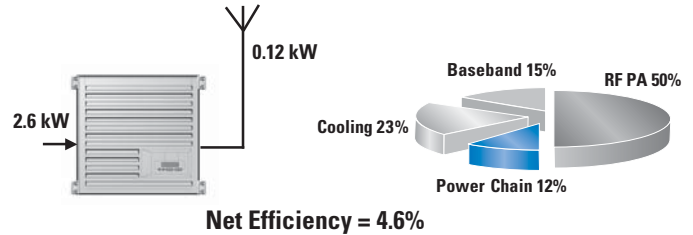
The primary energy consumption challenges in basestations are:

- 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.

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.



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.

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
DS100BR410/210/111	10 Gbps repeater	36 db input EQ, -12 dB output
DS64BR401	6.4 Gbps Quad Lane Redriver	33 dB input EQ gain, -12 dB output De-emphasis driver
DS64MB201	6.4 Gbps dual port mux/buffer	33 db input EQ, -12 dB output
DP83630/40	10/100 Ethernet PHY	Supports IEEE 1588

Wireless Basestation (BTS) Applications

Remote Radio Heads

Challenges:

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

Solutions:

National's CPRI/OBSAI Ser/Des 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 both the coexistence of 2G, 3G, and 4G in the same frequency band and scalability to wider bandwidths to provide more service with lower power requirements and smaller board areas.

Solutions:

The LMK family offers the industry's highest performance clock conditioners with superior clock jitter cleaning, generation, and distribution, as well as advanced features to simplify clock design. The LMK04808 features a cascaded PLL architecture enabling sub-100 fs rms jitter (10 kHz to 20 MHz) using a low-noise VCXO module or sub-200 fs rms jitter using an external crystal.

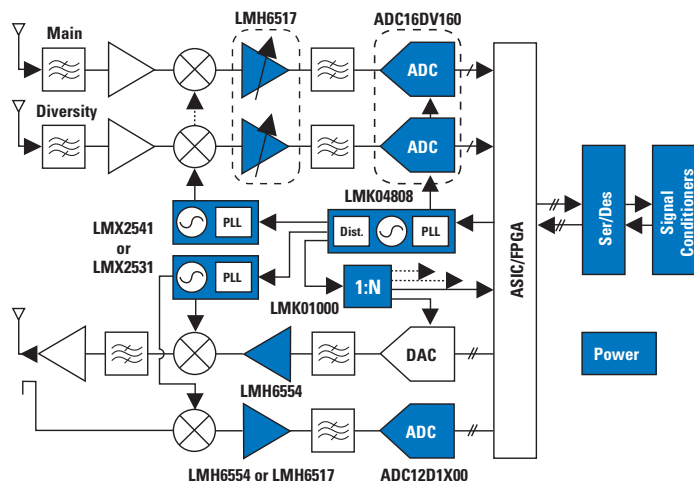
The LMX family includes the industry's lowest noise synthesizers, LMX2531 and LMX2541, which provide wide and flexible frequency coverage while delivering ultra-low-noise and spur performance at low power consumption for local oscillator applications. The LMX family combines integer/delta-sigma PLLs with integrated low noise VCOs and the latest synthesizer, LMX2541, can extend to 4 GHz.

The Gig ADC family features the industry's fastest 12-bit ADC at 3.6 GSPS—ADC12D1800—with a combination of high sample rate and dynamic range to make this an ideal solution for DPD feedback and point-to-point microwave links. With excellent dynamic performance supported beyond 2 GHz in some applications, it dramatically reduces board area and power consumption through RF sampling.

High dynamic range data converters including the 16-bit, 160 MSPS ADC16DV160, provide excellent dynamic performance across a large range of input frequencies, enabling high-bandwidth, high-sensitivity multi-carrier/multi-standard basestations.

High-performance variable gain amplifiers provide high linearity and low noise at low power consumption for enhanced receiver performance. The LMH6517 DVGA delivers a 5.5 dB noise figure and 44 dBm OIP3—ideal for addressing new multi-carrier/multi-standard wireless basestation designs.

High-Speed Radio Signal Path for Wireless Basestations



Multi-Standard Basestation Solution Products

Product	Function	Key Feature
LMK04808	Low-noise clock jitter cleaner with dual-loop PLLs	Sub-200 fs RMS jitter using external crystal and varactor
LMK01000	1.6 GHz low-noise clock distributor	30 fs additive RMS jitter
ADC12D1X00	12-bit, ultra-high-speed ADC with up to 3.6 GSPS	-148.6 dBm/Hz noise floor, 49.5 dB, -66 dBFS IMD3
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 $P_d = 1.3$ W
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	< 2-mrad of RMS noise with ultra-low spurs, 31.6 to 4000 MHz range

Power Solutions for Communications Infrastructure

Challenges:

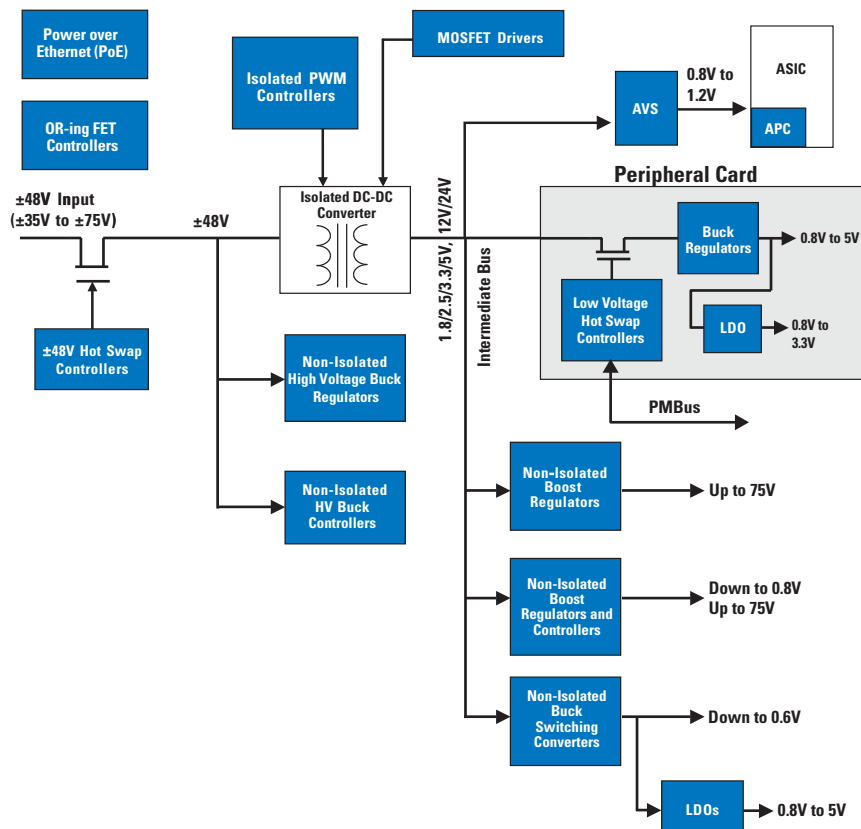
System designers are being challenged to supply more power in less space as data processing requirements for wired and wireless infrastructure equipment grows. With shrinking form factor requirements, high-power density and efficiency become critical—not only to reduce total power consumption, but also 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
 - Industry's most integrated family of full-bridge controllers with all four primary-side MOSFET drivers and synchronous rectifier control signals
 - Advanced topologies such as full-bridge, phase-shifted full-bridge, active clamp, and half-bridge 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 real-time power monitoring via PMBus 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

Ultra-High-Speed ADCs

ADC12D1000/1600/1800 – 12-Bit, 2.0/3.2/3.6 GSPS Ultra-High-Speed ADCs

Features

- Configurable to interleaved or dual mode
- Single 1.9V supply
- 292-ball, thermally-enhanced BGA package (leadless or lead-free)
- Multi-chip synchronization, time-stamp feature, and internal track-and-hold amplifier
- Programmable gain and offset adjustment per channel
- Extended self-calibration scheme enables flat response of all dynamic parameters for input frequencies >2 GHz while providing low 10^{-18} code error rate
- Pin-compatible with ADC10D1000/1500 – easy upgrade for higher resolution

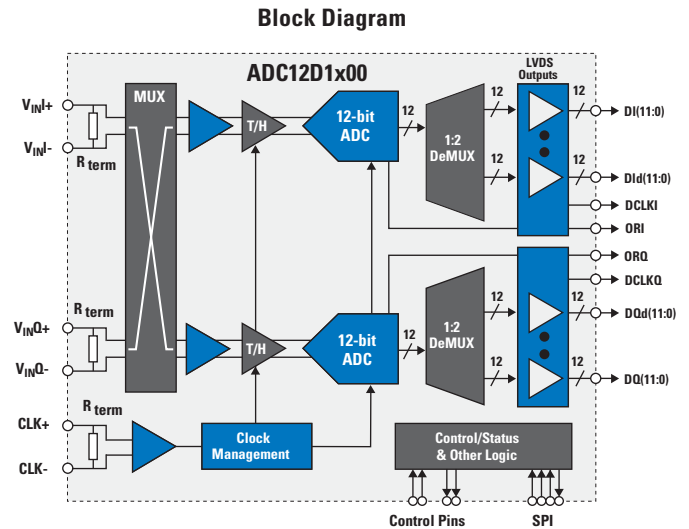
Applications

Ideal for applications requiring SDR technology, including wideband communications, data acquisition, optical infrastructure, microwave backhaul, and set-top boxes.

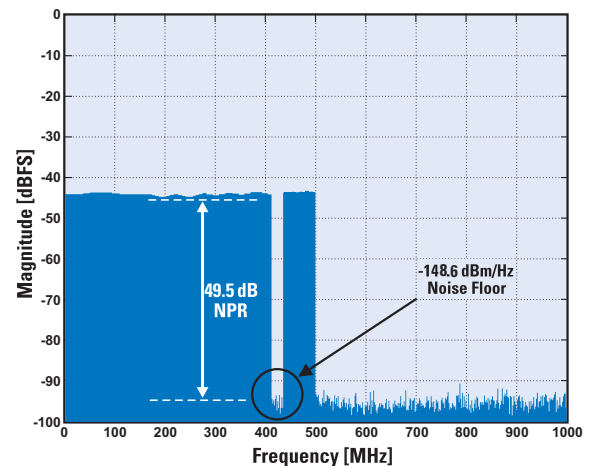
Optimal Performance

Wideband SDR architectures are employed to digitize a wide bandwidth input spectrum. As such, noise-floor, Noise-Power Ratio (NPR), and Intermodulation Distortion (IMD) provide the best measure of a system's capability to extract narrowband information from the large input bandwidth.

- -148.6 dBm/Hz noise floor
- 49.5 dB NPR
- -66 dBFS IMD3



ADC12D1X00 NPR and Noise Floor Performance



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)

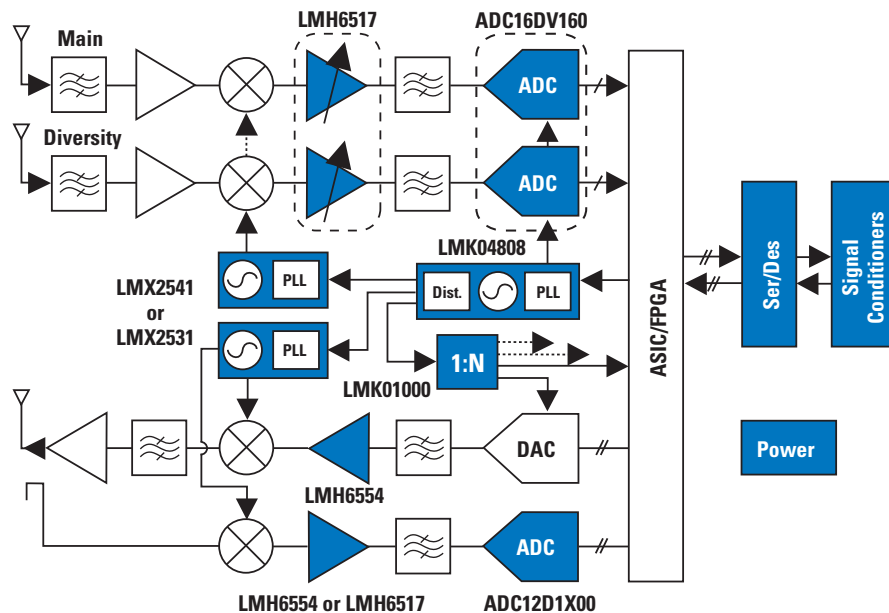
- SNR
 - 78.5 dBFS ($f_{IN} = 30$ MHz)
 - 76.3 dBFS ($f_{IN} = 197$ MHz)
- SFDR
 - 95 dBFS ($f_{IN} = 30$ MHz)
 - 91.2 dBFS ($f_{IN} = 197$ MHz)
- Full power bandwidth 1.4 GHz
- Power consumption
 - Core per channel: 591 mW
 - LVDS driver: 118 mW
 - Total: 1.3W

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

Applications

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

High-Speed Radio Signal Path for Wireless Basestations

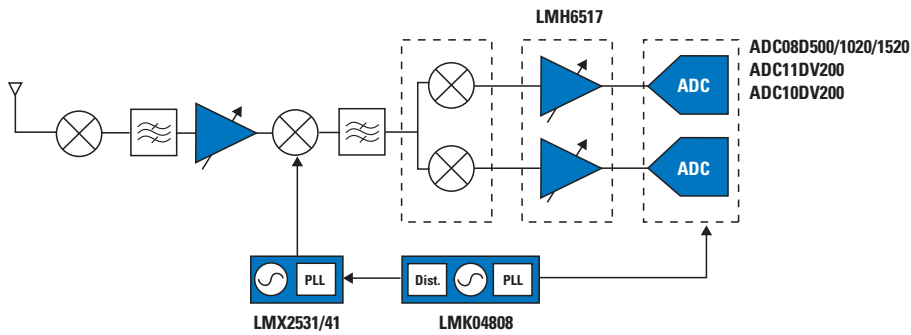


Recommended Power Solutions	
ADC12D1X00	LM25576 + LP38513
ADC16DV160	LM2734 + (LP3878 or LP5900)
LMH6517	LP3878
LMH6554	LP3878
LMK01000	LP3878
LMK04808	LP3878
LMX2531/41	LP5900 or LP3878

Data Conversion Solutions

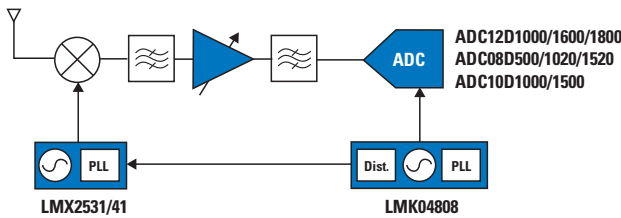
High-Speed ADCs

Direct Conversion



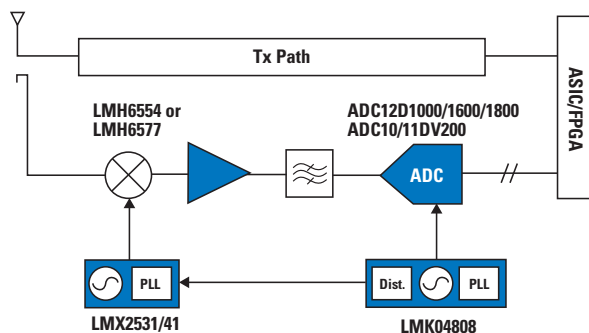
Recommended Power Solutions	
ADC10/11DV200	LM2734 + LP3878
ADC08D1020/1520	LM27341
ADC08D500	LM27341
LMH6517	LP3878
LMX2531/41	LP5900 or LP3878
LMK04808	LP3878

High-IF Sampling



Recommended Power Solutions	
ADC12D1X00	LM25576 + LP38513
ADC10D1000/1500	LM25576 + LP38513
ADC08D1020/1520	LM27341
LMX2531/41	LP5900 or LP3878
LMK04808	LP3878







































Digital Pre-Distortion (DPD) Feedback



Recommended Power Solutions	
ADC12D1X00	LM25576 + LP38513
ADC10/11DV200	LM2734 + LP3878
LMH6554	LP3878
LMX2531/41	LP5900 or LP3878
LMK04808	LP3878

Data Conversion Solutions

High-Speed MSPS A/D Converters

Product ID	Channels	Speed (MSPS)	Power (mW)	SNR (dB)	SFDR (dB)	Outputs	Packaging
16-bit							
ADC16DV160 ^E 	2	160	1300	78.5	95	LVDS	LLP-68
ADC16V130 ^E 	1	130	755	78.5	95.5	LVDS	LLP-64
14-Bit							
ADC14I155 ^E 	1	155	967	71.3	87	CMOS	LLP-48
ADC14V155 ^E 	1	155	951	71.7	86.9	Parallel LVDS	LLP-48
ADC14DS080/105 ^E 	2	80/105	800/1000	74.2/73	90	Serial LVDS	LLP-60
ADC14DC080/105 ^E 	2	80/105	600/800	73/74	90	CMOS	LLP-60
ADC14C080/105 ^E 	1	80/105	300/400	74.2/74	90	CMOS	LLP-32
ADC14L040 ^E 	1	40	235	73	90	CMOS	LQFP-32
ADC14L020 ^E 	1	20	150	74	93	CMOS	LQFP-32
12-Bit							
ADC12C170 ^E 	1	170	715	67.2	85.4	CMOS	LLP-48
ADC12V170 ^E 	1	170	781	67.2	85.8	Parallel LVDS	LLP-48
ADC12C105 ^E 	1	105	400	71	90	CMOS	LLP-32
ADC12DS080/105 ^E 	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 	1	80	300	71.2	90	CMOS	LLP-32
ADC12DL080 ^E 	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 	2	65	360	69	86	CMOS	TQFP-64
ADC12L063 	1	62	354	66	78	CMOS	LQFP-32
ADC12EU050 ^E 	8	50	384	69.3	77	Serial LVDS	LLP-68
ADC12DL040 ^E 	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 	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 	1	80	78.6	59.5	79	CMOS	TSSOP-28
ADC10DL065 	2	65	370	61	85	CMOS	TQFP-64
ADC10065 	1	65	68.4	59.6	80	CMOS	TSSOP-28
ADC10D040 	2	40	267	60	72	CMOS	TQFP-48
ADC10040 	1	40	55.5	59.6	80	CMOS	TSSOP-28
ADC10D020 	2	20	150	59	75	CMOS	TQFP-48

 PowerWise® product ^E Evaluation board

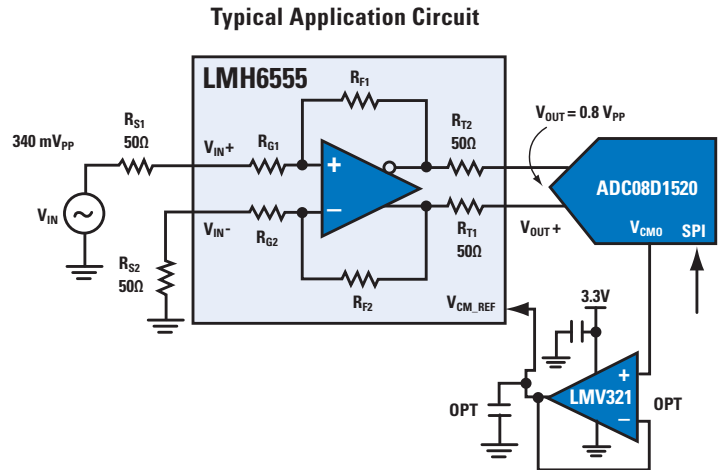
ADC08D1520 – 8-Bit, Dual 1.5 GSPS or Single 3.0 GSPS A/D Converter

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 A/D Converters

Product ID	Speed	Power (W)	NPR (dB)	IMD (dBFS)	Noise Floor (dBm/Hz)	ENOB (bits)	SNR (dB)	SFDR (dBc)	Packaging
NEW ADC12D1800 ^E	1800/3600	4.4	48.5	-61	-149.5	9.4	58.5	73	TEPBGA-292
NEW ADC12D1600 ^E	1600/3200	3.88	48.5	-63	-149.6	9.4	58.5	70.3	TEPBGA-292
NEW ADC12D1000 ^E	1000/2000	3.38	49.5	-66	-148.6	9.6	60.2	71	TEPBGA-292
ADC10D1500 ^E	1500/3000	3.59	48	-67.6	-144.7	8.9	57	66	TEPBGA-292
ADC10D1000 ^E	1000/2000	2.77	48	-67.6	-144.7	9.1	57	66	TEPBGA-292
ADC083000 ^E	3000	1.6	—	—	—	7.2	45.3	55.4	eLQFP-128
ADC08D1520 ^E	1500/3000	2	—	—	—	7.4	46.8	58	eLQFP-128
ADC08D1020 ^E	1000/2000	1.6	—	—	—	7.4	46.8	58	eLQFP-128
ADC08D1000 ^E	1000/2000	1.6	—	—	—	7.4	47	55	eLQFP-128
ADC08D500 ^E	500/1000	1.4	—	—	—	7.5	47	55	eLQFP-128
ADC08B200 ^E	200	0.306	—	—	—	7.2	46.3	56	TQFP-48
ADC08500/1000/1500 ^E	500/1000/1500	0.8/1.45/1.2	—	—	—	7.5/7.5/7.4	47.5/48/47	55/59/56	eLQFP-128
ADC08B3000	3000	1.9	—	—	—	7.2	45.4	57	eLQFP-128

PowerWise product ^E Evaluation board

Data Conversion Solutions

Low Power ADCs

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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW*}	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 ^{EW*}	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 ^{EW*}	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 ^{EW}	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 ^{EW}	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 † Evaluation board * 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
NEW DAC161S055 ^E	16	1	5	2.7 to 5.25	2200	3450*	±1.0	-1, +1.1	External	Serial (SPI)	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
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

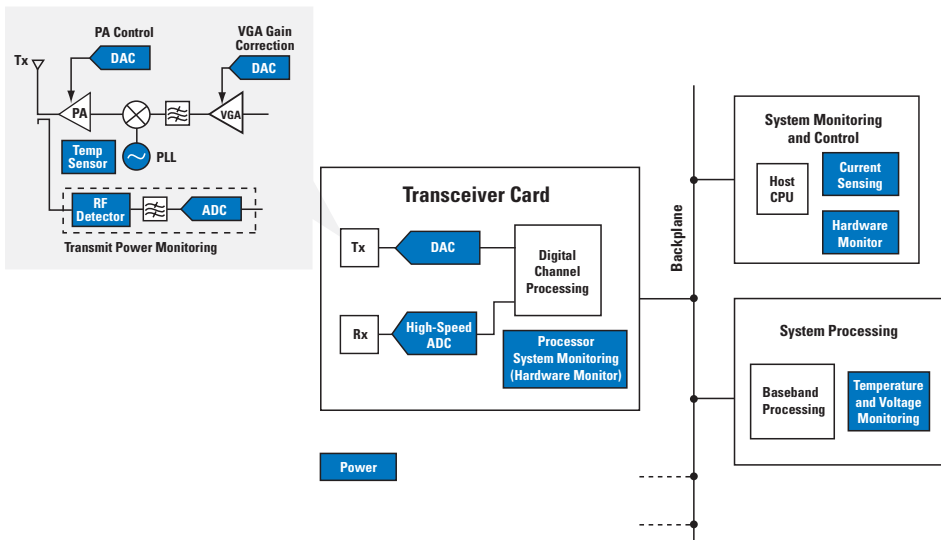
Product ID	Res (bits)	Inputs	Pin and Function Compatible	Speed Range (kSPS)	Supply Voltage Range (V)	Typ Power (mW)		Static Performance (Typ)		ENOB (bits) Typ	Temp Range (°C)	Packaging
						3V	5V	INL (LSB)	DNL (LSB)			
DAC081C081 ^E	8	1	↕	6	2.7 to 5.5	0.38	0.73	±0.1	±0.08	Supply	-40 to 125	MSOP-8
DAC101C081 ^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 *5.25V **3.6V 5.5V PowerWise® product ^E Evaluation board ^W WEBENCH enabled

Precision Signal Path Applications

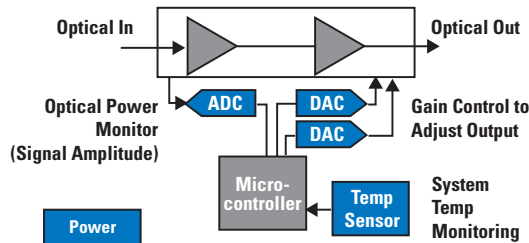
Monitoring and Control Solutions for Communications Systems

Wireless Basestation



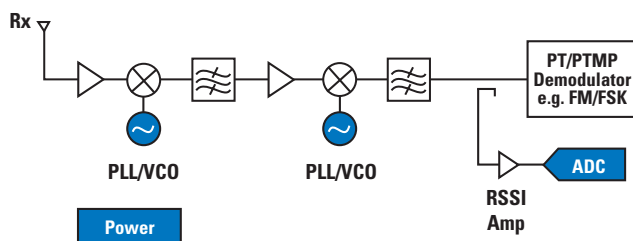
Recommended Solutions	
DAC	DAC121S101, DAC12xS085, DAC161S055
ADC	ADC12xS021, ADC10xS021, ADC128S022, ADC108S022, ADC128D818
Temp Sensor	LM73, LM94022
RF Detector	LMV225/26/28, LMH2100
Hardware Monitor/Control	LMP92001, LM96080, LM87, LM96194, LMV7231
PLL	LMX2541
Power	LM41xx, LM27341, LP5900

Optical Networks



Recommended Solutions	
ADC	ADC12xS021
DAC	DAC121S101, DAC101S101, DAC12xS085, DAC10xS085, DAC16S055
Temp Sensor	LM73, LM57
Power	LM4140

RSSI (Receive Signal Strength Indicator) in Channelized Communication



Recommended Solutions	
ADC	ADC122S021
PLL/VCO	LMX2541
Power	LM41xx, LP5900

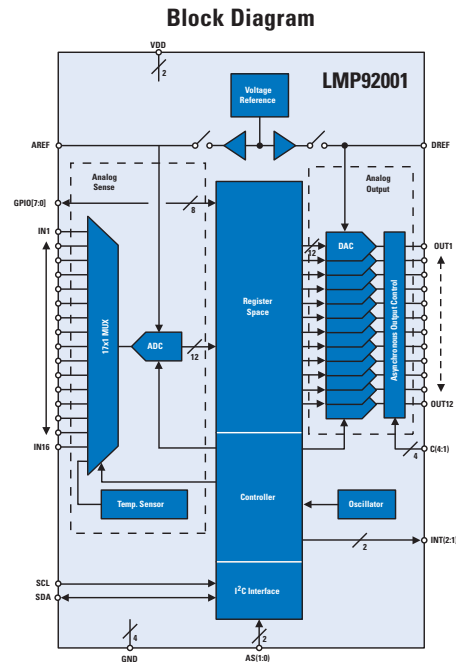
LMP92001 – Analog System Monitor and Controller

Features

- Fully integrated system monitor and controller
- Twelve 12-bit DACs with independent pin-controlled output switches
- 16-channel, 12-bit ADC with programmable window comparator function
- User-selectable voltage reference, internal or external
- Internal temperature sensor
- Mirrored pinout

Applications

Ideal for use in RF PA monitoring and control, as well as power supply system monitoring and control.



Select Temperature Sensors and Monitors

Product ID	Description	Temperature Range (°C)	Accuracy	Scale Factor / Resolution	Supply Voltage (V)	Supply Current	Package
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
NEW! LMP92001 ^E	Integrated analog system monitor	-40° to +125°	± 2°C (-25°C to 85°C) ± 25°C (-45°C to 125°C)	0.005°C/LSB	4.75 to 5.5	6.5 mA	LLP-54

PowerWise® product ^E Evaluation board

RF Detectors and High-Speed Comparator Solutions

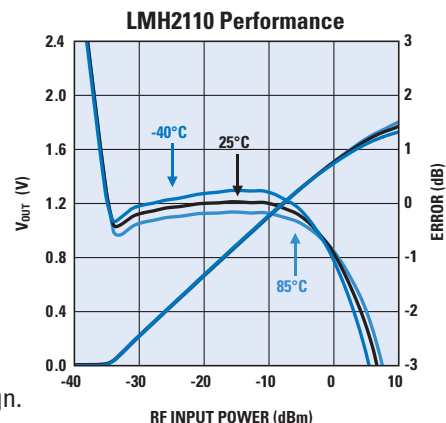
LMH2110 – 6 GHz Logarithmic RMS RF Power Detector

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 to 6 GHz

Applications

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



RF Detectors

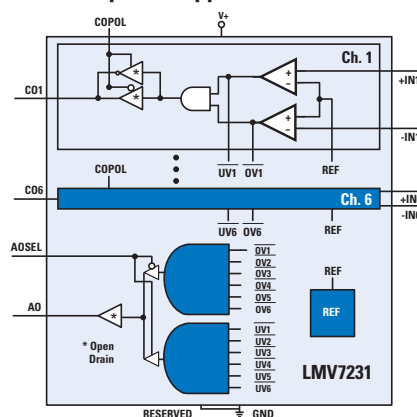
Product ID	Application	Channels	Supply Voltage Range (V)	Dynamic Range (dB)	Frequency Range (MHz)	Packaging
LMV221 ^E	CDMA, WCDMA, GSM, GPRS	1	2.7 to 3.3	40	50 to 3500	LLP-6
LMV225/6/8 ^E	CDMA, WCDMA, GSM, EDGE, GPRS, TDMA	1	2.7 to 5	>30	450 to 2000	micro SMD-4, LLP-6
LMV232 ^E	3G, UMTS, WCDMA, CDMA2000, 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 $\pm 1.5\%$ (max)
- Wide supply voltage range 2.2 to 5.5V
- Internal hysteresis 6 mV
- Propagation delay 7 μ s
- Supply current 7 μ A per channel

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

Simplified Application Circuit



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, SC-70
LMV7231 ^E	Hardware monitor, low-power hex comparator	7 μ A	2.2 to 5.5	7 μ s	—	LLP-24
LMP7300 ^E	Precision comparator and reference	10 μ A	2.7 to 12	10 μ s	—	SOIC-8, MSOP-8

LMH6629 – Ultra-Low-Noise High-Speed Operational Amplifier

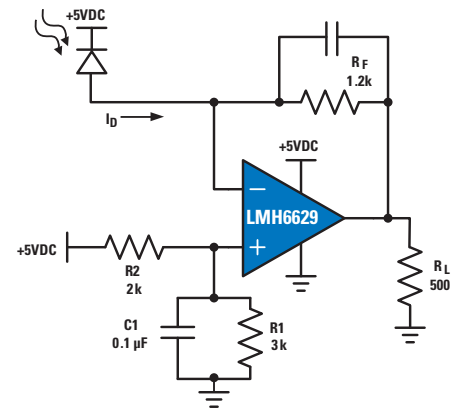
Features

- -3 dB bandwidth 900 MHz at a gain of 10V/V
- 0.69 nV/√Hz input voltage noise
- ±780 μV input V_{OS-MAX} at 25°C
- 1600V/μs slew rate and 15.5 mA supply current
- -90/-94 dBc (HD2/HD3) at $f = 1$ MHz, $2V_{PP}$
- 2.7 to 5.5V operation with selectable gain ≥ 4 or ≥ 10

Applications

Ideal for use in basestation amplifiers, wide band active filters, and transimpedance amplifiers.

Typical Application Circuit



LMH6517 – Low-Power, Low-Noise IF and Baseband Dual 16-Bit ADC Driver

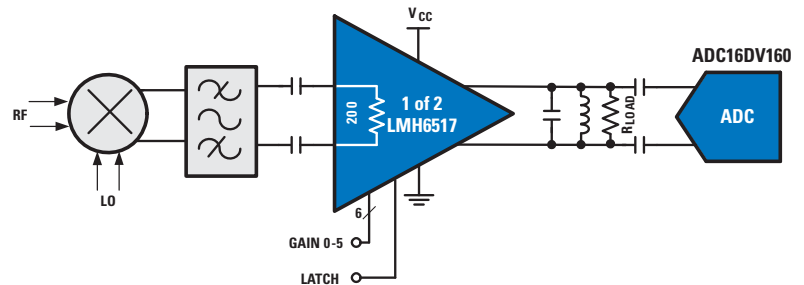
Features

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

Applications

Ideal for use in cellular basestations and IF sampling receivers.

Typical Application Circuit



LMH6618/19 – Single/Dual 130 MHz, 1.25 mA RRIO Operational Amplifiers

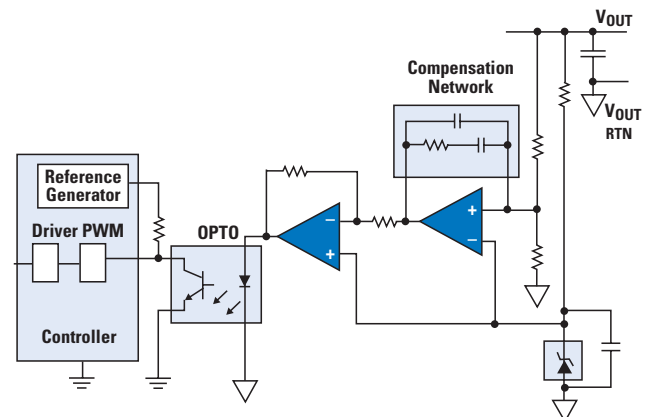
Features

- 2.7 to 11V supply voltage range
- 1.25 mA supply current per channel
- 130 MHz small signal bandwidth
- ±0.6 mV input offset voltage (MAX at 25°C)
- 55 V/μs slew rate

Applications

Ideal for active filters, current sensing, and driving ADCs.




Feedback Control Loop in Isolated DC-DC Module





















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 Bandwidth (MHz, A _v = 1)	I _{cc} (mA/ch)	2nd/3rd HD (R _L = 100)	Voltage Noise (nV/√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 ^{EW}	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 ^{EW} 	Single RRO op amp	460	365	3.3	-64/-66 at 10 MHz	10	TSOT23-6
LMH6618/9 ^{EW} 	Single/dual RRIO op amp	57	140	1.35	-74/-73 at 1 MHz	10	TSOT23-6, SOIC-8
LMH6622 ^{EW} 	Dual op amp	85 ²	160 ²	4.3	-90/-94 at 1 MHz	1.6	SOIC-8, MSOP-8
LMH6624 ^{EW} 	Single op amp	350 ¹	95 ¹	12	-63/-80 at 10 MHz	0.92	SOT23-5, SOIC-8
LMH6626 ^{EW} 	Dual op amp	320 ¹	85 ¹	12	-63/-80 at 10 MHz	1	SOIC-8, MSOP-8
LMH6628 ^{EW} 	Dual op amp	550 ²	300	9	-65/-74 at 10 MHz	2	SOIC-8
LMH6629 ^E 	Single ultra low noise op amp	1200 ³	800 ³	15	-90/-91 at 0.5 MHz	0.65	LLP-8, SOT23-5
LMH6702 ^{EW} 	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 ^{EW} 	Dual, wideband op amp	1300 ²	400 ²	5.8	-60/-75 at 20 MHz	3.4	SOIC-8
LMH6720 ^{EW} 	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/√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
LMP8645 ^E	High-voltage current sense variable gain amplifier	0.6	1.0	0.85	120	TSOT-6
 LMP8640 ^E	High-voltage current sense fixed gain amplifier	0.5	0.9	0.95	117	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 Performance

LMK04808 – Low-Noise Jitter Cleaner with Dual-Loop PLLs

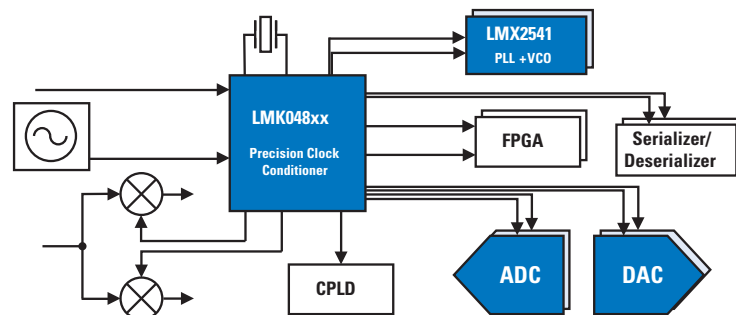
Features

- Dual-loop PLLatinum® architecture provides low-noise jitter cleaner and clock generation
- Integrated low-noise crystal oscillator circuit
- Ultra-low RMS jitter performance
 - 115 fs RMS jitter (12 kHz to 20 MHz)
 - 125 fs RMS jitter (100 Hz to 20 MHz)
- LVPECL, LVDS, or LVCMOS programmable outputs
- Clock rates of up to 1536 MHz
- Hold-over, zero delay, analog, and programmable digital delay modes

Applications

Ideal for data converter clocking, wireless infrastructure, networking, SONET/SDH, DSLAM

Typical Application Circuit



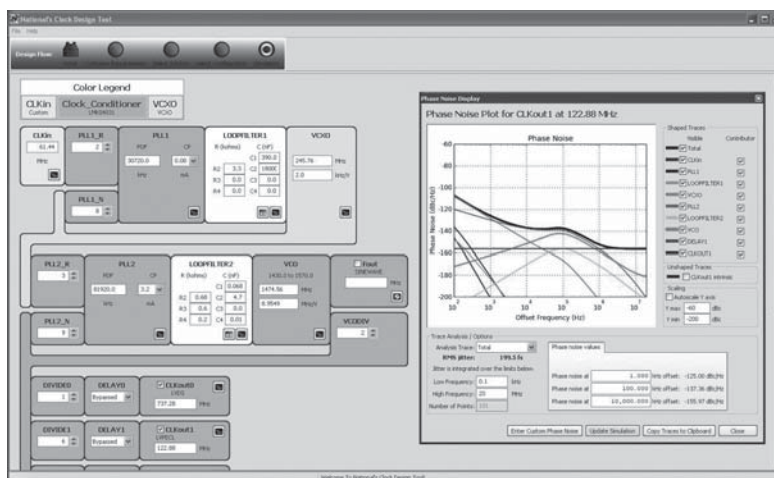
National's Clock Design Tool

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

Features

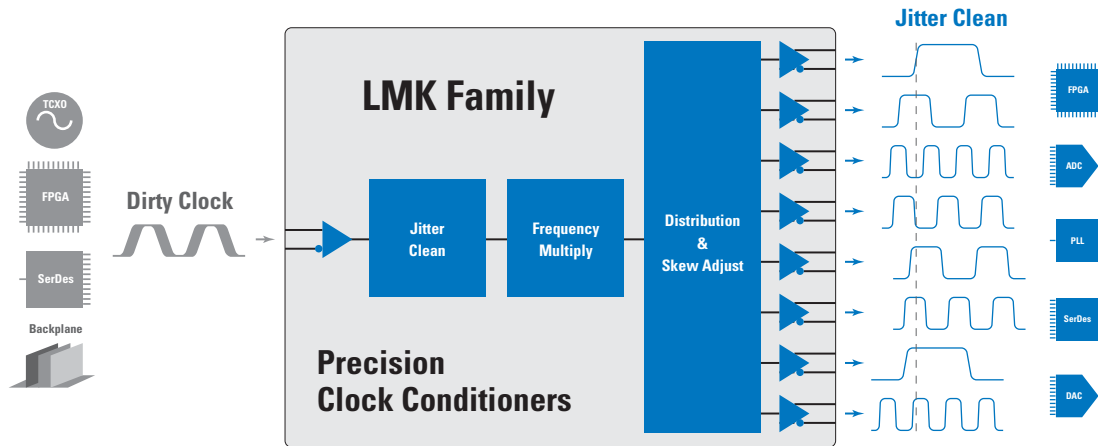
- Easy design parameter entry
- LMK part selection and configuration
- PLL and loop filter customization
- Input clock and VCXO phase noise entry
- Phase noise and jitter simulations and plotting
- Updated to support LMX2531 and LMX2541 part selection and design

Visit national.com/timing to test the Clock Design Tool.



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	LVCOS				
LMK01000 ^E	5	3	0	2:8 Clock Distribution	1 to 1600	NA	0.03 (additive)
LMK01010 ^E	0	8	0		1 to 1600	NA	0.03 (additive)
LMK01020 ^E	8	0	0		1 to 1600	NA	0.03 (additive)
LMK02000 ^E	5	3	0	PLL + Clock Distribution (needs external VCXO)	1 to 860	NA	0.2 (+VCXO)
LMK02002 ^E	4	0	0		1 to 860	NA	0.2 (+VCXO)
LMK03000C ^E	5	3	0	PLL + VCO + Clock Distribution	1 to 648	1185 to 1296	0.4
LMK03000 ^W	5	3	0		1 to 648	1185 to 1296	0.8
LMK03000D	5	3	0		1 to 648	1185 to 1296	1.2
LMK03001C ^E	5	3	0		1 to 785	1470 to 1570	0.4
LMK03001 ^W	5	3	0		1 to 785	1470 to 1570	0.8
LMK03001D	5	3	0		1 to 785	1470 to 1570	1.2
LMK03002C ^E	4	0	0		1 to 860	1566 to 1724	0.4
LMK03002	4	0	0		1 to 860	1566 to 1724	0.8
LMK03033C ^E	4	4	0		1 to 1080	1840 to 2160	0.5
LMK03033	4	4	0		1 to 1080	1840 to 2160	0.8
LMK03200	5	3	0	1 to 800	1185 to 1296	0.8	
LMK04000 ^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)
LMK04001 ^E	3	0	4		1 to 785	1430 to 1570	0.15/0.2 (+VCXO/Crystal)
LMK04011 ^E	5	0	0		1 to 785	1430 to 1570	0.15/0.2 (+VCXO/Crystal)
LMK04010	5	0	0		1 to 785	1185 to 1296	0.15/0.2 (+VCXO/Crystal)
LMK04031 ^E	2	2	2		1 to 785	1430 to 1570	0.15/0.2 (+VCXO/Crystal)
LMK04002 ^E	3	0	4		1 to 875	1566 to 1750	0.15/0.2 (+VCXO/Crystal)
LMK04033 ^E	2	2	2		1 to 1080	1840 to 2160	0.15/0.2 (+VCXO/Crystal)
NEW LMK04808 ^E	Supports 12 programmable outputs			Cascaded PLLs + VCO + Programmable Clock Distribution	1 to 1536	2750 to 3072	0.115

*Integrated from 10 kHz to 20 MHz

^E Evaluation board

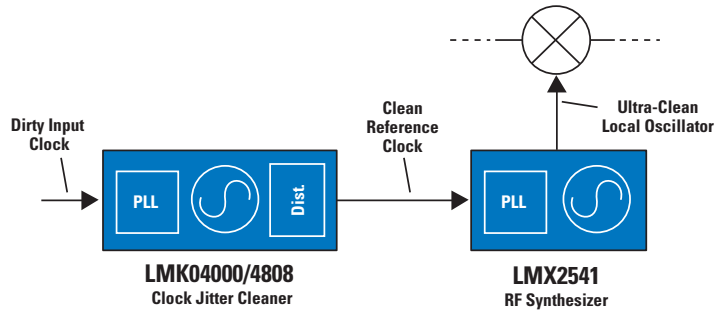
^W WEBENCH enabled

High-Performance Frequency Synthesizer Solutions

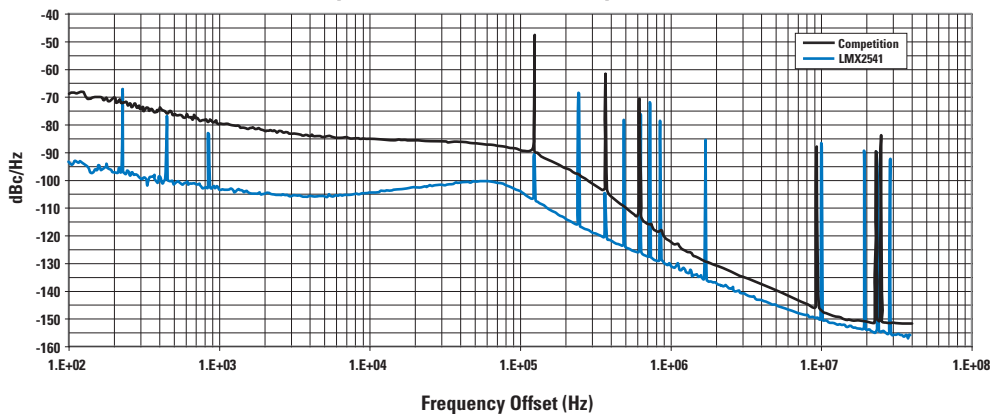
LMX2541 – Ultra-Low-Noise PLLatinum® Frequency Synthesizer with Integrated VCO

The LMX2541 family is the industry's lowest noise integrated frequency synthesizer. With the world's lowest noise Phase-Locked Loop (PLL), it provides less than 2 mrad 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 all LMK clock jitter cleaner, the LMX2541 significantly improves system error vector magnitude (EVM) for enhanced receiver sensitivity and transmitter spectral purity.



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







High-Performance PLLatinum® Family of PLL Products

High-Performance 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
LMX2487 ^{E,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
LMX2485 ^{E,W}	0.05 to 3.0	75 to 800	-209	5	2.5 to 3.6	LLP-24

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
LMX2531LQ1742E ^{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

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

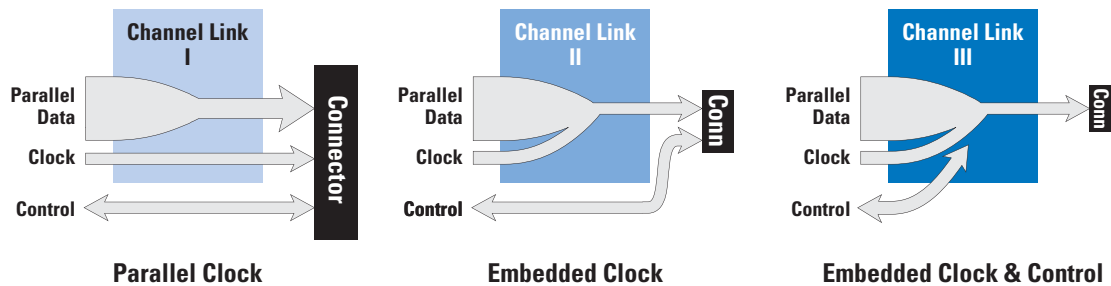
Serializers and Deserializers

Data Interface

Evolution of Channel Link Families of Serializers and Deserializers

Through three generations of Channel Link Serializers and Deserializers (Ser/Des), National has enabled robust high-speed data serialization in a wide array of high-speed data and video transport applications.

The latest Channel Link II and III Ser/Des deliver twice the cable length performance at half the system cost and are among the lowest-power chipsets in the industry.



Channel Link I

- Reduced parallel data bus
- 21-/28-/48-bit parallel data bus
- Eliminates the need for local reference oscillators and training/synchronization patterns

Channel Link II

- Clock and data bus over one wire pair
- Up to 32-bit parallel data bus
- Integrated signal conditioning and low EMI extend cable reach over inexpensive cables

Channel Link III

- Clock, data, and bidirectional control bus over one wire pair
- Up to 21-bit parallel data bus
- Integrated signal conditioning and low EMI extend cable reach over inexpensive cables

DS92LX1621/22 – 16-Bit, 10 to 50 MHz Channel Link III Embedded Clock Ser/Des

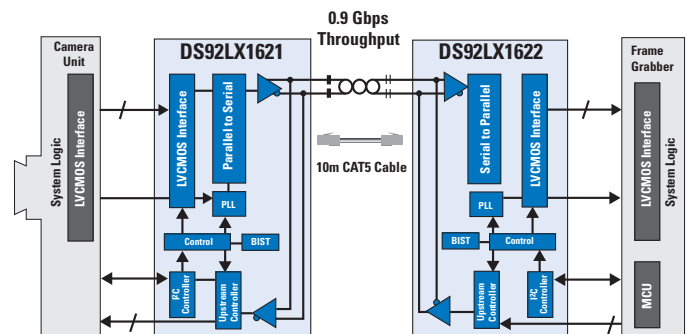
Features:

- Supports up to 900 Mbps application data payload
- Wide operating range up to 16-bit parallel data (LVCMOS), 10 to 50 MHz parallel clock
- Zero-latency, bidirectional, I²C-compatible control channel eliminates additional control wires
- Up to 6 general purpose, upstream control signals for increased design flexibility
- Embedded clock architecture eliminates external clock channel or reference clock
- Integrated signal conditioning (EQ) for inexpensive, long interconnects
- Automatic validation of data integrity
- Spread-spectrum clocking, staggered output control, and slew rate control for lower EMI

Applications

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

Typical Application Circuit



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
Channel Link III	✓	Moderate Rx EQ, Tx De-Emphasis	✓	DS92LX1621	DS92LX1622	16	LVC MOS	10	50	16:1
				DS92LX2121	DS92LX2122	21	LVC MOS	10	50	21:1
Channel Link II	✓	Moderate Rx EQ, Tx De-Emphasis	✓	NEW DS92LV2421	NEW DS92LV2422	24	LVC MOS	10	75	24:1
				DS92LV2411	DS92LV2412	24	LVC MOS	5	50	24:1
				NEW DS92LV0421	NEW DS92LV0422	4	LVDS	10	75	4:1
				DS92LV0411	DS92LV0412	4	LVDS	5	50	4:1
				DS99R103	DS99R104	24	LVC MOS	3	40	24:1
				DS92LV3241	DS92LV3242	32	LVC MOS	20	85	32:4
				DS92LV3221	DS92LV3222	32	LVC MOS	20	50	32:2
Channel Link	—	—	—	DS90CR217 ^E	DS90CR218A ^E	21	LVC MOS	20/12	85	21:3
				DS90CR287 ^E	DS90CR288A ^E	28	LVC MOS	20	85	28:4
				✓ DS90CR483A ^E	✓ DS90CR484A ^E	48	LVC MOS	33	112	48:8
				✓ DS90CR485 ^E	✓ DS90CR486 ^E	48	LVC MOS	66	133	48:8
8-/10-Bit Ser/Des	✓	Moderate Rx EQ, Tx Driver	✓	SCAN25100 ^E	SCAN25100	10	LVC MOS	30.72	122.88	10:1
10-/16-/18-Bit Ser/Des	✓	—	—	DS92LV1021A ^E	DS92LV1212A ^E	10	LVC MOS	16	40	10:1
				SCAN921025H	SCAN921226H	10	LVC MOS	20	80	10:1
				SCAN928028 ^E	SCAN926260 ^E	n×10	LVC MOS	25/16	66	10:1
				DS92LV16 ^E	DS92LV16	16	LVC MOS	25	80	16:1
				DS92LV18 ^E	DS92LV18	18	LVC MOS	15	66	18:1

^E Evaluation board

Comparison of Ser/Des Technology Alternatives

Technology	Max Serial Datarate	Cable Reach	ESD	Reference Clock	Solution Cost
Channel Link III	1.2 Gbps	> 10m	> 8 kV	Not required	Low
Channel Link II	2.7 Gbps	> 10m	> 8 kV	Not required	Low
Channel Link	0.6 Gbps	< 5m	> 8 kV	Not required	Low
FPGA-Link	3.125 Gbps	> 15m	> 8 kV	Not required	Low
Low-cost FPGA Ser/Des	3.125 Gbps	Limited	< 2 kV	Required	High
8-/10-bit Ser/Des	Variable	Limited	< 8 kV	Required	Moderate

LVDS and CML Repeaters, Equalizers

Signal Conditioning — Extend Your Reach

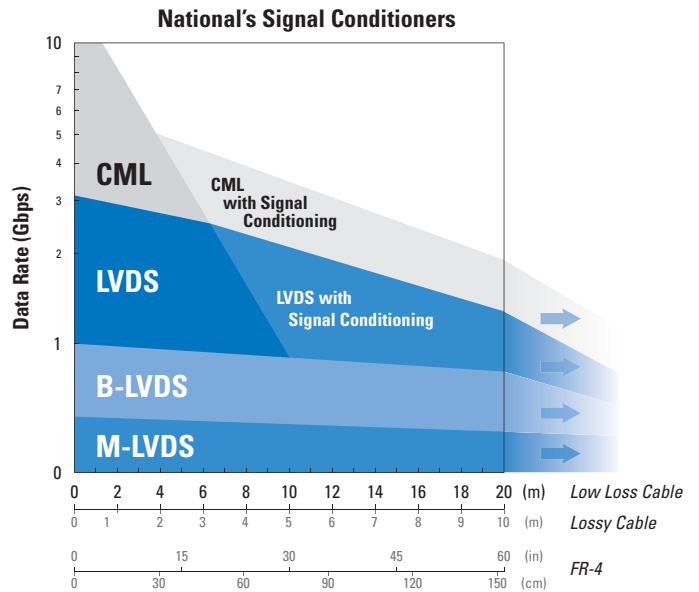
National offers an array of signal conditioning solutions, covering data rates from DC to 10 Gbps and topologies ranging from point-to-point to 32 multidrop loads.

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.



DS50PCI401 – PCIe Standards-Approved Gen-1 and Gen-2 Quad Transceiver

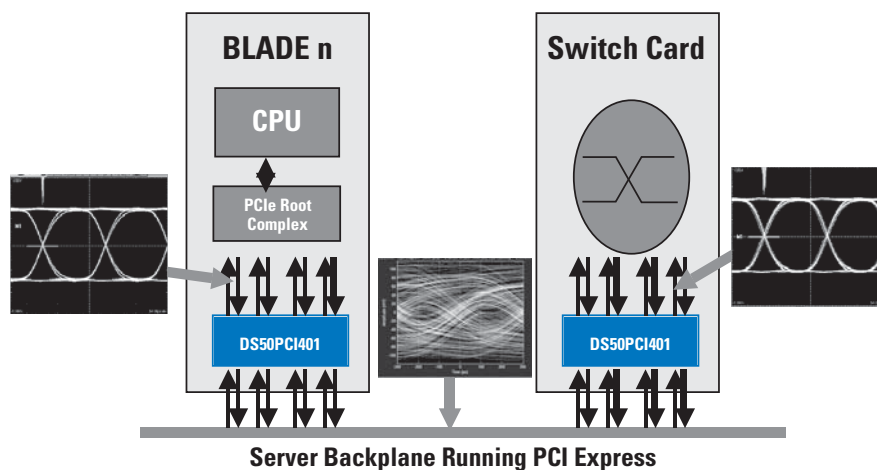
Features

- 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

Applications

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



Signal Conditioners

PCIe, SAS, SATA, CPRI, Infiniband

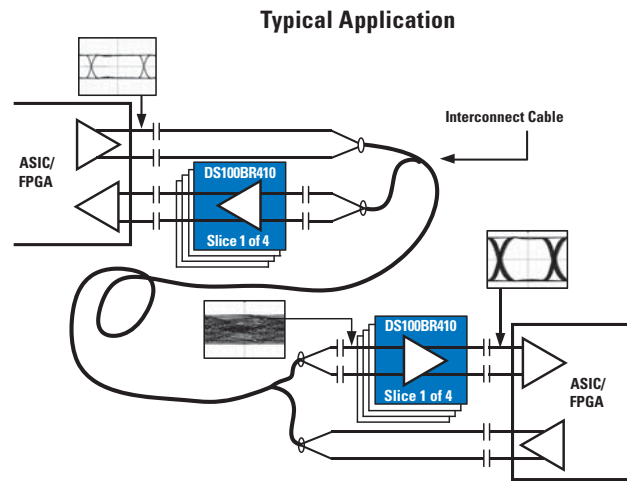
DS100BR410/210/111 – 10 Gbps Repeaters with Equalizer and De-Emphasis Driver

Features

- DS100BR410 (quad, uni-directional), DS100BR210 (dual, uni-directional), DS100BR111 (dual, bi-directional)
- Low power consumption with option to power down unused channel
- Adjustable receive equalization +36 dB
- Adjustable transmit de-emphasis
- <.3 UI of residual DJ at 10 Gbps with 50' FR-4
- Signal conditioning programmable via pin selection or SMBus interface

Applications

Designed for use in active copper cable assemblies and backplane interconnects.



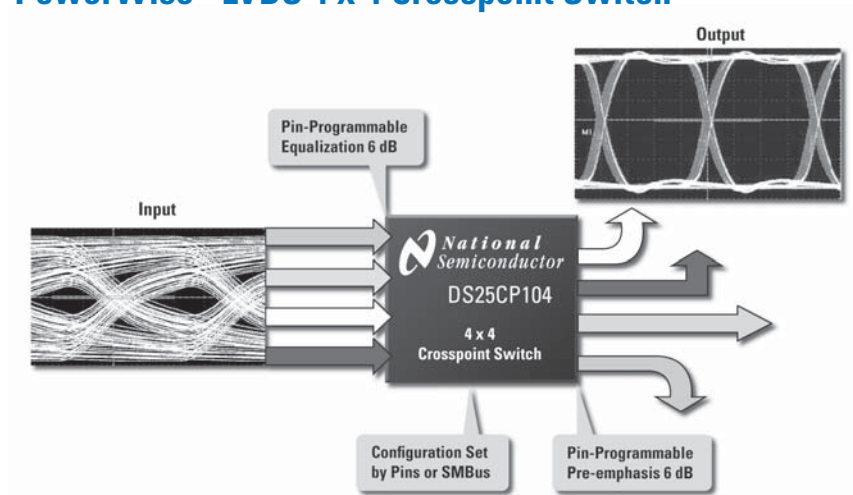
Signal Conditioners

Product ID	Channels	Protocol	Max Speed/Ch (Gbps)	Input SigCon (Max dB)	Output SigCon (Max dB)	Power/Ch (mW)	Packaging	Control Interface
Protocol-Specific Signal Conditioners								
DS50PCI402 ^E	8	PCIe	5.0	26	-12	95	LLP-54	Pin or SMBus
DS64BR401 ^E	8	SAS/SATA	6.4	33	-12	95	LLP-54	Pin or SMBus
Product ID	Channels	I/O Compatibility	Max Speed/Ch (Gbps)	Input SigCon (Max dB)	Output SigCon (Max dB)	Power (mW)	Packaging	Configuration
Multi-Protocol Signal Conditioners								
NEW DS100BR410 ^E	4	LVDS/LVPECL/CML	10.3	36	-9.0	55	LLP-40	Pin or SMBus
NEW DS100BR111/210	2	LVDS/LVPECL/CML	10.3	36	-12.0	65	LLP-24	Pin or SMBus
DS80EP100 ^E	1	LVDS/LVPECL/CML	12.5	7.0	—	0	LLP-6	Fixed
DS64BR401 ^E	8	LVDS/LVPECL/CML	6.4	33	-12	95	LLP-54	Pin or SMBus
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
Multi-Protocol Buffers, Stub-Hiders								
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

^EEvaluation 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.

DS64MB201 – Dual-Lane 2:1/1:2 Mux/Buffer with Equalization and De-Emphasis

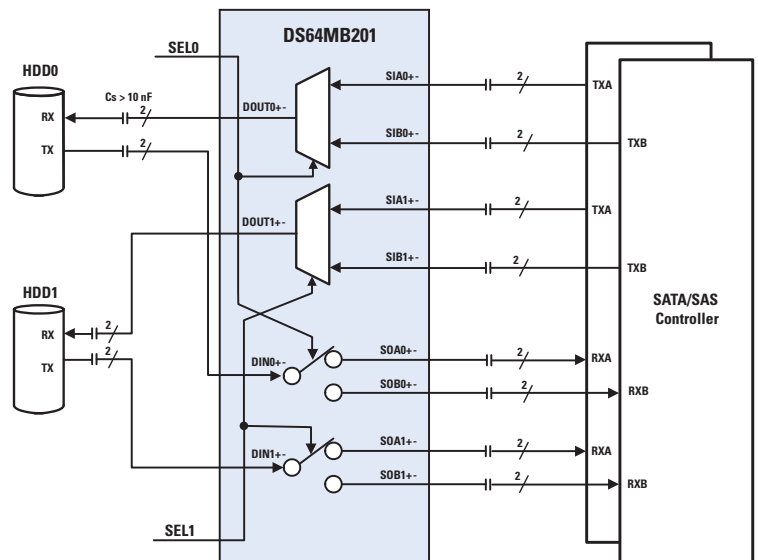
Features

- Adjustable receive equalization up to +33 dB gain
- Adjustable transmit de-emphasis up to -12 dB
- Adjustable transmit VOD
- <0.25 UI of residual DJ at 6.4 Gbps with 40" FR4 trace
- SATA/SAS OOB signal pass-through
- Low power consumption 100 mW per port
- Signal conditioning programmable via pin selection or SMBus interface
- Single 2.5V supply operation

Applications





Ideal for use in SAS, SATA, XAUI, sRIO, Fiber Channel, Infiniband, and FR-4 backplane traces.

Typical Circuit





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 Narrow	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
 DS64MB201 ^E 	2:1 & 1:2	2	6.4	EQ,33	De-E, -12	800	LLP-54	SAS, SATA, OOB support
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

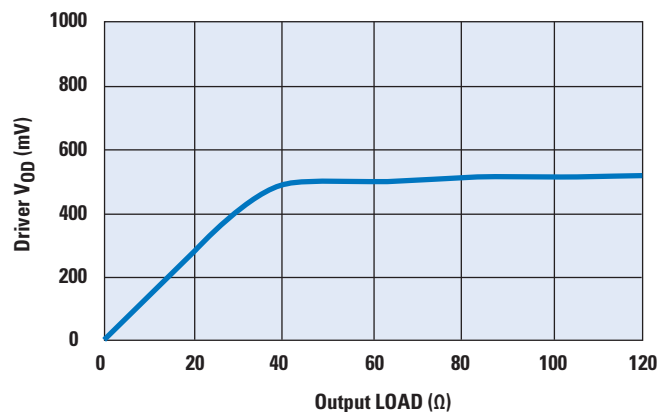
Features

- 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

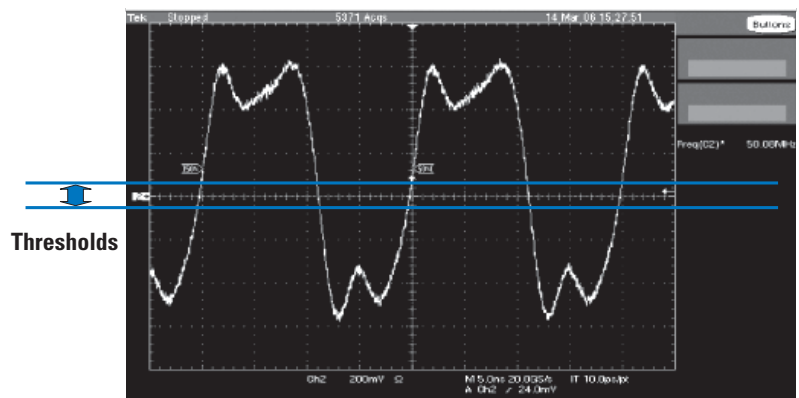
Applications

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	LVTTTL	LVDS	17	SOIC-8	>8 kV ESD
DS90LV027A	Line driver	2	600	LVTTTL	LVDS	27	SOIC-8	Available in AEC-Q
DS90LT012A	Receiver	1	400	LVDS	LVTTTL	18	SOT23-5	Available in AEC-Q
DS90LV011A	Line driver	1	400	LVTTTL	LVDS	17	SOT23-5	Available in AEC-Q
DS90LV018A	Receiver	1	400	LVDS	LVTTTL	18	SOIC-8	>7 kV ESD
DS90LV028A	Receiver	2	400	LVDS	LVTTTL	18	SOIC-8/LLP-8	Available in AEC-Q
DS90LV047A	Line driver	4	400	LVTTTL	LVDS	14	SOIC-16	Ganged enable
DS90LV048A	Receiver	4	400	LVDS	LVTTTL	30	SOIC-16/TSSOP-16	Ganged enable
DS90LV049	Driver+receiver	2+2	400	LVTTTL/LVDS	LVTTTL/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/LVTTTL/LVDS	TTL/LVTTTL/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	LVTTTL/M-LVDS	LVTTTL/M-LVDS	221	LLP-32	Failsafe, '176 pinout
DS91M047 ^E	M-LVDS line driver	4	250	LVC MOS	M-LVDS	215	SOIC-16	Failsafe, '180 pinout
DS91M124 ^E	M-LVDS repeater	1:4	250	LVC MOS	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	LVTTTL/M-LVDS	LVTTTL/M-LVDS	66	SOIC-8	Failsafe
DS91C180	M-LVDS driver/receiver pair	1+1	200	LVTTTL/M-LVDS	LVTTTL/M-LVDS	56	SOIC-14	8 kV ESD
DS91D176	M-LVDS transceiver	1	200	LVTTTL/M-LVDS	LVTTTL/M-LVDS	66	SOIC-8	
DS91D180	M-LVDS driver/receiver pair	1+1	200	LVTTTL/M-LVDS	LVTTTL/M-LVDS	66	SOIC-14	8 kV ESD
DS92LV040A	B-LVDS transceiver	4	155	LVTTTL/LVDS	LVTTTL/LVDS	231	LLP-44	
DS92LV010A	B-LVDS transceiver	1	100	LVTTTL/LVDS	LVTTTL/LVDS	53	SOIC-8	
DS92LV090A	B-LVDS transceiver	9	100	LVTTTL/LVDS	LVTTTL/LVDS	429	LQFP-64	Low skew
SCAN92LV090	B-LVDS transceiver	9	100	LVTTTL/LVDS	LVTTTL/LVDS	429	FBGA-64/ LQFP-64	Low skew

^E Evaluation board

Ethernet Backhaul and IEEE 1588 Solutions

High-Speed Ethernet Connectivity, Single Port Solutions

DP83630/40 – Precision PHYTER® – IEEE 1588 Precision Time Protocol Transceiver

Features

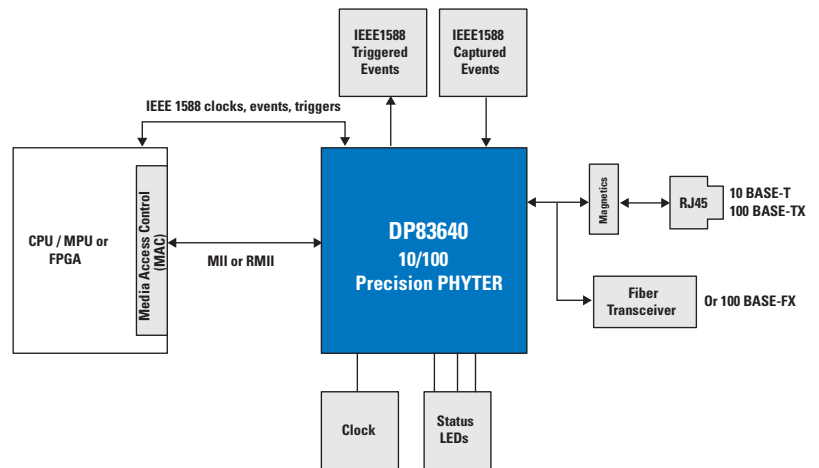
- Enable IEEE 1588 with any MAC based microcontroller, FPGA or ASIC
- Node synchronization accuracy to <10 nS
- Replace E1/T1 lines and expensive GPS clocks
- Synchronized clock output
- Synchronous Ethernet support
- IEEE 802.3 compliant
- Industry's lowest deterministic latency
- Cable health diagnostic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

See Power-over-Ethernet (PoE) solutions on page 40.

Applications

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

Typical Application Diagram



DP83630/40 Precision PHYTER

Parameter	Industrial
Temp Range (°C)	-40 to 85
Number of Ports	Single
Interface	MII/RMII
IEEE 1588 Precision Time Protocol v1 and v2	< 10 nS
Cable Health Diagnostics	•
Fiber Support	•
Synchronized GPIOs	12
Synchronized Clock Output	•
IEEE 1149.1 (JTAG)	•
LEDs	3
Packaging	LLP-48, LQFP-48
Package Size (mm)	7 x 7 x 1.4

Comparing Latency in IEEE 1588 Solution Implementations

Approach	Development Required	Aggregate Delay
SW Only	Software changes	> 10 µs
FPGA	Significant HW changes	> 30 ns
	Software changes	
Microcontroller	HW changes	> 30 ns
	Software changes	
Embedded in PHY (DP83640)	Software changes	< 10 ns

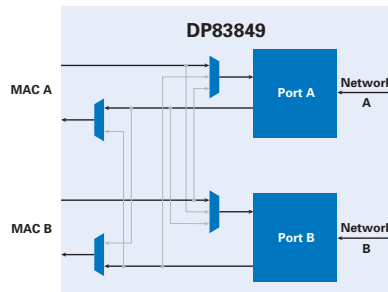
Ethernet Backhaul and IEEE 1588 Solutions

High-Speed Ethernet Connectivity, Dual Port Solutions

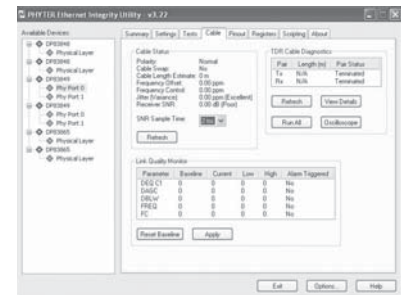
DP83849 – Dual PHYTER® 10/100 Ethernet PHY

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)



Unique flexible switching capability



Enhanced cable diagnostics

See Power-over-Ethernet (PoE) solutions on page 40.

Applications

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

High-Speed Industrial Ethernet

Product ID	Temp Range (°C)	Number of Ports	IEEE 1588	Interface	Typ Power (mW)	Fiber Support	Flexible Port Switching	IEEE 1149.1 (JTAG)	Wake-on-LAN (WOL)	Rx Packet Filtering	Package
NEW DP83620	-40 to 85	10/100 Single		MII/RMII	280	✓		✓			LLP-48
NEW DP83630/40 ^E	-40 to 85	10/100 Single	✓	MII/RMII	280	✓		✓			LLP-48/ LQFP-48
DP83848C ^E	0 to 70	10/100 Single		MII/RMII/SNI	265			✓			LQFP-48
DP83848I ^E	-40 to 85	10/100 Single		MII/RMII/SNI	265			✓			LQFP-48
DP83848VYB	-40 to 105	10/100 Single		MII/RMII/SNI	265			✓			LQFP-48
DP83848YB ^E	-40 to 125	10/100 Single		MII/RMII/SNI	265			✓			LQFP-48
DP83848M/T/H ^E	0 to 70 -40 to 85 -40 to 125	10/100 Single		MII/RMII	265						LLP-40
DP83848J/K ^E	0 to 70 -40 to 85	10/100 Single		MII/RMII	265						LLP-40
DP83849C ^E	0 to 70	10/100 Dual		MII/RMII/SNI	300 / Port						TQFP-80
DP83849I ^E	-40 to 85	10/100 Dual		MII/RMII/SNI	300 / Port		✓	✓			TQFP-80
DP83849ID ^E	-40 to 85	10/100 Dual		MII/RMII/SNI	300 / Port	✓					TQFP-80
DP83849IF ^E	-40 to 85	10/100 Dual		MII/RMII/SNI	300 / Port	✓	✓				TQFP-80
DP83816 ^E	0 to 70	10/100 + MAC Single		V2.2 33 MHz PCI bus	116				✓	✓	LQFP-144
DP83865	0 to 70	10/100/1000 Single		GMII / RGMII	1100			✓	✓		PQFP-128

^E Evaluation board available

JTAG System Product Solutions

Remote Diagnostic and Reconfiguration Solutions

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
- Remotely manage, diagnose, and reconfigure systems
- Monitor critical analog voltages

SCANSTA476 – 8 Channel IEEE 1149.1 Analog Voltage Monitor

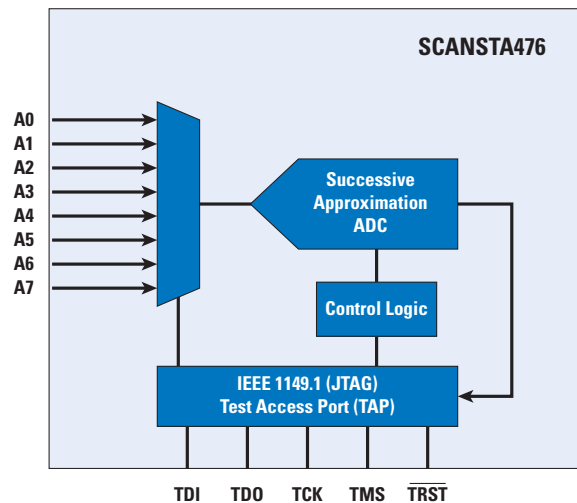
Features

- 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.

Block Diagram



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 Communications Infrastructure

Wired and wireless infrastructure equipment continues 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

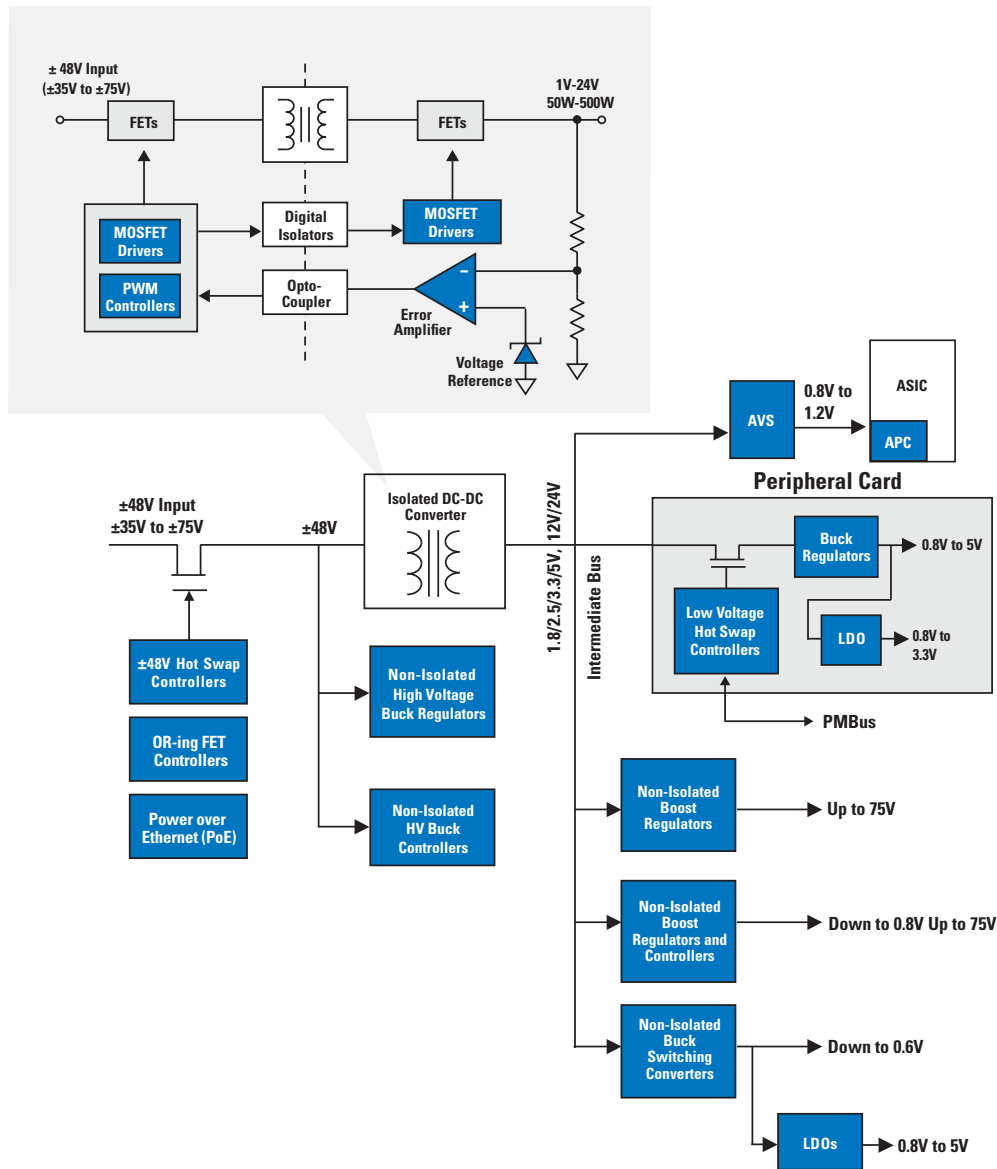
entire power chain—from the AC main power supply down to point-of-load. Each of National's power products are designed for best-in-class performance with advance process technology, chip-scale packaging, and proprietary circuitry.

Power Management Solutions

Product	Features	Benefits
System Protection and Management		
Hot Swap Controllers	Current and Power Limiting for MOSFET SOA protection Complete coverage for all bus voltages (+48V, -48V, 3 to 17V) Integrated telemetry functionality with digital communication of voltage, current, and power parameters	Maximum system protection to improve system robustness Complete system coverage across multiple platforms Complete system protection and management solution to increase system reliability and efficiency
OR-ing FET Controllers	Wide input operating range Precision/fast reverse current comparator for near ideal diode emulation MOSFET short detection/diagnostic	Flexibility across multiple rails with transient headroom for spike protection Minimizes potential system damage against reverse current and optimizes efficiency Improves system reliability by enabling user to replace defective FETs before catastrophic system failure
Isolated Power		
POE Controllers	Integrated PD controller and PWM controller V_{IN} range up to 100V	Allows user to integrate power conversion, robustness, and handle fault situations more effectively Eliminates additional bias regulation and protection circuitry
Isolated PWM Controllers	Integrated bias regulators and high voltage drivers Support for multiple switching topologies, including Active Clamp, half-bridge, full-bridge, push, pull, and Cascade	Enables higher power density and smaller module form factors Design flexibility to support designs from <100W to more than 500W
MOSFET Gate Drivers	High voltage, high current support	Higher power density
Point-of-Load Power		
SIMPLE SWITCHER® Power Modules	Single DAP package with exposed leads Low EMI	Easy prototyping and manufacturing Complies with EN55022 (CISPR22) Class B Radiated EMI standard
Non-Isolated Controllers and Regulators	Wide operating voltage range Integrated synchronous FETs	Flexibility for use in multiple applications Smaller form factors, higher efficiency and reduced bill of materials
Low Dropout Regulators	Low noise Low dropout	Preserve signal fidelity in analog signal path Higher efficiency

Power Solutions for Communications Infrastructure

End-to-End Power Management Solutions



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:

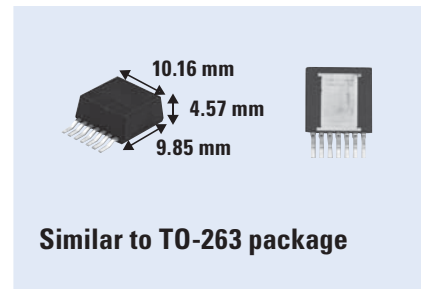
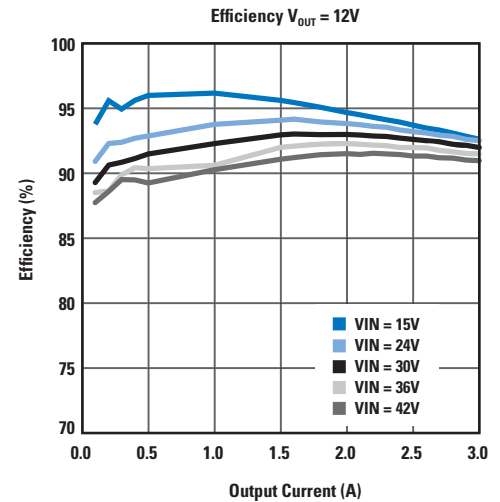
- Single DAP and standard IC leads in a convenient size and lead pitch
- Compatible with pick-and-place manufacturing used for TO-263
- Easy to hand solder for quick prototyping
- Fully RoHS compliant
- Pin-to-pin compatibility and identical footprint for different load currents within each module series

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.

Visit national.com/switcher for more information about the entire line of energy-efficient SIMPLE SWITCHER products.

LMZ14203H Efficiency



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.

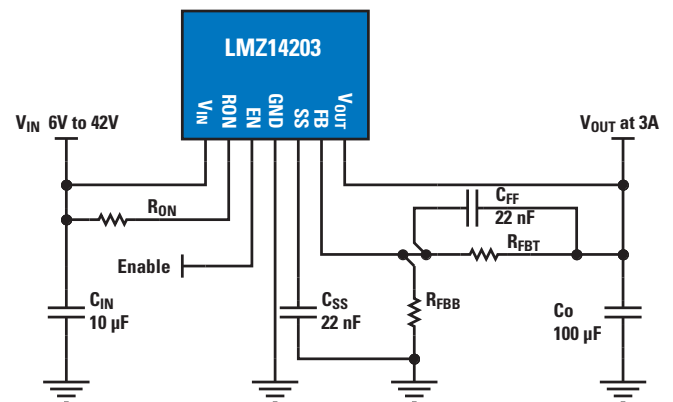
Features

- 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.

Simplified Application Circuit



SIMPLE SWITCHER Power Modules

Product ID	Output Current (A)	Input Min Voltage (V)	Input Max Voltage (V)	Output Min (V)	Output Max (V)	Freq (kHz)	Packaging
LMZ10503/EXT ^{EW}	3	2.95	5.5	0.8	5	1000	TO-PMOD-7
LMZ10504/EXT ^{EW}	4	2.95	5.5	0.8	5	1000	TO-PMOD-7
LMZ10505/EXT ^{EW}	5	2.95	5.5	0.8	5	1000	TO-PMOD-7
LMZ12001/EXT ^{EW}	1	4.5	20	0.8	6	1000 max	TO-PMOD-7
LMZ12002/EXT ^{EW}	2	4.5	20	0.8	6	1000 max	TO-PMOD-7
LMZ12003/EXT ^{EW}	3	4.5	20	0.8	6	1000 max	TO-PMOD-7
LMZ14201/EXT ^{EW}	1	6	42	0.8	6	1000 max	TO-PMOD-7
LMZ14202/EXT ^{EW}	2	6	42	0.8	6	1000 max	TO-PMOD-7
LMZ14203/EXT ^{EW}	3	6	42	0.8	6	1000 max	TO-PMOD-7
^{NEW} LMZ14201H ^{EW}	1	6	42	5	24	1000 max	TO-PMOD-7
^{NEW} LMZ14202H ^{EW}	2	6	42	5	24	1000 max	TO-PMOD-7
^{NEW} LMZ14203H ^{EW}	3	6	42	5	24	1000 max	TO-PMOD-7

PowerWise® product

^E Evaluation board

^W WEBENCH enabled

Power-over-Ethernet Solutions

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

Features

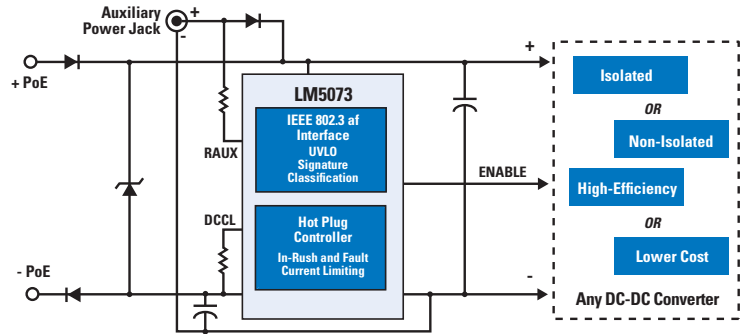
- Fully compliant IEEE 802.3af PD interface
- Versatile auxiliary power options, including flexible interface to AC adaptor
 - 13V minimum front auxiliary power range
 - 9V minimum rear auxiliary power range
- Programmable DC current limit up to 800 mA
- Complimentary open drain outputs allow flexible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

Application Diagram



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

LM25066 – System Power Management and Protection IC with PMBus

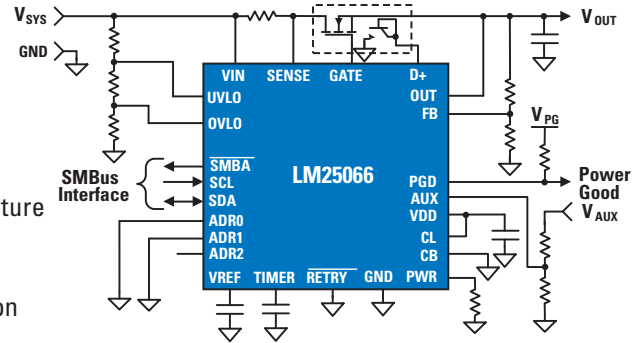
Features

- 2.9 to 17V input voltage range
- 25 or 50 mV current limit threshold
- Power limited control of hot-swap insertions, in-rush current, and circuit breaker functions
- Real-time system telemetry monitoring
- Multi-level configuration and monitoring of system fault conditions via PMBus
- I²C-compliant/SMBus interface and PMBus-compliant command structure

Applications

Ideal for use in server backplane systems, basestation power distribution systems, and solid-state circuit breakers.

Typical Block Diagram

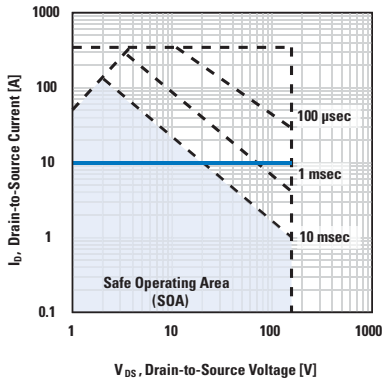


Power Limiting Protects External Pass Device for Improved System Reliability

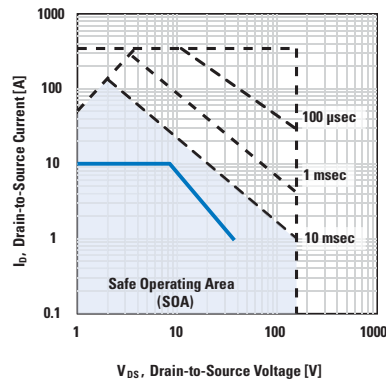
To ensure system reliability, MOSFET drivers must operate within the SOA in order to avoid FET failure. National's LM(2)506x hot swap controllers provide both current and

power limiting to dynamically adjust the current limit at large V_{DS} and ensure the MOSFET stays in the SOA at all conditions.

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/OVLO	Active In-Rush Current Limiting	Active Current/Power Limiting	Fault Latch-Off / Auto Retry	Monitoring	Digital Interface	Packaging
LM5067 ^E	-9 to -80V	V_{DS}	✓	✓	✓	✓	—	—	MSOP-10, LLP-10
LM5069 ^E	+9 to +100V	V_{DS}	✓	✓	✓	✓	—	—	MSOP-10
LM25061 ^E	+2.9 to +16V	V_{OUT} (Adj.)	UVLO	✓	✓	✓	—	—	MSOP-10
NEW LM25066 ^E	+2.9 to +17V	V_{DS} (Adj.)	✓	✓	✓	✓	Current, voltage, power, temp	I ² C/SMBus with PMBus-compliant	LLP-24
LM25069 ^E	+2.9 to +16V	V_{DS}	✓	✓	✓	✓	—	—	MSOP-10
LM5060 ^E	+5.5 to +65V	V_{DS}	✓	✓	✓	Latch-off	—	—	MSOP-10

PowerWise[®] product

^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, Cascade	LM5034, LM5041
1/4 Brick	300 to 400W	Cascade, Half-Bridge, Full-Bridge	LM5041, LM5035, LM5039, LM5037, LM5045, LM5046
1/8 Brick	100 to 250W	Active Clamp Forward, Half-Bridge, Full Bridge	LM5025, LM5026, LM5027, LM5035, LM5039, LM5045/46
1/16 Brick	< 100W	Active Clamp Forward	LM5025, LM5026, LM5027

LM5045/46 – Most Integrated Family of Full-Bridge PWM Controllers

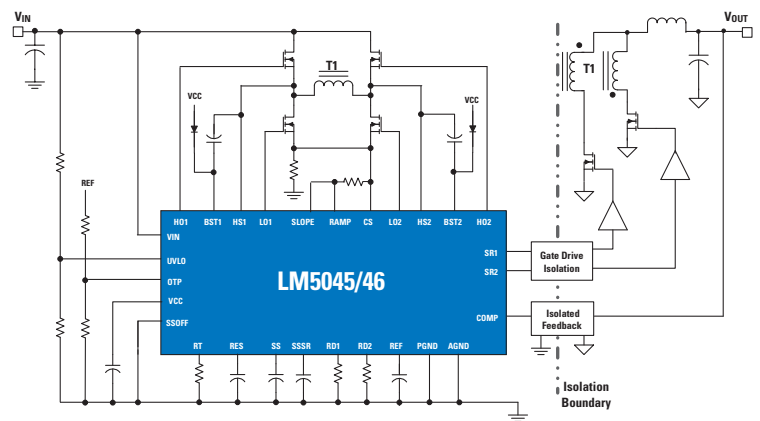
Features

- High current 2A full-bridge gate drivers
- Intelligent sync rectifier start-up for linear turn-on into pre-biased loads
- 5V sync rectifier drive for digital isolators or transformer
- 105V high-current start-up regulator
- Independently programmable synchronous rectifier delays (LM5045)
- Programmable resonant times for ZVS operation (LM5046)

Applications

Ideal for use in high power density module manufacturing.

Block Diagram



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, half-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, half-bridge, full-bridge	100	15	1.5	1000	C	TSSOP-20	Dual-mode current limit
LM5033 ^E	Push-pull, half-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	Half-bridge	105	13	2	1000	V/C	LLP-24, eTSSOP-20, TSSOP-28	Sync rectification for high efficiency
LM5037 ^E	Push-pull, half-bridge, full-bridge	105	13	1.2	2000	V	TSSOP-16	Alternating outputs
LM5027/A ^E	Forward active clamp	105	13	2/1/3	1000	V	eTSSOP-20, LLP-24	3A sync rectifier driver
LM5039 ^E	Half-bridge	105	13	2	1000	V/C	LLP-24, eTSSOP-20	Average, Cycle-Cycle, Hiccup
NEW LM5045/46 ^E	Full-bridge	105	14	2	2000	V/C	eTSSOP-28, LLP-28	Pre-bias startup

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

MOSFET and OR-ing FET Drivers

LM5050 – High Side OR-ing FET Controller

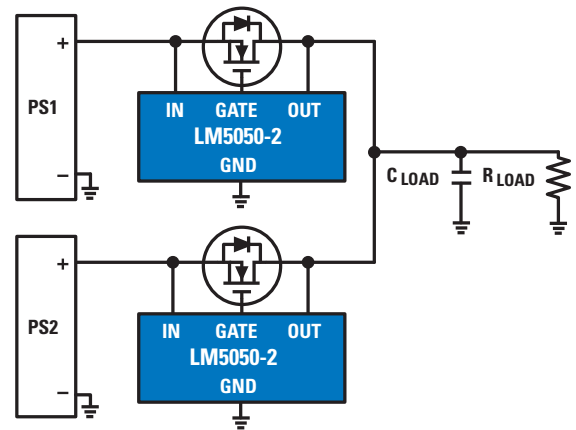
Features

- Charge pump gate driver for external N-channel MOSFET
- Input operating range from 6 to 75V
- +100V transient capability
- Precision reverse current comparator for near ideal diode emulation
- FET diagnostic test mode allows system controller to test for shorted MOSFETs

Applications

Ideal for use in communications infrastructure equipment and industrial and merchant power applications.

Block Diagram



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, eMSOP-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, LLP-10
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, LLP-8, 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
NEW LM5050-2 ^E	OR-ing FET Controller	75	6	75	2	N/A	N/A	N/A	N/A	Single	TSOT-6

^E Evaluation board

Non-Isolated High-Voltage Buck Regulators

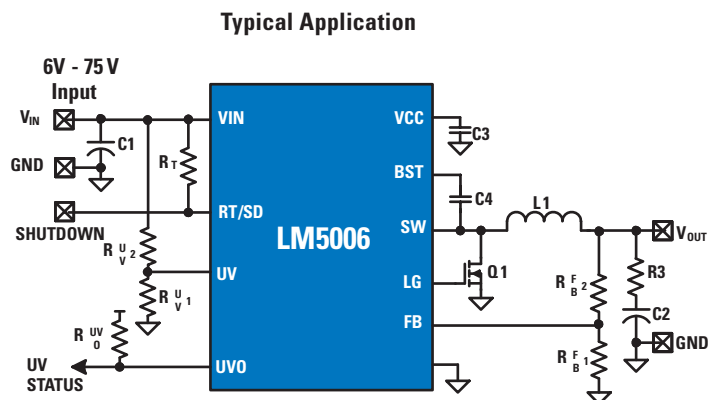
LM5006 – 80V, 650 mA Constant On-Time Synchronous Buck Switching Regulator

Features

- Operating input voltage range 6 to 75V
- Gate output driver for synchronous rectification
- Programmable input UV detector with status flag output
- Integrated 80V, N-channel buck switch
- No loop compensation required
- Ultra-fast transient response
- Operating frequency remains constant with line and load variations
- Adjustable output voltage from 2.5V
- Precision internal reference $\pm 2.5\%$

Applications

Ideal for use as a non-isolated telecommunications buck regulator capable of operating in synchronous or non-synchronous rectification mode.



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 ^{EW}	0.15	9.5 / 6	95	2.5	85	50 to 600	—	Constant on-time	LLP-8, MSOP-8
LM5008/A ^{EW}	0.35	9.5 / 6	95	2.5	75	50 to 600	—	Constant on-time	LLP-8, MSOP-8
LM22671/74 ^{EW}	0.5	4.5	42	1.285	30	500/Adj. to 1000	—	Voltage	PSOP-8
LM(2)5007 ^{EW}	0.5	9	42/75	2.5	37/73	50 to 800	—	Constant on-time	MSOP-8
LM25574 ^{EW}	0.5	6	42	1.23	40	50 to 1000, Sync	—	Current	TSSOP-16
LM5574 ^{EW}	0.5	6	75	1.23	70	500, Sync	—	Current	TSSOP-16
NEW LM5006 ^{EW}	0.65	6	75	2.5	70	50 to 800	✓	Constant on-time	MSOP-10
LM3103 ^{EW}	0.75	4.5	42	0.6	38	1000	✓	Constant on-time	eTSSOP-16
LM22672/75 ^{EW}	1	4.5	42	1.285	30	500/Adj. to 1000	—	Voltage	PSOP-8
LM5010/A ^{EW}	1	8 / 6	75	2.5	70	50 to 1000	—	Hysteretic	LLP-10, eTSSOP-14
LM25575 ^{EW}	1.5	6	42	1.23	40	50 to 1000, Sync	—	Current	eTSSOP-16
LM5575 ^{EW}	1.5	6	75	1.23	70	500, Sync	—	Current	eTSSOP-16
LM22680 ^{EW}	2	4.5	42	1.285	30	500	—	Voltage	PSOP-8
LM(2)5005 ^{EW}	2.5	7	42/75	1.23	40/70	500, Sync	—	Current mode	TSSOP-20
LM3102 ^{EW}	2.5	4.5	42	0.8	38	1000	✓	Constant on-time	eTSSOP-20
LM22670/73/76 ^{EW}	3	4.5	42	1.285	30	200 to 1000	—	Voltage	TO-263 THIN, PSOP-8
LM25576 ^{EW}	3	6	42	1.23	40	50 to 1000, Sync	—	Current	eTSSOP-20
LM5576 ^{EW}	3	6	75	1.23	70	500, Sync	—	Current	eTSSOP-20
LM22677/78/79 ^{EW}	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

Designed to support higher current applications.

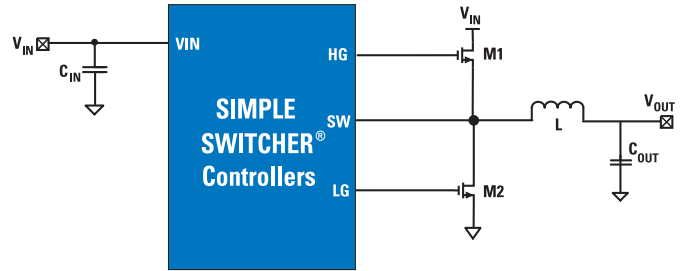
Features

- Input voltage ranging from 6 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.

Topology Diagram



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	Synchronous	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 ^{EW}	4.5	75	1	1.2	70	50 to 1000, Sync	—	Constant on-time	eTSSOP-16
LM5118 ^{EW}	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 ^{EW}	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	50 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 ^{EW}	6	42	1	0.6	40	1000	✓	Constant on-time	TSSOP-14
LM3151/52/53 ^{EW}	6	42	1	3.23	3.37	250, 500, 750	✓	Constant on-time	TSSOP-14

PowerWise product

^E Evaluation board

^W WEBENCH enabled

Non-Isolated Synchronous Regulators

Point of Load (POL)

LM2121x – Family of High Current (12 -15A) High-Efficiency Synchronous Buck Regulators

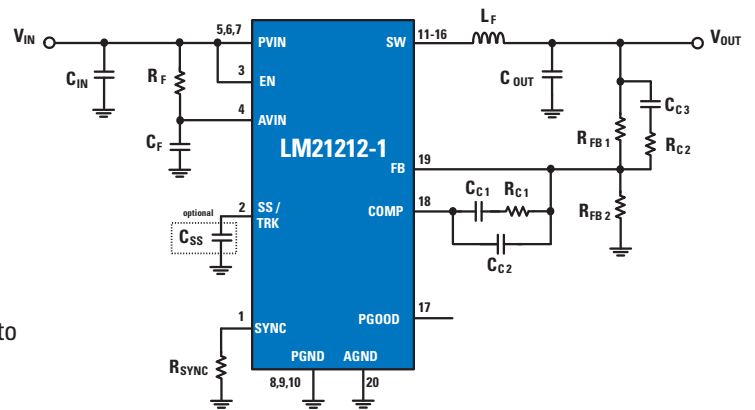
Features

- Greater than 97% peak efficiency
- Capable of delivering up to 15A of continuous output current
- Sub 7 mΩ integrated FET switches
- Adjustable output voltage down to $0.6V \pm 1\%$
- Output voltage tracking capability
- Precision enable pin with hysteresis
- Integrated OVP, OTP, UVLO, and Power Good

Applications

Ideal for use in basestations, servers, and 5V POL conversions to drive high-performance ASICs and FPGAs.

Block Diagram



Non-Isolated PoL (<42V) Synchronous 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	PWM Mode	Packaging
LM3670 ^{E,W}	0.35	2.5	5.5	0.7	3.3	1000, Fixed	Voltage, feed-forward	SOT23-5
LM3673/79 ^{E,W}	0.35	2.7	5.5	1.1	3.3	2000, Fixed	Voltage, feed-forward	micro SMD-5
LM3671/74 ^{E,W}	0.6	2.7	5.5	1.1	3.3	2000, Fixed	Voltage, feed-forward	SOT23-5, LLP-6
LM3676/77 ^E	0.6	2.9	5.5	1.1	3.3	2000, Fixed	Voltage, feed-forward	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
LM20123/33/43 ^{E,W}	3	2.95	5.5	0.8	5	460 to 1500, Sync	Current	eTSSOP-16
LM2853 ^{E,W}	3	3.0	5.5	0.8	3.3	550, Fixed	Voltage	TSSOP-14
LM20323/33/43 ^{E,W}	3	4.5	36	0.8	32	200 to 1500, Sync	Current	eTSSOP-20
LM20124/34/44/54 ^{E,W}	4	2.95	5.5	0.8	5	460 to 1500, Sync	Current	eTSSOP-16
LM2854 ^{E,W}	4	2.95	5.5	0.8	5	500, 1000, Fixed	Voltage	TSSOP-14
LM20125/45 ^{E,W}	5	2.95	5.5	0.8	5	250 to 750, Fixed	Current	eTSSOP-16
LM20136/46 ^{E,W}	6	2.95	5.5	0.8	5	250 to 750, Sync	Current	eTSSOP-16
LM21305 ^E	5	3.0	18	0.6	5	300 to 1500, Sync	Current	LLP-28
LM10500	5	3.0	18	0.6	5	300 to 1500, Sync	Current	LLP-28
LM21212/15 ^{E,W}	12/15	2.95	5.5	0.6	5	300 to 1500, Sync	Voltage	eTSSOP-20

NEW

PowerWise product

^E Evaluation board

^W WEBENCH enabled

Non-Isolated Non-Synchronous Buck Regulators

Point of Load (POL)

LM25011 – 42V COT Buck Regulator with Current Limit Adjustable to 2A

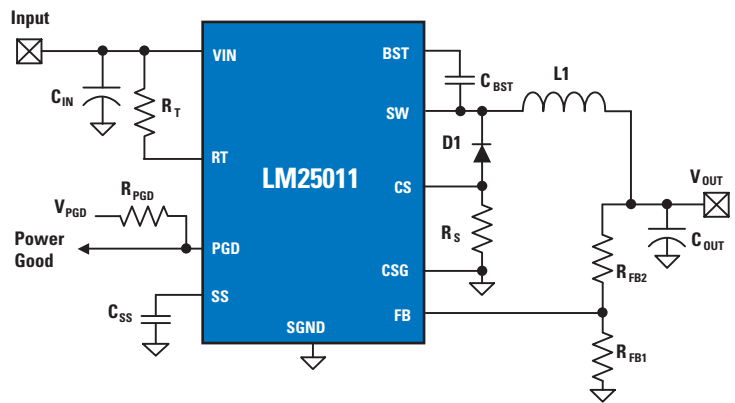
Features

- 6 to 42V input operating voltage range
- Integrated 2A N-channel buck switch
- Adjustable current limit for smaller inductor
- Adjustable output voltage from 2.51V
- Power GOOD output
- Switching frequency adjustable to 2 MHz

Applications

Ideal for use in high-efficiency point-of-load, non-isolated telecommunications buck regulators, and secondary high-voltage post regulators.

Block Diagram



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/B ^{E,W}	0.6	8/6	40	2.5	30	2000/2600 (max)	Constant on-time	micro SMD-10
LM2736 ^{EW}	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 ^{EW}	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 ^{EW}	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 ^{EW}	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
LM25011 ^E	2	6	42	2.51	40	Adj to 2000	Constant on-time	eMSOP-10
LM2832 ^{EW}	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 ^{EW}	3	4.5	24	1.29	20	100 to 500	Constant on-time	TSSOP-16

^W PowerWise product

^E Evaluation board

^W WEBENCH enabled

Non-Isolated Synchronous Controllers

Point of Load (POL)

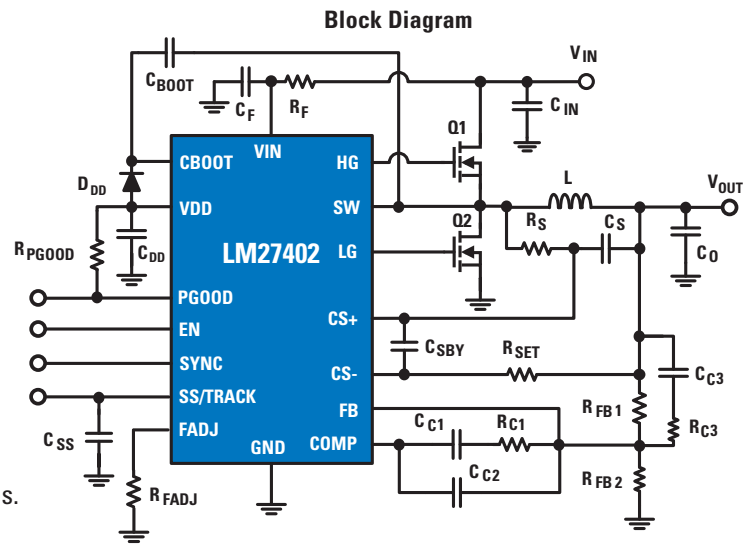
LM27402 – Full-Featured 20 V_{IN} Synchronous Buck Controller

Features

- Input voltage range of 3 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
LM3152 ^{EW}	6	33	3.3	3.3	250, 500, 750	Constant on-time	TSSOP-14
LM2642 ^E	4.5	30	1.3	27	300	Current	TSSOP-28, eTSSOP-28
LM2647 ^E	5.5	28	0.6	5	200 to 500	Voltage	LLP-28, TSSOP-28
LM27402 ^{EW}	3	20	0.6	19	200 to 1200	Voltage	LLP-16, TSSOP-16
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	13.5	50 to 2000	Voltage	TSSOP-14
LM2742	1	16	0.6	13.5	50 to 2000	Voltage	TSSOP-14
LM2743 ^{EW}	1	16	0.6	13.5	50 to 1000	Voltage	TSSOP-14
LM1770 ^{EW}	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	13.5	50 to 1000, Sync	Voltage	TSSOP-14
LM2747 ^E	1	14	0.6	13.5	50 to 1000, Sync	Voltage	TSSOP-14
LM2748	1	14	0.6	13.5	50 to 1000	Voltage	TSSOP-14

PowerWise product

^E Evaluation board

^W WEBENCH enabled

Dual Output Converters

LM(2)5119 – 42/65V, Dual-Channel, Dual-Phase, Emulated-Current-Mode Buck Controller

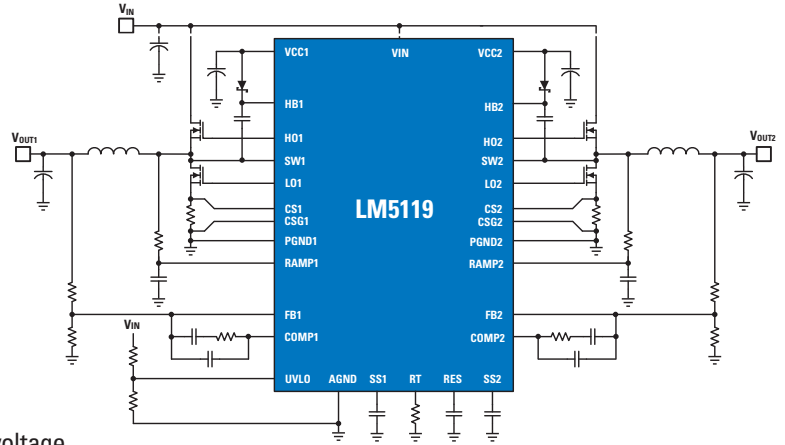
Features

- Emulated Current Mode (ECM)
- Wide operating range
 - 5.5 to 65V (LM5119)
 - 4.5 to 42V (LM25119)
- Dual outputs or interleaved single output
- Programmable output from 0.8V
- Optional Diode Emulation Mode
- Automatic switchover to external bias supply
- Precision 1.5% voltage reference across entire temperature range


Applications

Ideal for use in applications requiring a widely changing input voltage and large step-down conversions, such as basestations, servers, and routers.






Typical Application Circuit



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
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
LM2657 ^E	4.5 to 28	200 to 500	0.6V to 5	TSSOP-28	Supports dual-channel interleaved switching, Adaptive duty cycle clamping reduces peak currents
LM5642/X ^E 	4.5 to 36	150 to 500, Sync	1.3V to 32	TSSOP-28, eTSSOP-28	Configurable for single output parallel operation
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
 LM(2)5119 ^{E,W} 	4.5 to 42, 5.5 to 65	50 to 750	0.8 to 90% V _{IN}	LLP-32	EMC, dual-or single-interleaved output, diode emulation mode

 PowerWise product

^E Evaluation board

^W WEBENCH enabled

Buck-Boost Switching Regulators and Controllers

LM5118 – Wide-Voltage Range Buck-Boost Controller

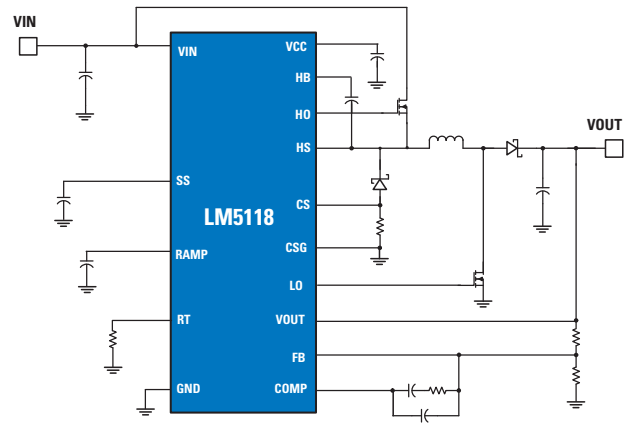
Features:

- 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.

Typical Application



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 ^{EW}	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 ^{EW}	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 ^{EW}	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

^E PowerWise product

^E Evaluation board

^W WEBENCH enabled

Low Dropout (LDO) Linear Regulators

LP5900 – Ultra-Low-Noise 150 mA Linear Regulator

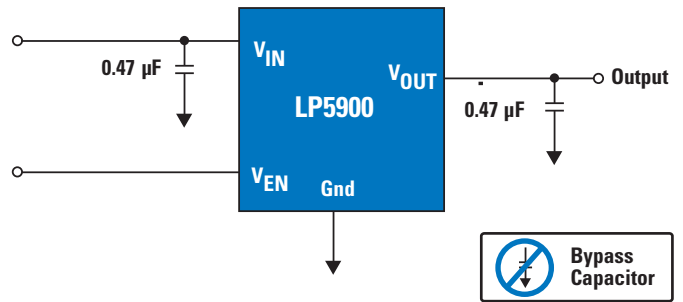
Features

- Industry's lowest noise ($6.5 \mu\text{V}_{\text{RMS}}$) combined with 85 dB of Power Supply Ripple Rejection (PSRR) guarantees signal integrity
- 25 μA I_q 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.

Typical Application



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

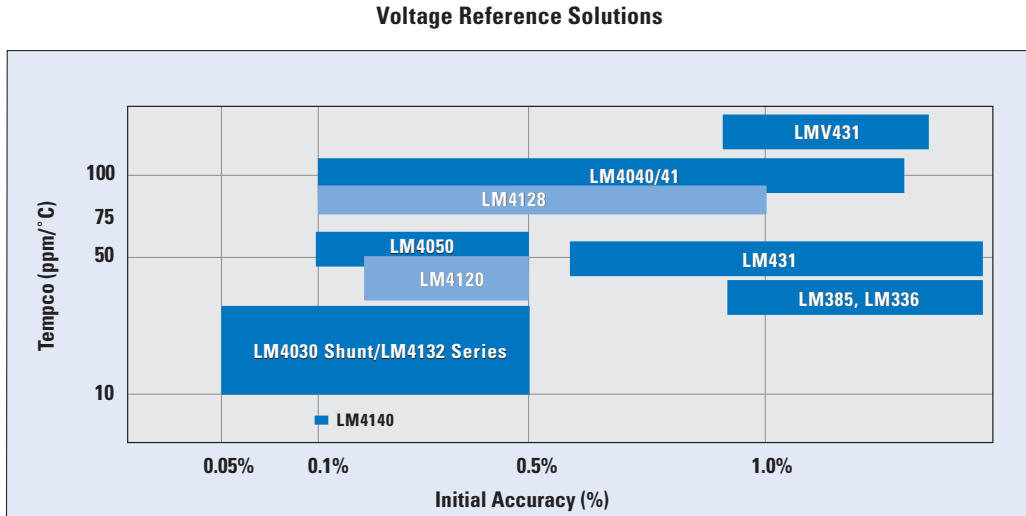
Product ID	Output Current (mA)	Input Max Voltage (V)	Input Min Voltage (V)	Dropout Voltage (V)	Output Voltage (V)	On/Off Pin	Quiescent Current (mA)	PSRR (dB)	Voltage Noise (rms)	Packaging
LP3995	150	6	2.5	0.06	3, 2.8, 1.9	—	0.085	60	25	micro SMD-5, LLP-6
LP3999	150	6	2.5	0.06	1.5, 2.4, 1.8, 2.5, 2.8, 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

Voltage References

LM4140 – High-Precision 3 ppm/°C Tempco, 2.2 μ V Noise Series Voltage Reference



Applications

Developed for 20-bit precision data converter support.

Shunt Voltage References

Product ID	V _{OUT} Options (V)	Initial Accuracy (%)	Tempco (ppm/°C)	Quiescent Current (mA)	Noise (μ V _{pp})	Packaging
LM385-2.5	2.5	3.0	150	0.02	120	TO-92, SOT-23, SOIC-8
LMV431A	1.24	1.0	138, 129	0.055	8.0	TO-92, SOT-23
LMV431B	Adj	0.5	129	0.055	8.0	SOT-23
LMV431	Adj	1.5	138, 129	0.055	8.0	TO-92, SOT-23
LM4041	1.225, Adj	0.2, 2, 0.5, 1, 0.1	150, 100	0.06	20	SOT-23, SC-70, TO-92
LM4051	1.225, Adj	0.1	50	0.06	20	SOT-23
LM4040	4.096, 10, 5, 2.5, 3	0.2, 2, 0.5, 1, 0.1	150, 100	0.06, 0.068, 0.91, 0.074, 0.091, 0.1	35	TO-92, SOT-23, SC-70
LM4431	2.5	2.0	30	0.1	35	SOT-23
LM4125	4.096, 2.048, 2.5	0.2, 0.5	50	0.16	20	SOT-23
LM4121	1.25, Adj	0.2, 0.5	50	0.16	20	SOT-23
LM431	Adj	1.0	54	1.0	8.0	TO-92, SOT-23, SOIC-8 Narrow
LM4050	2.0, 2.5, 4.096, 5.0, 8.2, 10	0.1, 0.2, 0.5	50	0.06 to 15.0	41	SOT23-3, CerPack
LM4132	1.8, 2.0, 2.5, 3.0, 3.3, 4.096	0.05, 0.1, 0.2, 0.4, 0.5	10, 20, 30	0.06	170	SOT23-5
LM4128	1.8, 2.0, 2.5, 3.0, 3.3, 4.096	0.1, 0.2, 0.5, 1	75, 100	0.06	170	SOT23-5
LM4030	2.5, 4.096, 5.0	0.05, 0.1, 0.15	10, 20, 30	0.065	105	SOT23-5
LM4120	1.8, 2.048, 2.5, 3.0, 3.3, 4.09, 5	0.2, 0.5	50	0.16	20	SOT23-5
LM4140	1.024, 1.25, 2.048, 2.5, 4.096	0.1	3, 6, 10	0.23	2.2	SOIC-8
LM385	Adj	2.0	150	.01	120	TO-92, SOIC-8 Narrow
LM385-1.2	1.235	2.0	150	.01	120	TO-92, SOT-23, SOIC-8

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 addition, the board includes 3 channels with trace characteristic impedances of 80, 100, and 130 Ohms. The board can act as driver or receiver and a 7th channel is 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.

Visit national.com/comms to find more Communications Infrastructure Reference Designs, articles, and application notes.

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.
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High-Voltage Solutions

LM5045 Evaluation Board	Demonstrates a power converter based on full-bridge topology that delivers 3.3V at 30A from an input voltage range of 36 to 75V. LM5045 supports both current and voltage-mode control and provides dual 2A high and low side gate drivers for the four external bridge MOSFETs plus control signals for the secondary side synchronous rectifier MOSFETs.
LM5046 Evaluation Board	Same board features as LM5045. Additionally, the LM5046 phase shifted full-bridge topology achieves zero voltage switching of the primary MOSFETs and therefore aids the power converter in achieving high efficiency and low EMI emissions.
LM5039 Evaluation Board	Demonstrates a power converter based on half-bridge topology that delivers 3.3V at 30A from an input voltage range of 36 to 75V. LM5039 features average current limiting that balances the center-point of the half-bridge capacitor during current limiting.
LM5027 Evaluation Board	Demonstrates a power converter based on the active clamp topology that delivers 3.3V at 30A from an input voltage range of 36 to 75V. LM5027 features soft start of the synchronous rectifier allowing the power converter to turn linearly in a pre-biased condition.

Power-over-Ethernet (PoE) Solutions

PoE Phyter	Integrates both LM5072 PoE controller and DP83848 10/100 Mbs 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 and 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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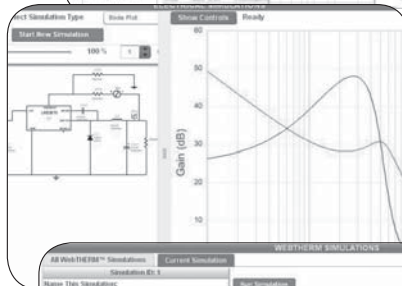
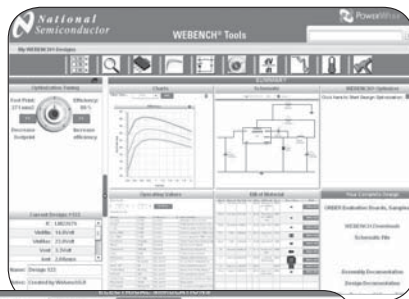
- Input your design requirements
- Choose a recommended part from a customized list

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

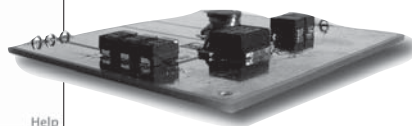
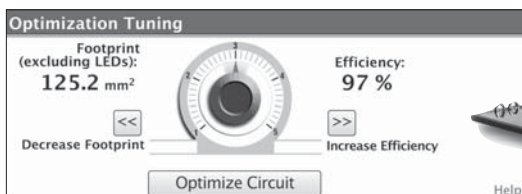
- Simulate your circuit and evaluate performance using electrical and thermal simulations
- Simulate electrical characteristics, choose probe points, and examine waveforms to determine performance
- Simulate thermal behavior and your circuit on a PCB in your defined environment and view color heat maps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

Solve your design problems before you prototype

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