

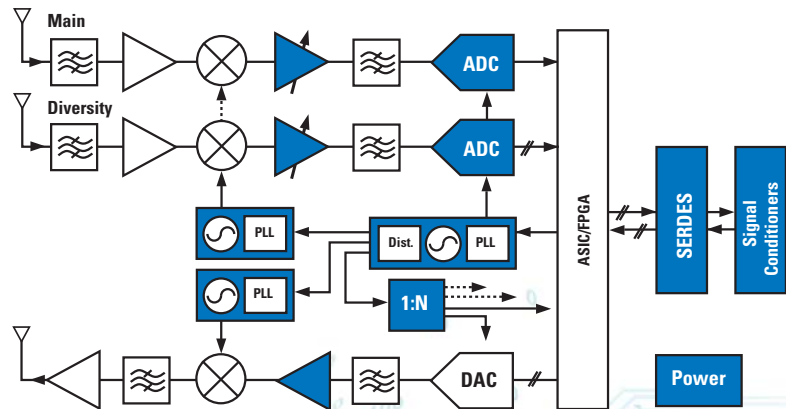
# Communications Infrastructure

Solutions Guide

[national.com/comms](http://national.com/comms)

2009 Vol. 2

- Data Conversion Solutions
- Amplifier Solutions
- Temperature Sensor Solutions
- SerDes Solutions
- LVDS Solutions
- Clock and Timing Solutions
- Power Solutions
- Reference Designs



National's communications infrastructure solutions optimize system efficiency, increase power density, and deliver outstanding system performance. PowerWise® subsystem reference designs solve energy-efficiency problems at an architectural level in a small footprint, reducing cooling requirements while delivering better performance. National's energy-efficient products, combined with easy-to-use online design tools and reference designs, address the specific needs of wired data centers, wireless basestations, and merchant power supply applications.

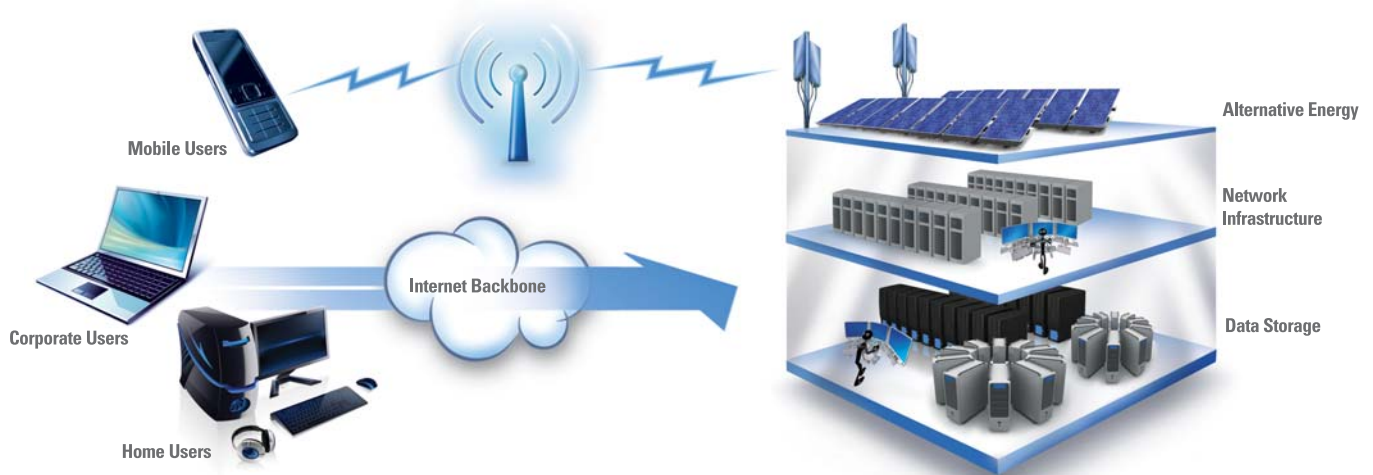
### Wired and Data Center Applications

See how National's products, tools and reference designs are powering more energy efficient, highly reliable, cost efficient data centers.

### Wireless Basestation (BTS) Applications

Addressing wireless basestation performance, monitoring and capacity challenges, National offers energy-efficient, flexible, integrated system-level infrastructure solutions.

Download the latest reference designs and design-in a product using the WEBENCH® Designer online design tool. Visit: [www.national.com/comms](http://www.national.com/comms)



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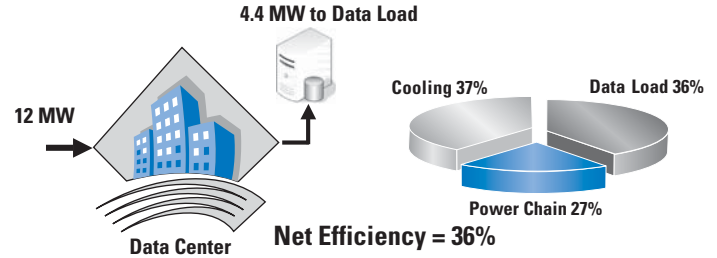
# Wired and Data Center Applications

Energy consumption in 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.<sup>1</sup> 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 data center 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



### Data Center Efficiency

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

Data Center Energy	61 kWh*
CO <sub>2</sub> Footprint	31B kg
# Households	5.7M
# Cars	8M

\* EPA-US only

### Challenges:

- Increase of data load computing and data center energy consumption.

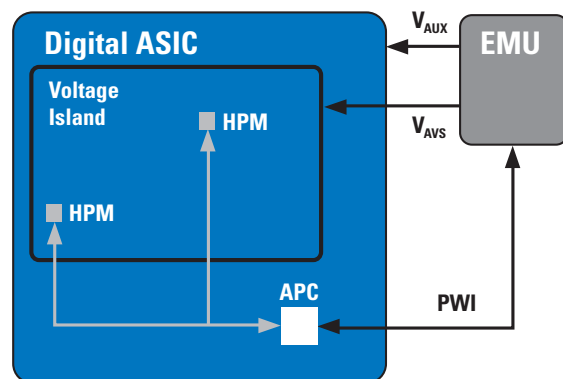
### Solutions:

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

- PowerWise AVS technology minimizes system energy consumption and improves reliability
- PowerWise AVS enables typically 20% to 40% power savings over traditional fixed-voltage scheme
- National has developed AVS technology, and created its infrastructure, to enable a seamless implementation

PowerWise<sup>®</sup> AVS technology is an advanced closed-loop technology for reducing active and standby energy consumption of digital processing engines and ASICs. Hardware Power Monitor (HPM) is designed into the digital engine with an Advanced Power Controller (APC) to monitor the performance of the silicon based on process and temperature variation. Information is fed back to an Energy Management Unit (EMU) which then sets the

voltage precisely according to the processor's needs. AVS technology enables optimum energy management delivery to the processors, ASICs, and SoCs, which maximizes overall system energy savings. AVS technology is process and architectural independent. AVS enables typically 20% to 40% power savings over traditional fixed-voltage schemes across temperature range and guardbands typical in processors.

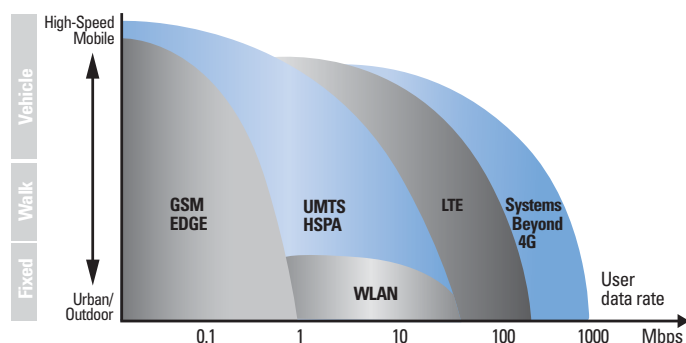


**PowerWise AVS technology minimizes system energy consumption and improves reliability**

<sup>1</sup> 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, 2008

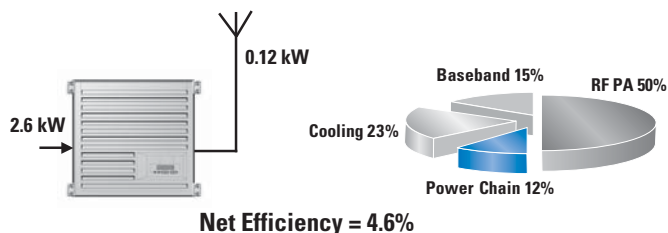
# Wireless Basestation (BTS) Applications

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



Evolution of Future Technologies

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



## Wireless Basestation Efficiency

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.

Basestation Energy	68 BkWh*
CO <sub>2</sub> Footprint	34B kg
# Households	6M
# Cars	8.5M

\* Worldwide

## 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 additional overhead needed to remove excess heat.

The primary energy consumption challenges in basestations are:

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

### Solutions:

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

## Increased Network Capacity

### Challenges:

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

### Solutions:

PowerWise® equalizers and switching devices based on SiGe process technology and advanced design techniques provide significant power savings.

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
DS38EP100	1 to 5 Gbps power-saver equalizer	Passive equalizer with 7 db effective boost
DS80EP100	4.25 to 12.5 Gbps power-saver equalizer	Passive equalizer with 7 db effective boost
DS64EV400	Quad 6.25 Gbps equalizer	Equalizes up to 40 inches of FR4 at 6.25 Gbps
DS25CP104A	3.125 Gbps 4 X 4 crosspoint	Low jitter, equalization and pre-emphasis
DS50EV401	6.4 Gbps quad bi-directional receiver	De-emphasis on transmit and equalization on receive
DP83640	100/100 Ethernet PHY	Supports IEEE 1588

# Wireless Basestation Applications (BTS)

## Remote Radio Heads

### Challenges:

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

### Solutions:

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

## New Multi-Standard/BTS Demand

### Challenges:

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

### Solutions:

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

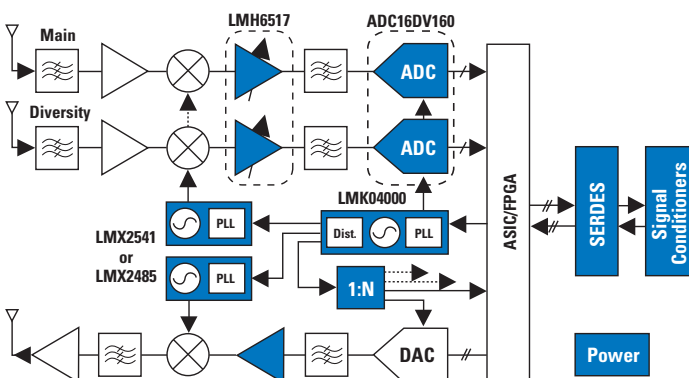
The ADC16DV160 is a 16-bit, 160-MSPS ADC that offers the industry's best dynamic performance in the smallest package at less than half the power of similar parts. Its large input bandwidth provides excellent dynamic performance across a large range of input frequencies, enabling high bandwidth, high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

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

It delivers a 6 dB noise figure and 45 dBm OIP3—ideal for meeting the demanding needs of new multi-carrier/multi-standard wireless basestation designs.

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

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



Product	Function	Key Feature
LMK04031B	Clock jitter cleaner with cascaded PLLs	sub-200 fs RMS jitter using a simple external crystal
LMK03000C	Clock jitter cleaner with integrate VCO	400 fs RMS jitter using integrated VCO
LMK01000	1.6 GHz low-noise clock distributor	30 fs additive RMS jitter
ADC16DV160	Dual-channel, 16-bit, 160 MSPS ADC with DDR LVDS outputs	91.2 dBFS SFDR and 76.3 dBFS SNR at $f_{IN} = 197$ MHz with $P_d = 1.3$ W
ADC16V130	16-bit, 130-MSPS ADC with LVDS outputs	90.6 dBFS SFDR and 76.7 dBFS SNR at $f_{IN} = 160$ MHz with $P_d = 755$ mw
LMH6517	Dual 1.2 GHz digitally controlled variable gain amplifier	22 dB Max Gain, 31.5 dB gain range, 0.5 dB steps, 45 dBm OIP3, 6 dB noise figure, 80 mA/ch supply current
LMX2531	Low phase noise frequency synthesizer	Low VCO phase noise and spurs, -115 dBc/Hz at 100 kHz offset at 2 GHz LO
LMX2541	Ultra-low RMS noise frequency synthesizer	Ultra-low noise PLL, < 2-mrad of RMS noise with ultra-low spurs, 31.6 to 4000 MHz range

# Merchant and Point of Load Power Solutions

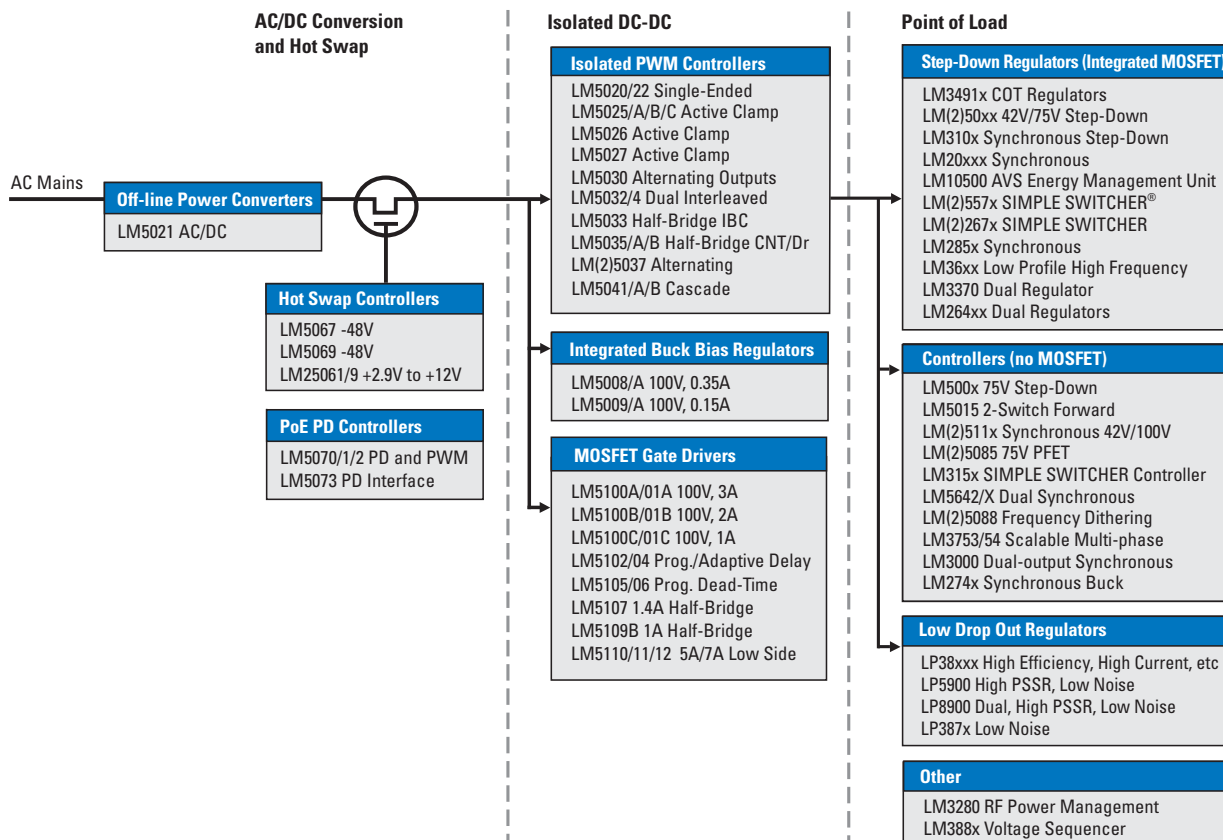
## Challenges:

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

## Solutions:

- Higher power density solutions enable smaller form factors
  - Advanced topologies like active clamp and half-bridge converters support high-power applications
  - Integrated solutions reduce BOM count and save valuable space
  - High switching frequencies (3 MHz and more) enable fast transient response and the use of smaller components
- A wide range of high-efficiency power ICs to reduce thermal dissipation in higher power modules
  - Synchronous converters minimize switching losses
  - Point of load converters with automatic PFM to PWM switching increase light load efficiency
- Protection and performance ICs improve system robustness
  - Hot swap/in-rush current controllers with power limiting and over- and under-voltage protection provide maximum system protection and reliability
  - Low-noise, low-power low dropout (LDO) regulators preserve signal fidelity in the analog signal path

## End-to-End Power Management Solutions



# Data Conversion Solutions

## ADC16DV160 – PowerWise® 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
- Available in LLP-68 packaging (10 x 10 x 0.8 mm, 0.5 mm pin-pitch)

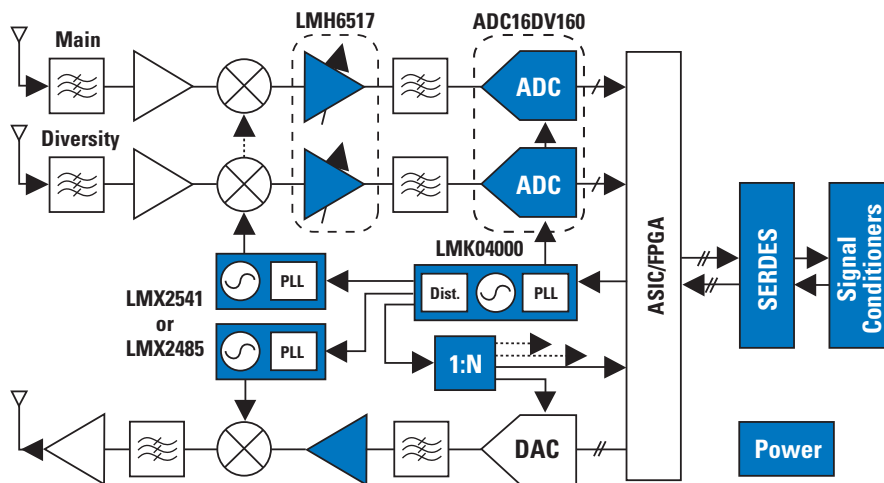
### Performance (typical)

- 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

### Ideal for use in

- Multi-carrier, multi-standard basestation receivers -MC-GSM/EDGE, CDMA2000, UMTS, LTE and WiMAX
- High IF sampling receivers
- Diversity channel receivers
- Communications instrumentation

### High-Speed Radio Signal Path for Wireless Basestations

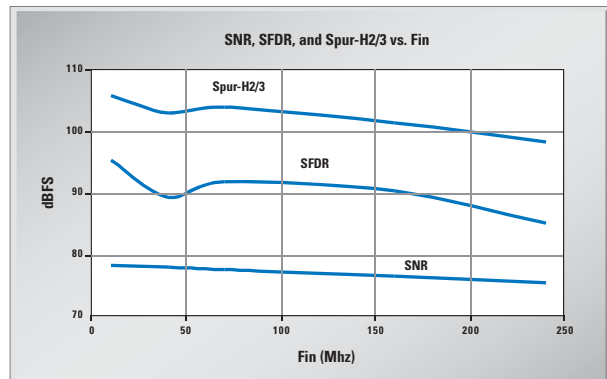
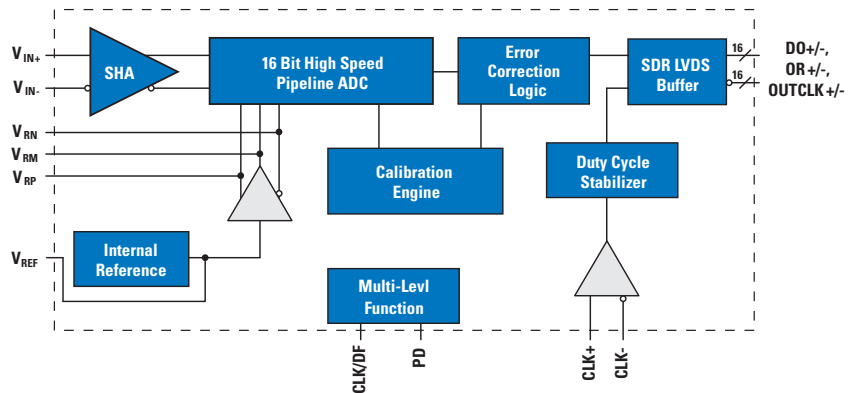




## ADC16V130 – PowerWise® 16-bit, 130 MSPS ADC for High-IF, High-Dynamic Performance Applications

### Features:

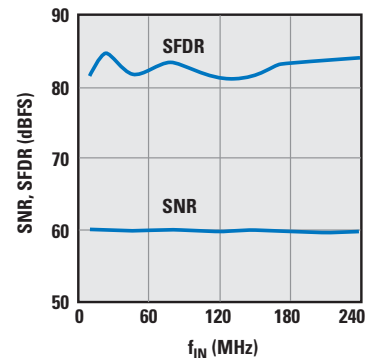
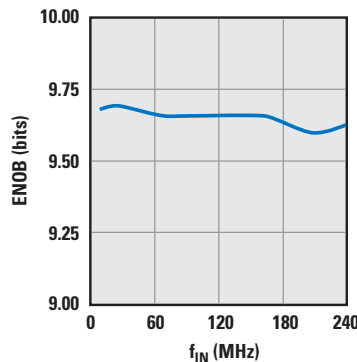
- 1.4 GHz full power bandwidth
- Performance:
  - 90.6 dBFS SFDR at  $f_{IN} = 160$  MHz
  - 76.7 dBFS SNR at  $f_{IN} = 160$  MHz
  - 101.5 dBFS worst harmonic or spur (except H2 & H3) at  $f_{IN} = 160$  MHz
- Low power: 755 mW
- Dual 3.0V/1.8V supply operation
- Parallel LVDS outputs
- Ideal for use in multi-carrier/multi-standard basestation receivers
  - GSM/EDGE, CDMA2000, UMTS, LTE, and WiMAX
- Reference board available with LMK04031B clock jitter cleaner
- Available in LLP-64 packaging (9 mm x 9 mm)



## ADC10/11DV200 – PowerWise® Dual 10- and 11-bit, 200 MSPS Dual ADCs for High-IF Sampling

### Features:

- 900 MHz full power bandwidth
- 59.9 dBFS SNR at 70 MHz input
- 82 dBFS SFDR at 70 MHz input
- LVDS or CMOS outputs
- 11-bit version available: ADC11DV200
- Low power consumption:
  - 225 mW/ch in LVDS mode at 200 MSPS
  - 140 mW/ch in CMOS mode at 170 MSPS
- Power scaling with sampling rate
- Single 1.8V power supply
- Over-range indicator
- Available in LLP-60 packaging



# Data Conversion Solutions

## High-Speed MSPS A/D Converters












Product ID	Channels	Speed (MSPS)	Power (mW)	SNR (dB)	SFDR (dB)	Outputs	Packaging
<b>16-bit</b>							
<b>NEW</b> ADC16DV160 <sup>E</sup>	2	160	1300	78.5	95	LVDS	LLP-68
ADC16DV130 <sup>E</sup>	1	130	755	78.5	95.5	LVDS	LLP-64
<b>14-Bit</b>							
ADC14155 <sup>E</sup>	1	155	967	71.3	87	CMOS	LLP-48
ADC14V155 <sup>E</sup>	1	155	951	71.7	86.9	Parallel LVDS	LLP-48
ADC14DS080/105 <sup>E</sup>	2	80/105	800/1000	74.2/73	90	Serial LVDS	LLP-60
ADC14DC080/105 <sup>E</sup>	2	80/105	600/800	73/74	90	CMOS	LLP-60
ADC14C080/105 <sup>E</sup>	1	80/105	300/400	74.2/74	90	CMOS	LLP-32
ADC14L040 <sup>E</sup>	1	40	235	73	90	CMOS	LQFP-32
ADC14L020 <sup>E</sup>	1	20	150	74	93	CMOS	LQFP-32
<b>12-Bit</b>							
ADC12C170 <sup>E</sup>	1	170	715	67.2	85.4	CMOS	LLP-48
ADC12V170 <sup>E</sup>	1	170	781	67.2	85.8	Parallel LVDS	LLP-48
ADC12C105 <sup>E</sup>	1	105	400	71	90	CMOS	LLP-32
ADC12DS080/105 <sup>E</sup>	2	80/105	800/1000	71	88	Serial LVDS	LLP-60
ADC12DC080/105 <sup>E</sup>	2	80/105	600/800	71.5/71	90	CMOS	LLP-60
ADC12C080 <sup>E</sup>	1	80	300	71.2	90	CMOS	LLP-32
ADC12DL080 <sup>E</sup>	2	80	447	69	82	CMOS	TQFP-64
ADC12L080/81 <sup>E</sup>	1	80	425	66	80	CMOS	LQFP-32
ADC12L066	1	66	357	66	80	CMOS	LQFP-32
ADC12QS065 <sup>E</sup>	4	65	800	69	83	Serial LVDS	LLP-60
ADC12DL065 <sup>E</sup>	2	65	360	69	86	CMOS	TQFP-64
ADC12L063	1	62	354	66	78	CMOS	LQFP-32
ADC12EU050 <sup>E</sup>	8	50	384	69.3	77	Serial LVDS	LLP-68
ADC12DL040 <sup>E</sup>	2	40	210	69	85	CMOS	TQFP-64
ADC12D040 <sup>E</sup>	2	40	600	68	80	CMOS	TQFP-64
ADC12040 <sup>E</sup>	1	40	340	69.5	84	CMOS	LQFP-32
ADC12020	1	20	185	70	86	CMOS	LQFP-32
<b>11-Bit</b>							
<b>NEW</b> ADC11DV200 <sup>E</sup>	2	200	450	62.5	82	CMOS or LVDS	LLP-60
ADC11C170 <sup>E</sup>	1	170	715	65.1	85.4	CMOS	LLP-48
ADC11C125 <sup>E</sup>	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
<b>10-Bit</b>							
<b>NEW</b> ADC10DV200 <sup>E</sup>	2	200	450	59.9	82	CMOS or LVDS	LLP-60
ADC10080 <sup>E</sup>	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 <sup>E</sup> Evaluation board

# Data Conversion Solutions

## Ultra-High-Speed ADCs

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

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

 PowerWise product

### 2/2.5G Digital Down Converter (DDC)

Product ID	Description
CLC5903	14-bit input resolution, 78 MSPS DDC with AGC control and 1.8V core supply voltage. Very low 290 mW power consumption. SFDR is 100 dB, SNR is 127 dB, and tuning resolution is 0.02 Hz.

# Data Conversion Solutions

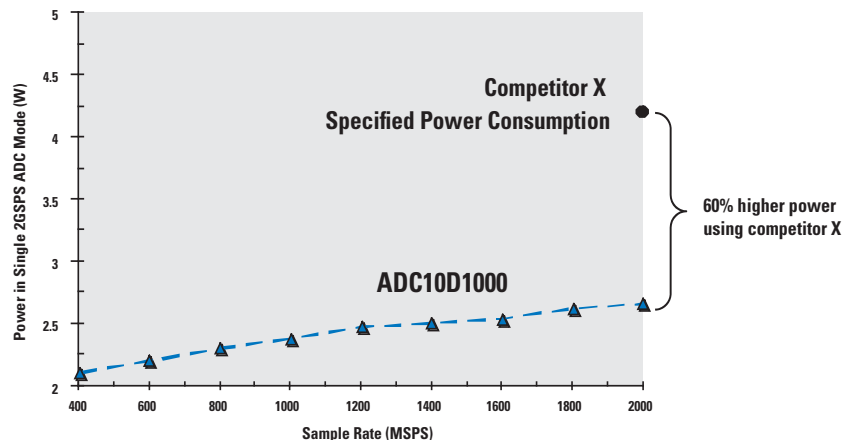
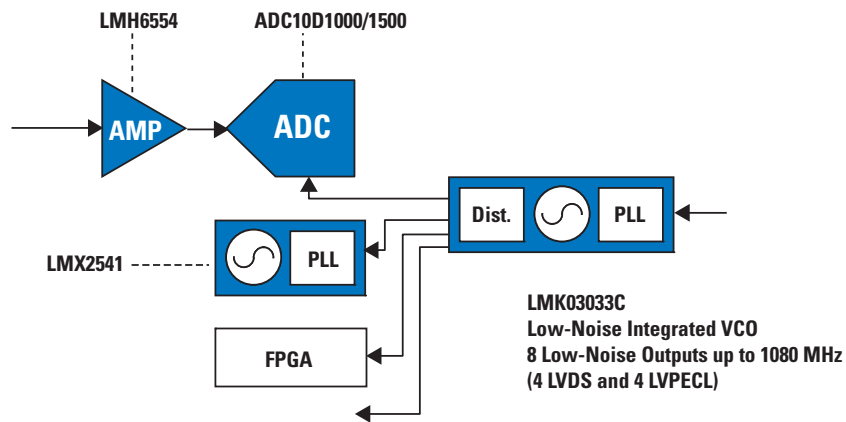
## ADC10D1000/ADC10D1500 – PowerWise® Low-Power, 10-Bit, Dual 1.0/1.5 GSPS or Single 2.0/3.0 GSPS A/D Converter

### Features

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

### Performance (typ) ADC10D1000 / ADC10D1500

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



# Low Power ADC Solutions

## Lowest Power, Broad Family

Product ID	Res (bits)	# Mux Inputs	Pin and Function Comp. Family	Max Speed Range (kSPS)	Supply Voltage (V)	Op. Power (typ) @ 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)				
<b>Analog-to-Digital Converters</b>														
ADC081S021 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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
<b>Differential-Input SPI A/D Converters</b>														
ADC121S625 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	12	2			50 to 200	4.5 to 5.5	—	±1.0	±0.95	11.25	69.5	Serial (SPI)	-40 to 105	MSOP-10
ADC122S655 <sup>E,W,*</sup>	12	2			200 to 500	4.5 to 5.5	—	±1.0	±0.95	11.25	69.5	Serial (SPI)	-40 to 105	MSOP-10
ADC122S706 <sup>E,*</sup>	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 <sup>E,W</sup>	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 <sup>E,W</sup>	16	1			50 to 250	4.5 to 5.5	—	±0.8	±0.5/±0.8	14.3	89	Serial (SPI)	-40 to 85	MSOP-10

\* Simultaneous Sampling    \* WEBENCH enabled    † Evaluation board    ‡ PowerWise product

# Data Conversion Solutions

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 <sup>1</sup>	Packaging
						3.6V	5.5V	INL (LSB)	DNL (LSB)			
<b>Digital-to-Analog Converters</b>												
DAC081S101 <sup>E</sup>	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 <sup>E</sup>	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 <sup>E</sup>	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 <sup>E</sup>	8	2		3	2.7 to 5.5	210	320	±0.14	+0.04, -0.02	External	Serial (SPI)	MSOP-10, LLP-10
DAC102S085 <sup>E</sup>	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 <sup>E</sup>	12	2		6	2.7 to 5.5	210	320	±2.4	+0.2, -0.1	External	Serial (SPI)	MSOP-10, LLP-10
DAC084S085 <sup>E</sup>	8	4		3	2.7 to 5.5	350	500	±0.14	+0.04, -0.02	External	Serial (SPI)	MSOP-10, LLP-10
DAC104S085 <sup>E</sup>	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 <sup>E</sup>	12	4		6	2.7 to 5.5	360	480	±2.4	+0.2, -0.1	External	Serial (SPI)	MSOP-10, LLP-10
DAC088S085 <sup>E</sup>	8	8		3	2.7 to 5.5	650	970	±0.125	±0.03	Dual External	Serial (SPI)	TSSOP-16, LLP-16
DAC108S085 <sup>E</sup>	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 <sup>E</sup>	12	8		6	2.7 to 5.5	650	970	±2.0	+0.15, -0.09	Dual External	Serial (SPI)	TSSOP-16, LLP-16

<sup>1</sup> SPI/QSPI/DSP compatible    PowerWise product    <sup>E</sup> Evaluation board

## Single-Ended Input I<sup>2</sup>C-Compatible A/D Converters with Alarm and Multiple Addresses

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)			
ADC081C021 <sup>1,E,W</sup>	8	1	↑ ↓	5.5 to 189	2.7 to 5.5	0.26	0.78	±0.2	±0.5	7.98	-40 to 105	TSOT-6, MSOP-8
ADC101C021 <sup>1,E,W</sup>	10	1		5.5 to 189	2.7 to 5.5	0.26	0.78	±0.5	±0.5	9.94	-40 to 105	TSOT-6, MSOP-8
ADC121C021 <sup>1,E,W</sup>	12	1		5.56 to 189	2.7 to 5.5	0.26	0.78	±0.5	±0.5	11.7	-40 to 105	TSOT-6, MSOP-8
ADC081C027 <sup>1,E,W</sup>	8	1		5.5 to 189	2.7 to 5.5	0.26	0.78	±0.5	±0.5	9.94	-40 to 105	TSOT-6
ADC101C027 <sup>1,E,W</sup>	10	1		5.5 to 189	2.7 to 5.5	0.26	0.78	±0.5	±0.5	9.94	-40 to 105	TSOT-6
ADC121C027 <sup>1,E,W</sup>	12	1		5.56 to 189	2.7 to 5.5	0.26	0.78	±0.5	±0.5	11.7	-40 to 105	TSOT-6

<sup>1</sup> Alarm Option    PowerWise® product    <sup>W</sup> WEBENCH enabled    <sup>E</sup> Evaluation board

## Single-Ended Input I<sup>2</sup>C Digital-to-Analog Converters

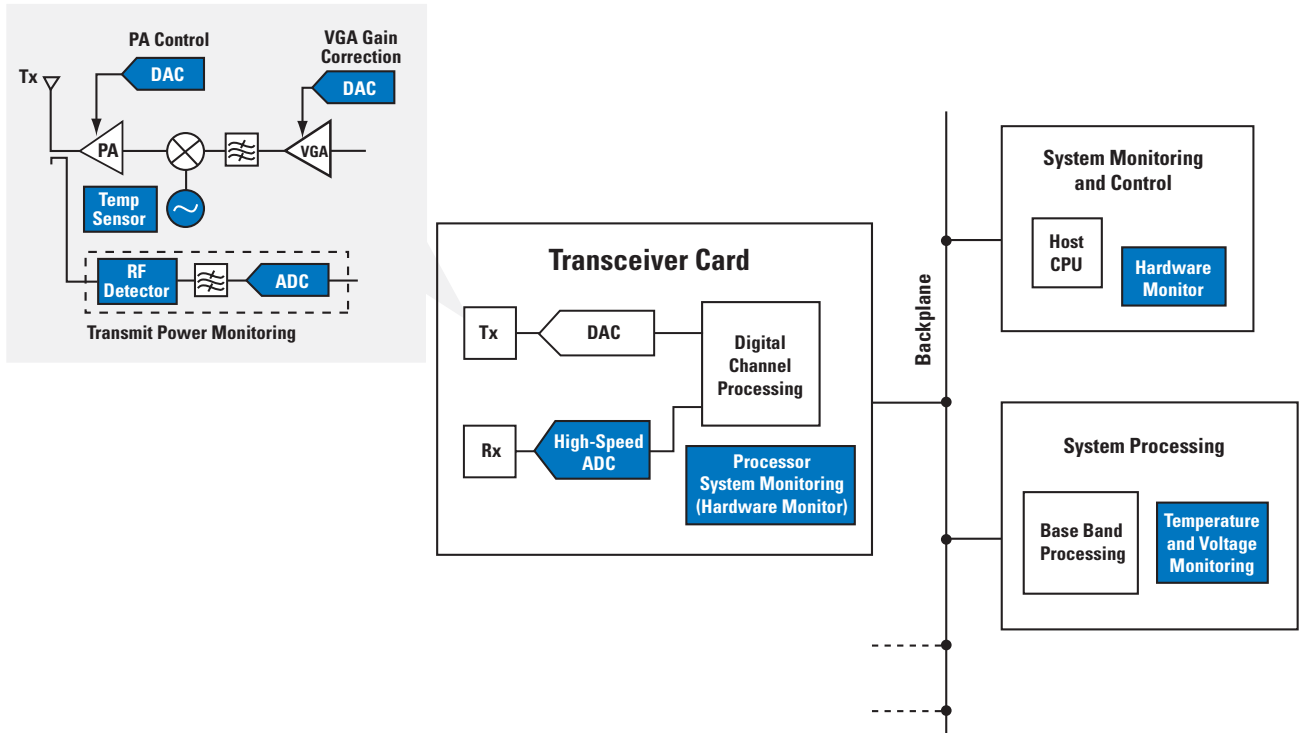
Product ID	Res (bits)	Inputs	Pin and Function Compatible	Speed Range (kSPS)	Supply Voltage Range(V)	Typ Power (mW)		Static Performance (Typ)		ENOB (bits) Typ	Temp Range (°C)	Packaging
						3V	5V	INL (LSB)	DNL (LSB)			
DAC081C081	8	1	↑ ↓	6	2.7 to 5.5	0.38	0.73	±0.1	±0.08	Supply	-40 to 125	MSOP-8
DAC101C081	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	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	8	1		6	2.7 to 5.5	0.38	0.73	±0.1	±0.08	External	-40 to 125	MSOP-10
DAC101C085	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	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

PowerWise® product

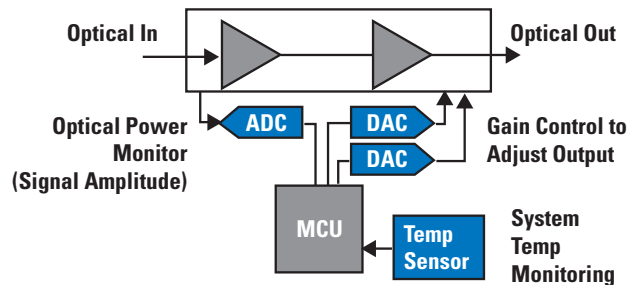
# Precision Signal Path Applications

## Monitoring and Control Solutions for Communications Systems

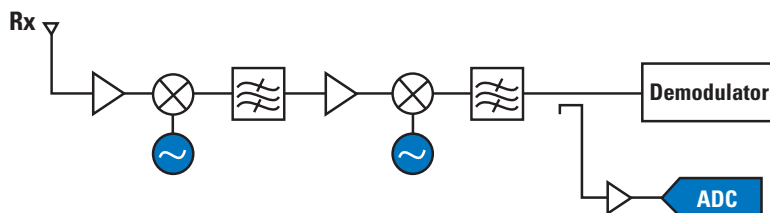
### Wireless Basestation



### Optical Networks



### RSSI (Receive Signal Strength Indicator) in Channelized Communication

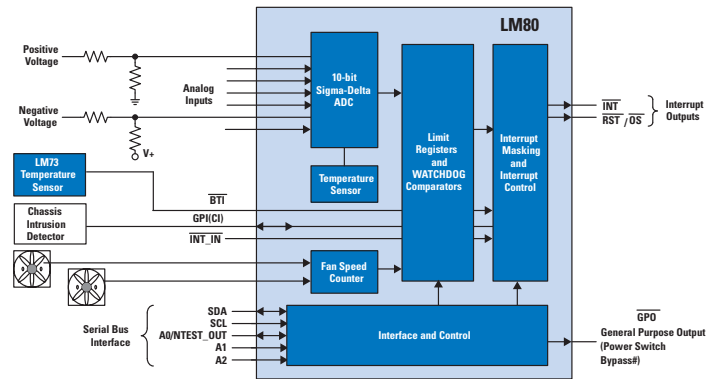


# Temperature Sensor Solutions

## LM80 – PowerWise® Serial Interface ACPI-Compatible Microprocessor System Hardware Monitor

### Features

- Temperature sensing
- 7 positive voltage inputs
- 2 programmable fan speed monitoring inputs
- 10 mV LSV and 2.56V input range accepts outputs from linear temperature sensors such as the LM50
- WATCHDOG comparison of all monitored values
- Separate input to show status in Interrupt Status Register of additional external temperature sensors such as the LM57 or LM75
- I<sup>2</sup>C-compatible serial bus interface compatibility
- Shutdown mode to minimize power consumption
- Available in TSSOP-24 packaging



### Applications

Ideal for use in routers, switches, and encoder/decoders

### Selected Temperature Sensors

Product ID	Description	Temperature Range (°C)	Accuracy	Scale Factor / Resolution	Power Supply Voltage (V)	Supply Current	Packaging
<b>Analog</b>							
LM94022	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	1.5V to 5.5V	5.4 µA	SC-70
<b>Digital</b>							
LM73	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	2.7V to 5.5V	320 µA	SOT23-6
LM75A	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	3.0V to 5.5V	250 µA	MSOP-8, SOIC-8
<b>Remote Diode</b>							
LM95214	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	3.0V to 3.6V	570 µA	LLP-14
<b>Temperature Switch</b>							
LM26LV	1.6 V factory preset temperature switch and temperature sensor	-50° to 150°	± 2.2°C (0°C to 150°C)	—	1.6V to 5.5V	8 µA	LLP-6
LM57	2.4V user programmable temperature switch and temperature sensor	-50° to 150°	±1.5, ±2.3 (-50°C to 150°C)	—	2.4V to 5.5V	24 µA	LLP-8
<b>Hardware Monitor</b>							
LM80	Hardware monitor with voltage monitoring, DAC output, TACH inputs	-40° to 150°	± 3.0°C (-25°C to 125°C)	0.0625°C/LSB	2.8V to 5.75V	0.2 mA	TSSOP-24
LM87	Hardware monitor with dual remote diodes, DAC output, TACH inputs	-40° to 125°	± 3.0°C (TA = 60°C to 125°C)	1°C/LSB	2.8V to 3.8V	0.7 mA	TSSOP-24
LM96194	Hardware monitor, 4 TruTherm® RDTs, 4 fan monitor, 2 fan controls, 8 voltage monitors, closed loop fan control for 4-pin fans	-40° to 85°	± 3°C (TA = 0°C to 85°C TD = 0°C to 100°C)	0.5°C/LSB	3.0V to 3.6V	1.6 mA	LLP-48
LM96163	Hardware monitor with 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	3.0V to 3.6V	4.56 mA	LLP-10

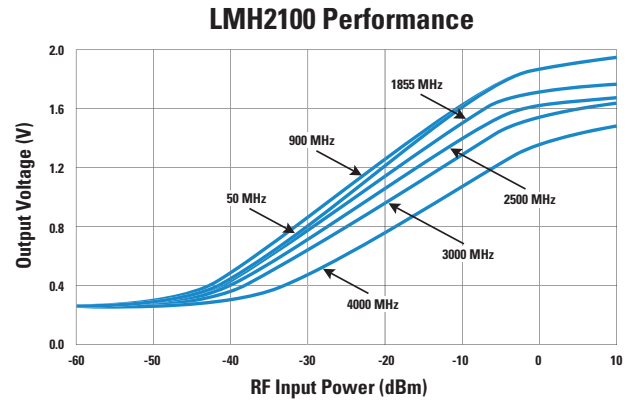


# RF Detectors and High-Speed Comparator Solutions

## LMH2100 – RF Power Detector

### Features

- 40 dB linear in dB power detection range
- Output voltage range 0.3 to 2V
- Multi-band operation from 50 MHz to 4 GHz
- 0.5 dB accurate temperature compensation
- Shutdown pin
- 0.4 mm-pitch micro SMD-6 package



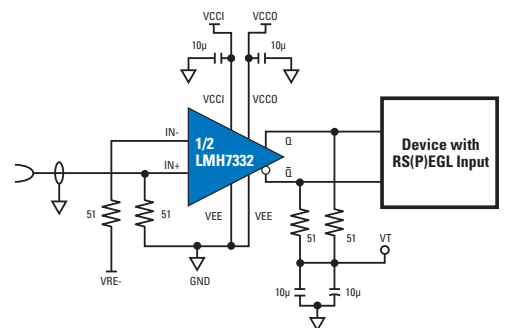
## RF Detectors

Product ID	Application	Channels	Supply Voltage Range (V)	Dynamic Range (dB)	Frequency Range (MHz)	Packaging
LMV221 <sup>E</sup>	CDMA, WCDMA, GSM, GPRS	1	2.7 to 3.3	40	50 to 3500	LLP-6
LMV225 <sup>E</sup>	CDMA, WCDMA, GSM, EDGE, GPRS, TDMA	1	2.7 to 5	>30	450 to 2000	micro SMD-4, LLP-6
LMV226 <sup>E</sup>	CDMA, WCDMA, GSM, EDGE, GPRS, TDMA	1	2.7 to 5	>30	450 to 2000	micro SMD-4
LMV228 <sup>E</sup>	CDMA, WCDMA, GSM, EDGE, GPRS, TDMA	1	2.7 to 5	>30	450 to 2000	micro SMD-4, LLP-6
LMV232 <sup>E</sup>	3G, UMTS, WCDMA, CDMA2000, LAN, GPS	2	2.5 to 3.3	20	50 to 2000	micro SMD-8
LMH2100 <sup>E</sup>	CDMA, WCDMA, GSM, GPRS	1	2.7 to 3.3	40	50 to 4000	micro SMD-6

<sup>E</sup> Evaluation board

## LMH7322 – PowerWise® Dual 700 ps High Speed Comparator with RSPECL Outputs

- Prop delay ( $\geq 100$  mV OD) 700 ps
- Dispersion
  - 20 mV to 100 mV OD: 5 ps
  - 100 mV to 1.0V OD: 75 ps
- Max toggle rate: 4 Gbps
- Supply current: 21 mA/ch
- Wide supply range: 2.7V to 12V
- Available in LLP-24 packaging (4 x 4 mm)
- Low power
  - Single-ended 5V supply voltage operation allows 40% power savings over  $\pm 5V$  operation
- Dual supplies give flexibility
  - RSPECL, ECL, or LVDS output configurations
  - Wide input voltage range, up to 10.5V



## Comparators

Product ID	Application	$I_{CC}$ (mA/ch)	$V_{CC}$ (V)	$t_{PD}$ (ns)	Toggle Rate (Mbps)	Packaging
LMH7322	Dual high-speed comparator with LVDS/RSPECL outputs	22.6	2.7 to 12	0.7	4000	LLP-24
LMH7324	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
LMP7300 <sup>E</sup>	Precision comparator and reference	10 $\mu$ A	2.7 to 12	10 $\mu$ S	—	SOIC-8, MSOP-8

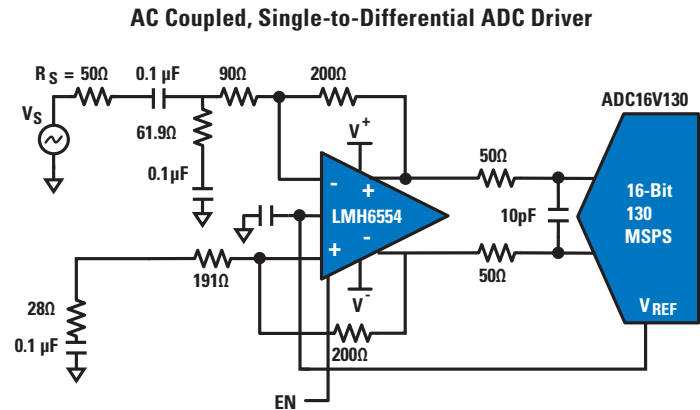
<sup>E</sup> Evaluation board

# Amplifier Solutions

## LMH6554 – PowerWise® 2.5 GHz Ultra-Linear Fully Differential Amplifier

### Features

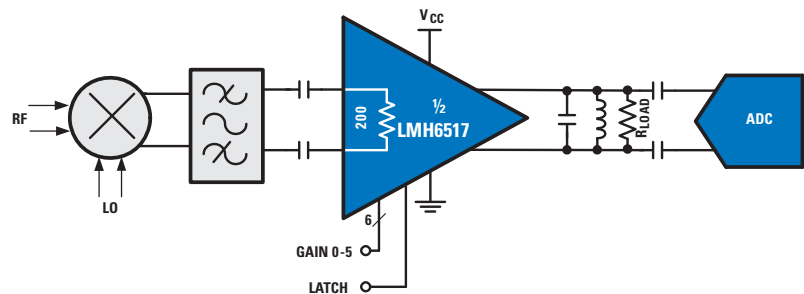
- 2.5 GHz small signal gain of 2 bandwidth
- 1.8 GHz large signal gain of 2 bandwidth
- 500 MHz 0.1 dB gain flatness
- -93/-97 dBc HD2/HD3 @ 75 MHz
- -82/-84 dBc HD2/HD3 @ 150 MHz
- 0.9 nV/√Hz input noise voltage
- 11 pA/√Hz input noise current
- 6200 V/μs slew rate
- 4.7 to 5.3V operation
- Available in quad FCOL-14 packaging
- Ideal match to National’s new ADC10D1000 1 GSPS dual ADC and ADC16V130 130 MSPS 16-bit ADC



## LMH6517 – Low-Power, High-Linearity IF and Baseband Dual 16-bit ADC Driver with Digitally-Controlled Gain

### Features

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



## Amplifiers





Product ID	Description	Small Signal Bandwidth (MHz, $A_v=1$ )	$I_{CC}$ (mA/ch)	Distortion HD/2HD3 ( $R_L=100\Omega, 2 V_{pp}$ )	Input Noise (nV/√Hz)	Packaging
LMH6550	Voltage feedback	400 MHz	20	-92/-103 at f=5 MHz	6.0	SOIC-8, MSOP8
LMH6551 <sup>E</sup>	Voltage feedback	370 MHz	12.5	-94/-96 at f=5 MHz	6.0	SOIC-8, MSOP8
LMH6552 <sup>E</sup>	Current feedback	1.5 GHz	22.5	-92/-93 at f=20 MHz	1.1	SOIC-8, LLP-8
LMH6553 <sup>E</sup>	Current feedback	900 MHz	29.1 mA	-79/-90 at f=20 MHz	1.2	PSOP-8, LLP-8
LMH6554 <sup>E</sup>	Current feedback	2.5 GHz	52 mA	-68/-70 at f=250 MHz	0.9	FCOL-14
LMH6555 <sup>E</sup>	13.7 dB fixed gain	1.2 GHz	120	-53/-54 at f=750 MHz	3.9	LLP-16

PowerWise product    <sup>E</sup> Evaluation board


















# Amplifier Solutions

## Select Amplifier Products

### Variable Gain Amplifiers





Product ID	Type	Max Gain/Gain Step Size (dB)	BW, Unity Gain (MHz)	I <sub>CC</sub> (mA/ch)	OIP3 (dBm)	Noise Figure (dB)	Packaging
LMH6514 <sup>E</sup> 	Digital variable gain amplifier	32/6	600	107	40 at 70 MHz	8.3	LLP-16
LMH6515 <sup>E</sup> 	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	45 at 200 MHz	5.5	LLP-32
CLC5526 	Digital variable gain amplifier	20/0.5	350	48	24.5 at 150 MHz	9.3	SSOP-20

### High-Speed Amplifiers

Product ID	Type	Slew Rate (V/μs, A <sub>v</sub> = 1)	Small Signal Bandwidth (MHz, A <sub>v</sub> = 1)	I <sub>CC</sub> (mA/ch)	2nd/3rd HD (R <sub>L</sub> = 100)	Voltage Noise (nV/√Hz)	Packaging
LMH6714 <sup>E</sup>	Single, wideband, op amp	1800 <sup>2</sup>	400 <sup>2</sup>	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 <sup>E</sup> 	Single differential I/O amplifier	3000	400	20	-78/-88 at 20 MHz	6	SOIC-8, MSOP-8
LMH6551 <sup>E</sup> 	Single differential I/O amplifier	2400	370	12.5	-94/-96 at 5 MHz	6	SOIC-8, MSOP-8
LMH6552 <sup>E</sup> 	Single differential I/O CFB amplifier	2500	1.5 GHz	22.5	-92/-93 at 20 MHz	0.9	SOIC-8, LLP-8
LMH6553 <sup>E</sup> 	Single differential I/O CFB amplifier	2300	900	29.1	-79/-90 at 20 MHz	1.2	PSOP-8, LLP-8
LMH6554 <sup>E</sup> 	Single differential I/O CFB amplifier	6200	2.5 GHz	52	-68/-70 at 250 MHz	0.9	FCOL-14
LMH6555 <sup>E</sup> 	1.2 GHz differential I/O amplifier	1500	1.2 GHz	130	-64/-66 at 150 MHz	1.4	LLP-16
LMH6601 <sup>EW</sup>	2.4 to 5.5V CMOS op amp	260	250	9.6	-61/-64 at 10 MHz	7	SC70-6
LMH6609 <sup>W</sup> 	Single, op amp	1400 <sup>2</sup>	900	7	-63/-57 at 20 MHz	3.1	SOT23-5, SOIC-8
LMH6611 <sup>EW</sup> 	Single RRO op amp	460	365	3.3	-64/-66 at 10 MHz	10	TSOT23-6
LMH6618/9 <sup>EW</sup> 	Single/Dual RRIO op amp	57	140	1.35	-74/-73 at 1 MHz	10	TSOT23-6/SOIC-8
LMH6622 <sup>EW</sup> 	Dual, op amp	85 <sup>2</sup>	160 <sup>2</sup>	4.3	-90/-94 at 1 MHz	1.6	SOIC-8, MSOP-8
LMH6624 <sup>EW</sup> 	Single, op amp	350 <sup>1</sup>	95 <sup>1</sup>	12	-63/-80 at 10 MHz	0.92	SOT23-5, SOIC-8
LMH6626 <sup>EW</sup> 	Dual, op amp	320 <sup>1</sup>	85 <sup>1</sup>	12	-63/-80 at 10 MHz	1	SOIC-8, MSOP-8
LMH6628 <sup>EW</sup> 	Dual, op amp	550 <sup>2</sup>	300	9	-65/-74 at 10 MHz	2	SOIC-8
LMH6702 <sup>EW</sup> 	Single, op amp	3100 <sup>2</sup>	1.7 GHz <sup>2</sup>	12.5	-63/-72 at 60 MHz	1.8	SOT23-5, SOIC-8
LMH6703 <sup>E</sup> 	Single, op amp	4500 <sup>2</sup>	1.2 GHz <sup>2</sup>	11	-69/-90 at 20 MHz	2.3	SOT23-5, SOIC-8
LMH6715 <sup>EW</sup> 	Dual, wideband, op amp	1300 <sup>2</sup>	400 <sup>2</sup>	5.8	-60/-75 at 20 MHz	3.4	SOIC-8
LMH6720 <sup>W</sup> 	Single, wideband, op amp w/disable	1800 <sup>2</sup>	400 <sup>2</sup>	5.6	-58/-70 at 20 MHz	3.4	SOIC-8, SOT23-5

<sup>1</sup> A<sub>v</sub> = +20    <sup>2</sup> A<sub>v</sub> = +2

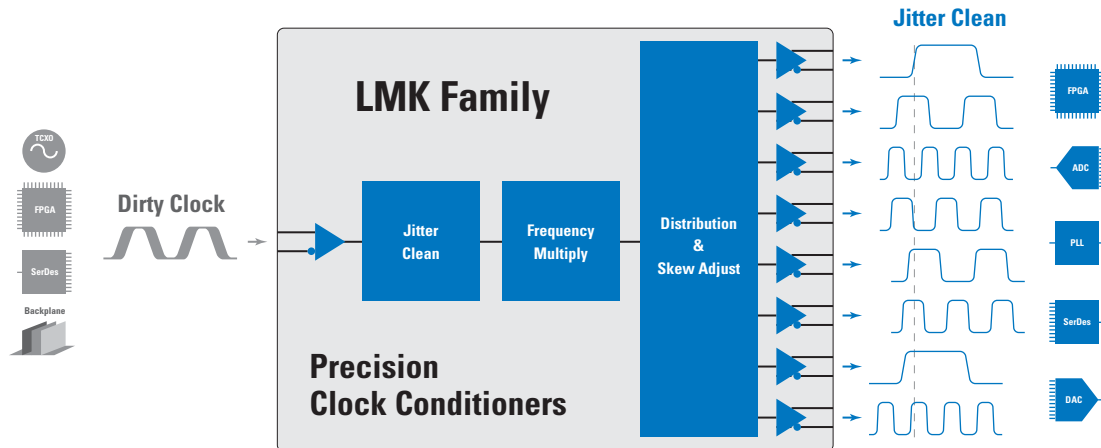
### Low Voltage & Precision Amplifiers

Product ID	Description	I <sub>CC</sub> /Ch (mA)	V <sub>OS</sub> (mV) Max.	GBW (MHz)	Noise (nV/√Hz)	Packaging
LMP7701/2/4 <sup>W</sup>	Precision single/dual/quad	0.7	0.2	2.5	9	SOT23-5, MSOP-8, TSSOP-14
LMP7711/12 <sup>W</sup> 	Precision single/dual	1.15	0.15	17	5.8	SOT23-6, MSOP-10
LMP7731 <sup>W</sup> 	Low noise precision amplifier	2.0	40 μV	21	3.3	SOT23-5
LM6211 <sup>W</sup>	Low noise 5 to 24V single with CMOS input	1.05	2.5	20	5.5	SOT23-5
LMV841 <sup>E</sup>	Single precision amp	1.0	0.5	4.5	20	SC-70
LMV842/44 <sup>E</sup>	Dual precision amp	1.0	0.5	4.5	20	SOIC-8, MSOP-8, SOIC-14, TSSOP-14
LPV531 	Programmable bandwidth amp	5 to 425 μA	1.0	0.7 to 4.6	20	TSOT23-5
LPV521 	Single nanopower amplifier	0.4	1.0	6.2 kHz	272	SC-70

 PowerWise product    <sup>E</sup> Evaluation board    <sup>W</sup> WEBENCH enabled

# LMK Clock Conditioner Family

## Jitter Cleaning + Multiplication + Distribution



## LMK Clock Conditioner Family

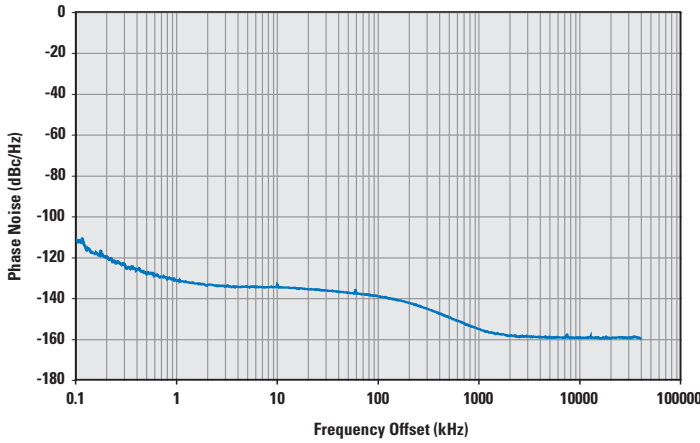
Product ID	Outputs			Architecture	Output Clock Range (MHz)	VCO Frequency Range (MHz)	RMS Jitter (ps) *
	LVPECL	LVDS	LVC MOS				
LMK01000ISQ <sup>E</sup>	5	3	0	2:8 Clock Distribution	1 to 1600	NA	0.03 (additive)
LMK01010ISQ <sup>E</sup>	0	8	0		1 to 1600	NA	0.03 (additive)
LMK01020ISQ <sup>E</sup>	8	0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

\*Integrated from 10 kHz to 20 MHz

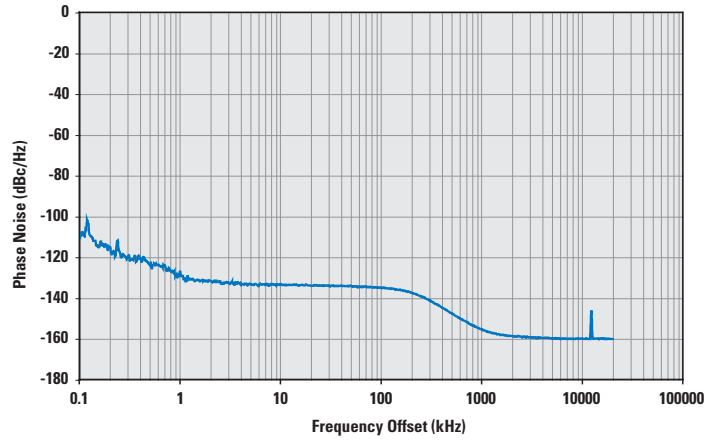
<sup>E</sup> Evaluation board

# LMK Clock Conditioner Family

## Superior Phase Noise Performance



LMK04031B LVC MOS Output Phase Noise at 122.88 MHz using a Crystek VCXO



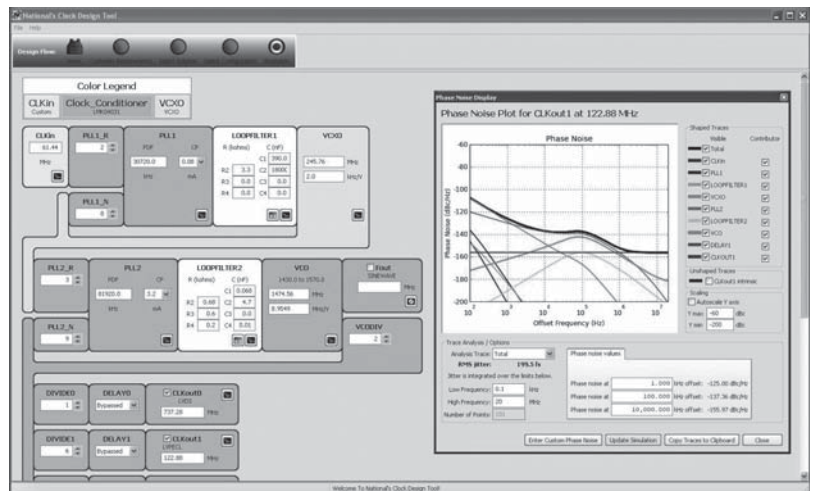
LMK04031B LVC MOS Output Phase Noise at 122.88 MHz using a Low-Cost Vectron Crystal

## National's Clock Design Tool

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

### Features

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

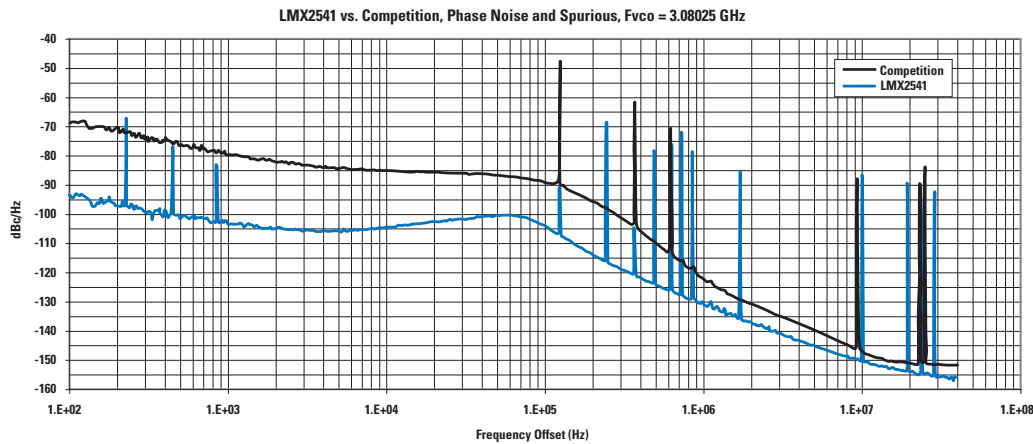


# High-Performance Frequency Synthesizer Solutions

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

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

The LMX2541 is well-suited for local oscillator (LO) applications in next-generation basestation radio transceivers such as Long-Term Evolution (LTE), Worldwide Interoperability for Microwave Access (WiMAX), and multi-standard radios. When paired with the LMK04000 clock jitter cleaner, the LMX2541 significantly improves system error vector magnitude (EVM), resulting in enhanced receiver sensitivity and transmitter spectral purity.



### 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
- External VCO mode (internal VCO powered down)
- Partially integrated loop filter components
- Supports crystal oscillator based reference clock input

### Design Tools and Resources

Design Tool	Clock Design Tool ( <a href="http://national.com/timing">national.com/timing</a> )
Handbook	PLL Performance, Simulation and Design Handbook 4th Edition
Handbook	Clock Conditioner Owner’s Manual
AN-1001	An Analysis and Performance Evaluation of a Passive Filter Design Technique for Charge Pump PLLs
AN-1006	Phase-Locked Loop Based Clock Generators
Web Seminar	Advantages and Pitfalls of Using Fractional N PLLs
Web Seminar	PLL Loop Filter Optimization
Web Seminar	Non-PLL Radio Frequency (RF) Basics
Web Seminar	PLL Building Blocks
Web Seminar	PLL Performance
Web Seminar	Fractional PLLs
AN-1939	Crystal-Based Oscillator Design with the LMK04000 Family
Web Seminar	Advanced PLL Concepts
Article	The Impact of Various PLL Parameters on System Performance
AN-1879	Fractional-N Frequency Synthesis
Evaluation Boards	Visit: <a href="http://national.com/wireless">national.com/wireless</a>
Software	PLL Codeloader Evaluation Software
AN-1910	LMK04000 Family Phase Noise Characterization

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

# High-Performance PLLatinum® Family of PLL Products

## High-Performance PLLatinum Family of PLL Products

Product ID	Main Operating Frequency Range (GHz)	Aux. Operating Frequency Range (MHz)	Main Normalized Phase Noise (dBc/Hz)	Supply Current (mA)	Supply Voltage (V)	Packaging
<b>Dual-Integer PLLs</b>						
LMX2434 <sup>E,W</sup>	1.0 to 5.0	500 to 2500	-219	7.0	2.35 to 2.75	TSSOP-20
LMX2433 <sup>E,W</sup>	0.5 to 3.6	250 to 1700	-219	5.2	2.25 to 2.75	TSSOP-20
LMX2430 <sup>W</sup>	0.25 to 3.0	100 to 800	-219	4.2	2.25 to 2.75	TSSOP-20
<b>Fractional-N PLLs</b>						
LMX2487 <sup>E,W</sup>	3.0 to 6.0	250 to 3000	-209	8.2	2.5 to 3.6	LLP-24
LMX2487E <sup>W</sup>	3.0 to 7.5	250 to 3000	-209	8.2	2.5 to 3.6	LLP-24
LMX2486 <sup>E,W</sup>	1.0 to 4.5	250 to 3000	-210	8.3	2.5 to 3.6	LLP-24
LMX2485 <sup>E,W</sup>	0.5 to 3.0	75 to 800	-209	5	2.5 to 3.6	LLP-24
LMX2485E <sup>E,W</sup>	0.05 to 3.0	75 to 800	-209	5	2.5 to 3.6	LLP-24
LMX2470 <sup>E,W</sup>	0.5 to 2.6	75 to 800	-210	4.1	2.25 to 2.75	UCSP-24

<sup>E</sup> Evaluation board

<sup>W</sup> WEBENCH enabled

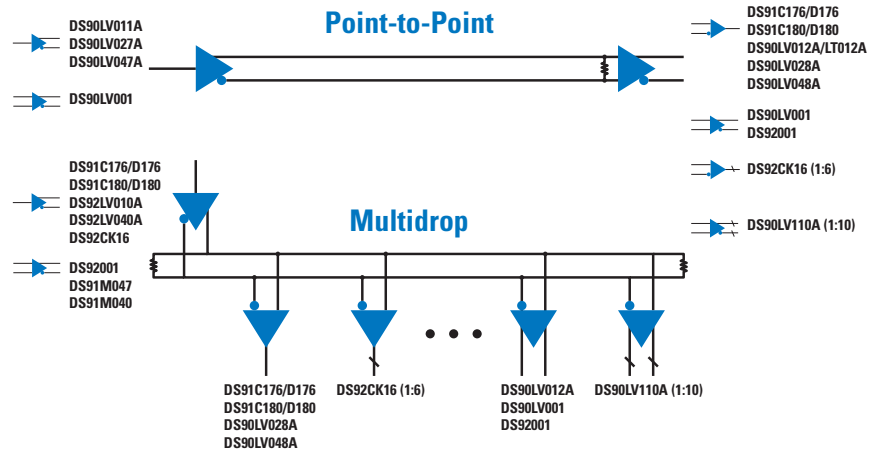
## LMX2531 PLLatinum Family of High-Performance, Low-Power Synthesizer

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	1184	1106	592	553	-212	-121	34
LMX2531LQ1226E	1268	1184	634	592	-212	-121	34
LMX2531LQ1312E	1360	1268	680	634	-212	-121	34
LMX2531LQ1415E	1470	1360	735	680	-212	-121	34
LMX2531LQ1500E	1510	1499	—	—	-212	-121	34
LMX2531LQ1515E	1580	1450	790	725	-212	-122	34
LMX2531LQ1650E	1700	1590	850	795	-212	-118	34
LMX2531LQ1700E	1770	1662	885	831	-212	-117	34
LMX2531LQ1742	1866	1760	933	880	-212	-117	34
LMX2531LQ1778E	1840	1726	920	863	-212	-117	34
LMX2531LQ1910E	2028	1834	1014	917	-212	-115	34
LMX2531LQ2080E	2274	1904	1137	952	-212	-113	34
LMX2531LQ2265E	2400	2178	1200	1089	-212	-113	38
LMX2531LQ2570E	2790	2336	1395	1168	-212	-112	38
LMX2531LQ2820E	2925	2710	1462	1355	-212	-111	38
LMX2531LQ3010E	3132	2910	1566	1455	-212	-110	38

# LVDS Clock Distribution

## Point-to-Point and Multidrop

National offers a comprehensive range of products for clock distribution from high-speed, low-jitter point-to-point LVDS buffers and translators, to slow edge rate M-LVDS and Bus LVDS drivers for multidrop applications. Splitters and crosspoints create multiple copies of your clock or can be used for clock redundancy.



Product ID	Drivers	Receivers	Input Compatibility	Output	Max Clock (MHz)	Packaging	Comments
<b>Point-to-Point Drivers</b>							
DS90LV001TM/TLDA <sup>E</sup>	1	1	LVDS/LVPECL/CML	LVDS	400	SOIC/LLP-8	Low jitter, high quality LVDS output
DS90LV011ATMF/ATLD	1	0	LVTTTL/LVCMOS	LVDS	200	SOT23-5, LLP-8	Flow-through pinout, tiny packages
DS90LV027ATM	2	0	LVTTTL/LVCMOS	LVDS	200	SOIC-8	Flow-through pinout
DS90LV047ATM/ATMTC	4	0	LVTTTL/LVCMOS	LVDS	200	SOIC/TSSOP-16	Flow-through pinout
<b>Multidrop Drivers</b>							
DS91C176TM/D176TM <sup>E</sup>	1	1	M-LVDS/LVDS	M-LVDS	100	SOIC-8	Half duplex, controlled edge rates
DS91C180TM/D180TM	1	1	M-LVDS/LVDS	M-LVDS	100	SOIC-14	Full duplex, controlled edge rates
DS91M040TMA <sup>E</sup>	4	4	LVTTTL/M-LVDS	M-LVDS/LVTTTL	125	LLP-32	Supports type 1 & 2 Rx
DS91M047TMA <sup>E</sup>	4	4	LVTTTL	M-LVDS	125	SOIC-16	2 nsec typical edges
DS92LV010ATM	1	1	LVDS/LVPECL/CML	Bus LVDS	80	SOIC-8	3.3V or 5V operation
DS92001TM/TLD	1	1	LVDS/LVPECL/CML	Bus LVDS	200	SOIC/LLP-8	Controlled edge rates
DS92LV040ATLQA	4	4	LVDS/LVPECL/CML	Bus LVDS	100	LLP-44	Controlled edge rates, low skew
<b>1:1 Receivers</b>							
DS91C176TM/D176TM <sup>E</sup>	1	1	M-LVDS/LVDS	M-LVDS	100	SOIC-8	Half duplex, type 2/1 wide common mode input
DS91C180TM/D180TM	1	1	M-LVDS/LVDS	M-LVDS	100	SOIC-14	Full duplex, type 2/1 wide common mode input
DS90LV012ATMF/ATLD	0	1	LVDS/LVPECL/CML	LVTTTL	200	SOT23-5, LLP-8	Flow-through pinout, tiny packages
DS90LV028ATM	0	2	LVDS/LVPECL/CML	LVTTTL	200	SOIC-8	Flow-through pinout
DS90LV048ATM/ATMTC	0	4	LVDS/LVPECL/CML	LVTTTL	200	SOIC/TSSOP-16	Flow-through pinout
DS92CK16TMTC	6	1	LVDS or LVTTTL	LVTTTL and Bus LVDS	125	TSSOP-24	Configurations: A) LVTTTL input to 6 LVTTTL + 1 BLVDS outputs B) LVDS input to 6 LVTTTL outputs
DS90LV110ATMT	10	1	LVDS/LVPECL/CML	LVDS	200	TSSOP-28	Low output jitter
<b>1: n Repeaters</b>							
DS10BR254TSQ	2	4	LVDS/LVPECL/CML	LVDS	1500	LLP-40	Select 1 of 2 inputs
DS25BR204TSQ <sup>E</sup>	2	4	LVDS/LVPECL/CML	LVDS	3125	LLP-40	Pre-emphasis, Equalization, Low Jitter
DS91M124TMA <sup>E</sup>	4	1	LVTTTL	M-LVDS	125	SOIC-16	2 nsec typical edges
DS91M125TMA <sup>E</sup>	4	1	LVDS/LVPECL/CML	M-LVDS	125	SOIC-16	2 nsec typical edges

Note: the products above are characterized over the full -40 to +85°C industrial temperature range.

<sup>E</sup> Evaluation board



# LVDS PHYs Solutions

## Single-Ended to Differential

### Single-Ended to Differential LVDS PHY Overview

#### Drivers

Single: DS90LV011A (SOT23-5, LLP-8)  
DS90LV017A

Dual: DS90LV027A  
DS90C401 (5V)

Quad: DS90LV047A  
DS90C031 (5V)  
DS91M047

#### Receivers

Single: DS90LV012A (SOT23-5, LLP-8)  
DS90LV018A

Dual: DS90LV028A  
DS90C402 (5V)

Quad: DS90LV048A  
DS90C032 (5V)

#### Transceivers

Single: DS90LV019 (LVDS)  
DS92LV010A (Bus LVDS) ▣  
DS91C176/D176 (M-LVDS) ▣

Quad: DS92LV040A ▣  
DS91M040

9-Ch: DS92LV090A ▣

#### 1:n Repeater

DS92CK16 (LVTTTL to LVTTTL ▣  
or LVDS to LVTTTL)

DS91M124  
DS91M125

#### Drivers and Receivers

Single: DS91C180/D180 (M-LVDS) ▣

Dual: DS90LV049  
DS36C200 (5V)

#### Output Drive

▣ Bus LVDS  
▣ M-LVDS

## M-LVDS Multipoint Transceivers

### Description

M-LVDS is a multipoint version of LVDS as described in the TIA/EIA-899 standard. M-LVDS is optimized for multipoint including features critical to multipoint applications such as:

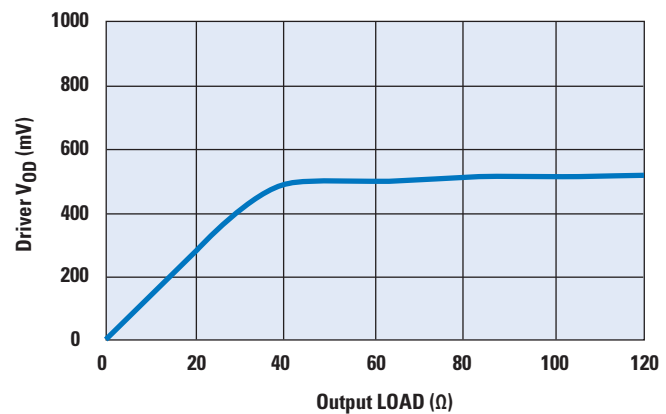
- Controlled edge rates
- Higher drive
- Extended common mode
- Tighter receiver thresholds

### Features

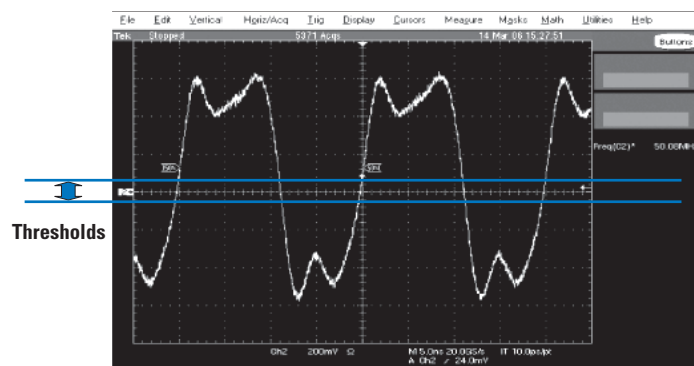
- 2 ns typical edge rates to minimize reflections
- Constant Output Voltage (Vod) for loads between 30Ω and 100Ω provides better noise margin even when driving heavy loads
- Common mode extended to -1.4V to 3.8V for improved noise immunity
- Tight 50 mV receiver thresholds add to noise margin
- Available with type 1 and type 2 (failsafe) receiver thresholds

The M-LVDS standard includes 2 types of receiver thresholds. Type 1 is a conventional LVDS input centered at 0V differential. Type 2 receivers have a built-in failsafe where the receiver threshold is offset by 100 mV. Zero volts on the receiver thresholds will always result in a logic LOW. In addition to providing a failsafe, type 2 receivers can be used in Wired-Or logic.

### DS91C176 Typical Performance



### DS91D176 driving 50 MHz clock on ATCA backplane - 13 loads - 1/2 inch stubs - Rx slot 7, Tx slot 14



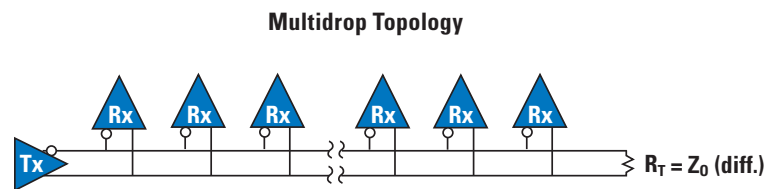
# LVDS PHYs Solutions

## Single-Ended to Differential

### Multi-Drop: Drive as Many as 32 Loads Using Bus LVDS

**Bus LVDS** is a multi-drop version of LVDS with beefed-up drive to support as many as 32 loads. Controlled edge rates help reduce reflections and allow B-LVDS to support data rates as high as 400 Mbps.

- High drive with controlled edge rates
- Up to 400 Mbps



Product ID	Drivers	Receivers	LVDS Type	Max Speed/Ch (Mbps)	Supply Voltage	Temperature (°C)	Packaging	Comments
<b>Transceivers</b>								
DS91C176TM <sup>E</sup>	1	1	M-LVDS	100 MHz	3.3	-40 to +85°	SOIC-8	M-LVDS, half duplex, type 2
DS91D176TM <sup>E</sup>	1	1	M-LVDS	100 MHz	3.3	-40 to +85°	SOIC-8	M-LVDS, half duplex, type 1
DS91C180TM	1	1	M-LVDS	100 MHz	3.3	-40 to +85°	SOIC-14	M-LVDS, full duplex, type 2
DS91D180TM	1	1	M-LVDS	100 MHz	3.3	-40 to +85°	SOIC-14	M-LVDS, full duplex, type 1
DS90LV019TM/TMTC	1	1	LVDS	155	3.3 or 5	-40 to +85°	SOIC-14, TSSOP-14	
DS92LV010ATM	1	1	Bus LVDS	155	3.3 or 5	-40 to +85°	SOIC-8	3.3V or 5V operation
DS92LV040ATLQA	4	4	Bus LVDS	200	3.3	-40 to +85°	LLP-44	Edge rate control, low skew
DS91M040TSQ <sup>E</sup>	4	4	M-LVDS	125 MHz	3.3	-40 to +85°	LLP-32	Supports type 1 & type 2
DS92LV090ATVEH	9	9	Bus LVDS	200	2.7 to 3.6	-40 to +85°	PQFP-64	Low part-to-part skew
<b>Single Drivers and Receivers</b>								
DS90LV011ATMF	1	0	LVDS	400	3.3	-40 to +85°	SOT23-5	Tiny package
DS90LV012ATMF	0	1	LVDS	400	3.3	-40 to +85°	SOT23-5	Tiny package
DS90LT012ATMF	0	1	LVDS	400	3.3	-40 to +85°	SOT23-5	Integrated termination
DS90LV017ATM <sup>2</sup>	1	0	LVDS	400	3.3	-40 to +85°	SOIC-8	
DS90LV018ATM <sup>2</sup>	0	1	LVDS	400	3.3	-40 to +85°	SOIC-8	
<b>Dual Drivers and Receivers</b>								
DS90LV027ATM <sup>2</sup>	2	0	LVDS	400	3.3	-40 to +85°	SOIC-8	
DS90LV028ATM/ATLD <sup>2</sup>	0	2	LVDS	400	3.3	-40 to +85°	SOIC-8, LLP-8	
DS90LV049TMT <sup>2</sup>	2	2	LVDS	400	3.3	-40 to +85°	TSSOP-16	
<b>Quad Drivers and Receivers</b>								
DS91M047TMA <sup>E</sup>	4	0	M-LVDS	250	3.3	-40 to +85°	SOIC-16	2 nsec edge rates
DS90LV031ATM/ATMTC	4	0	LVDS	400	3.3	-40 to +85°	SOIC-16, TSSOP-16	
DS90LV032ATM/ATMTC <sup>1,2</sup>	0	4	LVDS	400	3.3	-40 to +85°	SOIC-16, TSSOP-16	
DS90LV047ATM/ATMTC <sup>2</sup>	4	0	LVDS	400	3.3	-40 to +85°	SOIC-16, TSSOP-16	
DS90LV048ATM/ATMTC <sup>2</sup>	0	4	LVDS	400	3.3	-40 to +85°	SOIC-16, TSSOP-16	
<b>1:n Repeaters</b>								
DS92CK16TMTC	6	1	Bus LVDS	125 MHz	3.3	-40 to +85°	TSSOP-24	Configurations: A) 1 LVTTTL input to 6 LVTTTL + 1 BLVDS outputs B) 1 LVDS to 6 LVTTTL
DS91M124TMA <sup>E</sup>	4	1	M-LVDS	125 MHz	3.3	-40 to +85°	SOIC-16	LVC MOS Input
DS91M125TMA <sup>E</sup>	4	1	M-LVDS	125 MHz	3.3	-40 to +85°	SOIC-16	LVDS Input

<sup>1</sup> These products are also available qualified to QML for space and/or military applications

<sup>2</sup> Use evaluation board part number LVDS47/48EVK

<sup>E</sup> Evaluation board

# LVDS and CML PHYs Solutions

## Signal Conditioning—Extend Your Reach

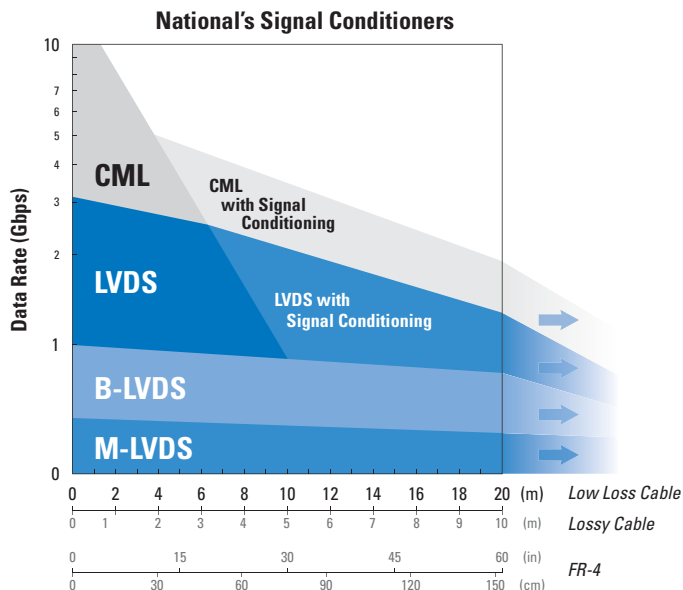
National offers an array of signal conditioning solutions, covering data rates from DC to 10 Gbps and topologies ranging from point-to-point to 32 multidrop loads.

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.

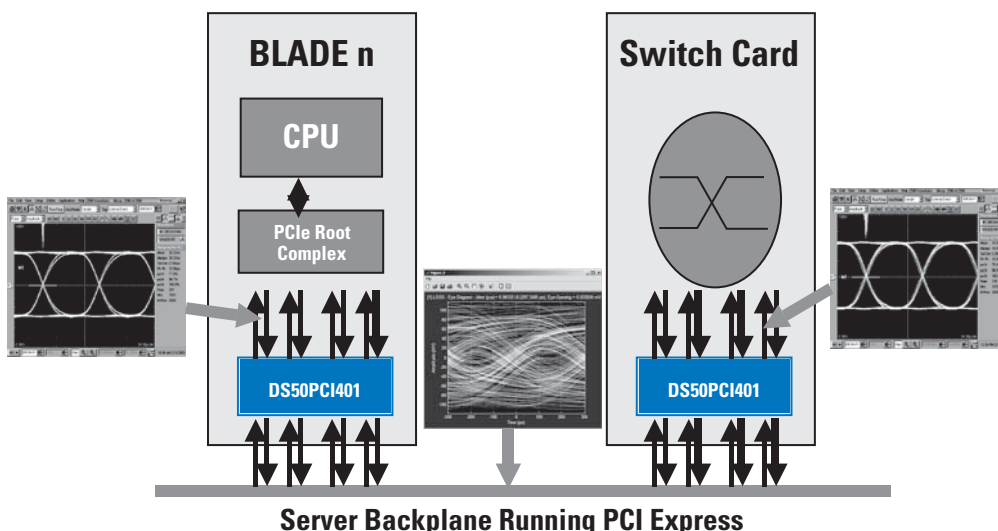
B-LVDS and M-LVDS are lower speed technologies that use controlled edge rates to improve signal integrity when driving multiple loads in multidrop or multipoint configurations.



Typical Data Rates and Cable Drive Strength

### DS50PCI401 – PCIe Standards Approved Gen-1/2 Quad Transceiver

- Includes both Tx de-emphasis and Rx equalization – extends reach and enables greater flexibility in physical placement. Automatic rate detect and signal-conditioning optimization between PCIe gen-1 and gen-2
- Full compliance to PCIe hand-shaking and electrical specifications – signaling levels, receiver and IDLE detect, beacon pass-through
- Low power – 95 mW/channel (typ), programmable power-down mode on a per-channel basis, single 2.5V supply



# LVDS and CML PHYs Solutions

## Signal Conditioning, Redundancy, Distribution

### Switching/Redundancy

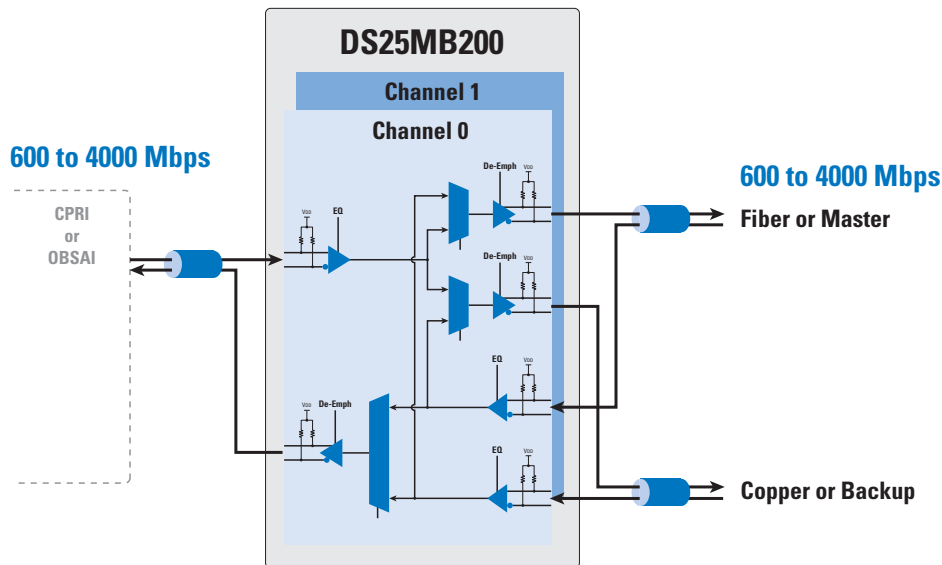
### Signal Conditioning

Product ID	Function	Switching/Redundancy			Signal Conditioning			Max Speed/Ch (Mbps)	Packaging	Comments	
		In-puts	Out-puts	Muxing Options	Input Compatibility	Output	Pre-emphasis (dB) <sup>1</sup>				Receive Equalization (dB)
<b>Buffers</b>											
DS10BR150TSD <sup>E</sup>	LVDS buffer	1	1	—	LVDS/LVPECL/CML	LVDS	—	—	1000	LLP-8	8 kV ESD
DS90LV001TM/TLD	Single LVDS buffer	1	1	—	LVDS/LVPECL/CML	LVDS	—	—	800	SOIC/LLP-8	Low jitter
DS92001TMA/TLD	Single bus LVDS buffer	1	1	—	LVDS/LVPECL/CML	Bus LVDS	—	—	400	SOIC/LLP-8	Controlled edge rates
DS25BR100TSD <sup>E</sup>	Single LVDS buffer	1	1	—	LVDS/LVPECL/CML	LVDS	0/6	4/8	3125	LLP-8	Int termination, 8 kV ESD
DS25BR110TSD	Single LVDS buffer	1	1	—	LVDS/LVPECL/CML	LVDS	—	0/4/8/16	3125	LLP-8	Int termination, 8 kV ESD
DS25BR120TSD	Single LVDS buffer	1	1	—	LVDS/LVPECL/CML	LVDS	0/3/6/9	—	3125	LLP-8	Int termination, 8 kV ESD
DS90LV804TSQ	Quad LVDS buffer	4	4	—	LVDS/LVPECL/CML	LVDS	—	—	800	LLP-32	Int termination, 15 kV ESD
DS90LV004TVS	Quad LVDS buffer	4	4	—	LVDS/LVPECL/CML	LVDS	0/2/4/6	—	1500	TQFP-48	Int termination, 15 kV ESD
DS15BR400TSQ/TVS <sup>E</sup>	Quad LVDS buffer	4	4	—	LVDS/LVPECL/CML	LVDS	0/6	—	2000	LLP-32, TQFP-48	Int termination, 15 kV ESD
DS15BR401TSQ/TVS	Quad LVDS buffer	4	4	—	LVDS/LVPECL/CML	LVDS	0/6	—	2000	LLP-32, TQFP-48	15 kV ESD
DS25BR440TSQ	Quad LVDS buffer	4	4	—	LVDS/LVPECL/CML	LVDS	0/3/6/9	0/3/6/9	3125	LLP-40	8 kV ESD
SCAN90004TVS <sup>E</sup>	Quad LVDS buffer	4	4	—	LVDS/LVPECL/CML	LVDS	0/2/4/6	—	1500	TQFP-48	Int termination, IEEE1149.6
DS25BR400TSQ <sup>E</sup>	Quad CML buffer	8	8	Loopback	LVDS/LVPECL/CML	CML	0/-3/-6/-9	0/5	2500	LLP-60	Int termination, 6 kV ESD
DS42BR400TSQ	Quad CML buffer	8	8	Loopback	LVDS/LVPECL/CML	CML	0/-3/-6/-9	0/5	4250	LLP-60	Int termination, 6 kV ESD
<b>NEW</b> DS50PCI401	Quad PCIe transceiver	8	8	—	CML	CML	0/3/6/9/22	0/9/15/21/26	5000	LLP-54	PCIe transceiver-SIG approved
<b>NEW</b> DS64BR401	Quad CML transceiver	8	8	—	CML	CML	0/3/6/9/22	0/9/15/21/26/33	6400	LLP-54	SATA, SAS, XAUI, others
<b>Equalizers</b>											
DS32EV100SQ <sup>E</sup>	Single CML equalizer	1	1	—	LVDS/LVPECL/CML	CML	—	15	3200	LLP-14	Settable EQ in 8 steps
DS32EV400SQ <sup>E</sup>	Quad CML equalizer	4	4	—	LVDS/LVPECL/CML	CML	—	15	3200	LLP-48	Settable EQ in 8 steps
DS64EV100SQ <sup>E</sup>	Single CML equalizer	1	1	—	LVDS/LVPECL/CML	CML	—	15	6400	LLP-14	Settable EQ in 8 steps
DS64EV400SQ <sup>E</sup>	Quad CML equalizer	4	4	—	LVDS/LVPECL/CML	CML	—	15	6400	LLP-48	Settable EQ in 8 steps
DS50EV401SQ <sup>E</sup>	Quad Gen II PCIe equalizer	4	4	—	CML	CML	—	24	5000	LLP-48	Meets PCIe Gen 1 & Gen 2
<b>NEW</b> DS50PCI401	Quad PCIe transceiver	8	8	—	CML	CML	0/3/6/9/22	0/9/15/21/26	5000	LLP-54	PCIe transceiver-SIG approved
<b>NEW</b> DS64BR401	Quad CML transceiver	8	8	—	CML	CML	0/3/6/9/22	0/9/15/21/26/33	6400	LLP-54	SATA, SAS, XAUI, others
<b>Multiplexers and Mux-Buffers</b>											
DS25MB100TSQ <sup>E</sup>	2:1/1:2 mux/buffer	3	3	2:1/1:2, LB	LVDS/LVPECL/CML	CML	0/-3/-6/-9	0/5	2500	LLP-36	Int termination, 6 kV ESD
DS42MB100TSQ	2:1/1:2 mux/buffer	3	3	2:1/1:2, LB	LVDS/LVPECL/CML	CML	0/-3/-6/-9	0/5	4250	LLP-36	Int termination, 6 kV ESD
DS08MB200TSQ	Dual 2:1/1:2 mux/buffer	6	6	2:1/1:2	LVDS/LVPECL/CML	LVDS	—	—	800	LLP-48	15 kV ESD
DS15MB200TSQ	Dual 2:1/1:2 mux/buffer	6	6	2:1/1:2	LVDS/LVPECL/CML	LVDS	0/6	—	2000	LLP-48	15 kV ESD
SCAN15MB200TSQ <sup>E</sup>	Dual 2:1/1:2 mux/buffer	6	6	2:1/1:2	LVDS/LVPECL/CML	LVDS	0/6	—	2000	LLP-48	IEEE1149.6, 15 kV ESD
DS25MB200TSQ <sup>E</sup>	Dual 2:1/1:2 mux/buffer	6	6	2:1/1:2, LB	LVDS/LVPECL/CML	CML	0/-3/-6/-9	0/5	2500	LLP-48	Int termination, 6 kV ESD
DS40MB200SQ <sup>E</sup>	Dual 2:1/1:2 mux/buffer	6	6	2:1/1:2, LB	LVDS/LVPECL/CML	CML	0/-3/-6/-9	0/5	4000	LLP-48	Int termination, 6 kV ESD
DS42MB200TSQ	Dual 2:1/1:2 mux/buffer	6	6	2:1/1:2, LB	LVDS/LVPECL/CML	CML	0/-3/-6/-9	0/5	4250	LLP-48	Int termination, 6 kV ESD
<b>Crosspoint Switches</b>											
DS10CP152TMA <sup>E</sup>	2 X 2 crosspoint	2	2	2 X 2	LVDS/LVPECL/CML	LVDS	—	—	1500	SOIC-16	9 ps jitter typical
DS25CP102TSQ <sup>E</sup>	2 X 2 crosspoint	2	2	2 X 2	LVDS/LVPECL/CML	LVDS	0/6	0/6	3125	LLP-16	9 ps typical jitter
DS25CP152TSQ <sup>E</sup>	2 X 2 crosspoint	2	2	2 X 2	LVDS/LVPECL/CML	LVDS	—	—	3125	LLP-16	9 ps typical jitter
DS10CP154ATSQ <sup>E</sup>	4 X 4 crosspoint	4	4	4 X 4	LVDS/LVPECL/CML	LVDS	—	—	1500	LLP-40	15 ps jitter typical
DS25CP104ATSQ <sup>E</sup>	4 X 4 crosspoint	4	4	4 X 4	LVDS/LVPECL/CML	LVDS	0/3/6/9	0/3/6/9	3125	LLP-40	SM Bus
<b>1:n Repeaters</b>											
DS90LV110ATMT	1:10 LVDS repeater	1	10	1:10	LVDS/LVPECL/CML	LVDS	—	—	400	TSSOP-28	Input failsafe
DS10BR254TSQ	1:4 LVDS repeater	2	4	1:04	LVDS/LVPECL/CML	LVDS	—	—	1500	LLP-40	Select 1 of 2 inputs
DS25BR204TSQ <sup>E</sup>	1:4 LVDS repeater	2	4	1:04	LVDS/LVPECL/CML	LVDS	0/3/6/9	0/3/6/9	3125	LLP-40	Select 1 of 2 inputs

# LVDS and CML PHYs Solutions

## Product Application Examples

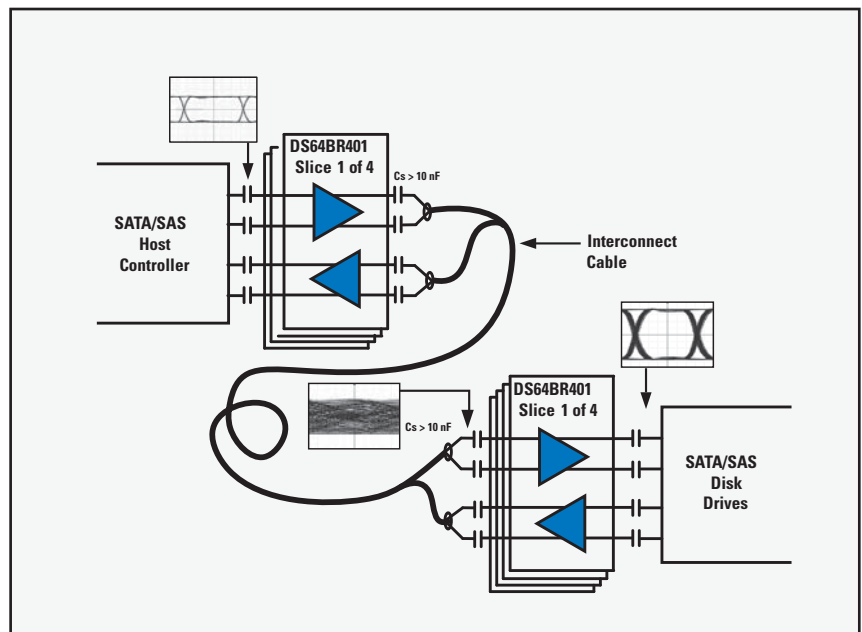
### DS25MB200 CPRI/OBSAI – Redundancy and Fiber+Copper Port Switching Example



### DS64BR401 – 6.4 Gbps Quad Transceiver for Storage/Server Applications

#### Features

- Four-lane transceiver for high-speed signaling (up to 6.4 Gbps)
- Adjustable Rx EQ, Tx de-emphasis, VoD to extend reach > 10m of cable or > 40-inch FR-4
- Low power: < 200 mW/lane (typ), Power-down control per channel
- 0.25 UI of residual DJ at 6.4 Gbps with 40-inch FR-4 trace
- Signal detect and OOB detection/pass-through for SAS/SATA
- Supports XAUI, RXAUI, Fibre-Channel, Infiniband and other high speed protocols
- SMBus or pin programmable



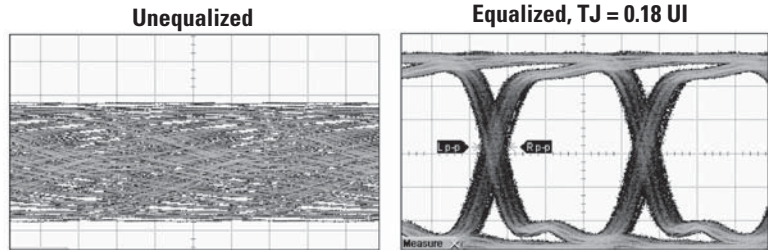
# LVDS and CML PHYs Solutions

## Cable Extension and Switching/Redundancy

### PowerWise® Cable and Backplane Equalizer Family Operates from 2.5 Gbps to 10 Gbps

#### Features

- Equalizes 40 inch FR4 or 10m 24 AWG Twin-AX at 6.4 Gbps
- 94 mW typical power consumption per channel



40" TYCO XAUI Backplane, PRBS-7 at 6.25 Gbps

Product ID	Description	Supply Voltage	Channels	Packaging
DS32EV400 <sup>E</sup>	Quad 1 to 5 Gbps general purpose equalizer	3.3	4	LLP-48
DS64EV400 <sup>E</sup>	Quad 5 to 10 Gbps general purpose equalizer	3.3	4	LLP-48
DS32EV100 <sup>E</sup>	Single channel 1 to 5 Gbps general purpose equalizer	3.3	1	LLP-14
DS64EV100 <sup>E</sup>	Single channel 5 to 10 Gbps general purpose equalizer	3.3	1	LLP-14
DS50EV401 <sup>E</sup>	Quad 2.5 to 8 Gbps PCI Express equalizer	2.5 to 3.3	4	LLP-48

PowerWise product

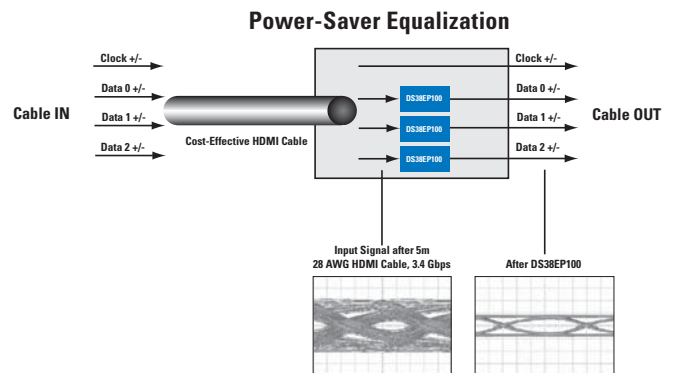
<sup>E</sup> Evaluation board

### PowerWise® Energy-Saver Equalizers

Energy-saver equalizers employ passive components to provide as much as 7 dB relative boost. Energy-savers require no power or ground, add no R<sub>j</sub> and are bi-directional. Energy-savers are ideal for placement in connectors, backplanes and cables and can act independently or in conjunction with an active equalizer.

Product ID	Data Rate	Boost	Packaging
DS38EP100	1 to 5 Gbps	7 dB	LLP-6
DS80EP100 <sup>E</sup>	5 to 12.5 Gbps	7 dB	LLP-6

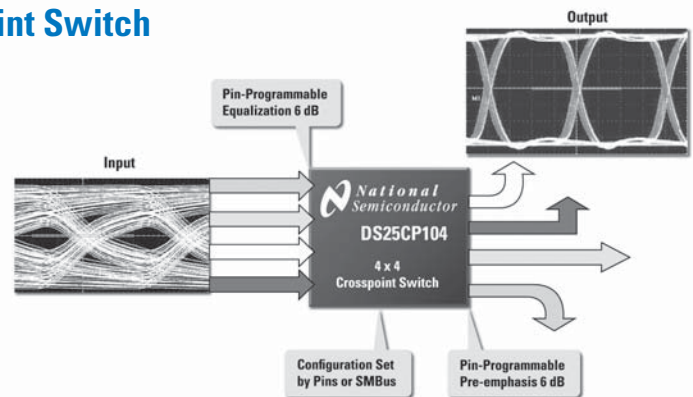
<sup>E</sup> Evaluation board



### DS25CP104 – PowerWise® LVDS 4 x 4 Crosspoint Switch

#### Features

- DC to 3.125 Gbps
- 10 ps typical jitter
- Programmable equalization and pre-emphasis
- Configurable using pins or SMBus

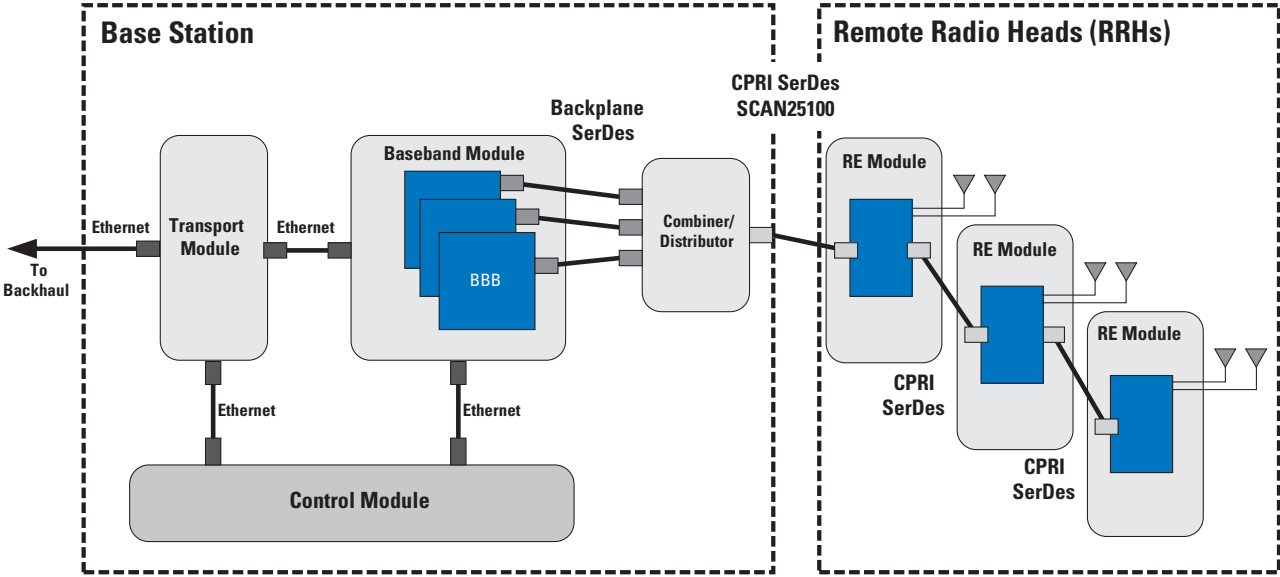
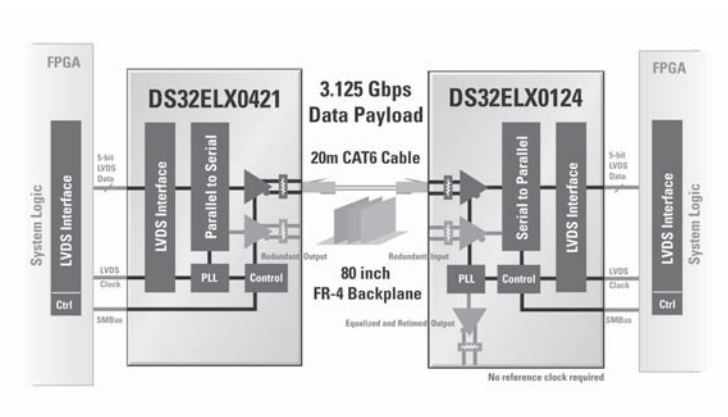


# SerDes-Data Interface

## DS32EL(X)0421/DS32EL(X)0124 — 3.125 Gbps FPGA-Link Serializers and Deserializers

### Features

- Wide serial data rate – 1.25 Gbps to 3.125 Gbps
- Tx de-emphasis, RX equalizer, DC balancing, scrambler
- Supports – CAT5e/6/7, FR-4, coax (50Ω, 75Ω)
- FPGA-friendly interface – 5-bit DDR LVDS data
- “Remote sense” back-channel enables self-healing link
- 35 ps<sub>pp</sub> (typ) TX jitter, 0.9 UI (typ) Rx jitter tolerance
- Low power – auto standby and configurable sleep modes
- ELX version features – retimed output and redundant I/O
- Sample FPGA IP for Ser/Des interfacing included



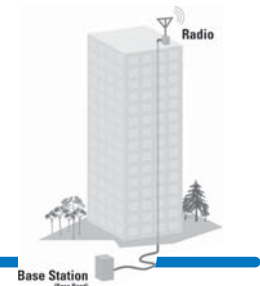
**Ethernet Solutions**  
 DP83640 (IEEE1588 supported)  
 DP83848 (Single)  
 DP83849 (Dual)

**Backplane SerDes**  
 DS32ELX0421/0124  
 SCAN928028/6260  
 DS92LV18  
 DS90UR241  
 DS90UR124

**CPRI SerDes**  
 SCAN25100  
 SCAN12100

# SerDes Solutions

## Embedded Clock and Bit Interleave SerDes



Product ID	MUX Ratio	Function	Ser	Des	Clock Min (MHz)	Clock Max (MHz)	Payload Channel/ Device (Mbps)	Temp Range °C	Packaging	Evaluation Kit
<b>Embedded Clock : FPGA-Link</b>										
DS32ELX0421SQ <sup>E</sup>	5:1 DDR LVDS	Serializer	1	—	125	312.5	3.125 Gbps	-40 to +85	LLP-48	AES-EX
DS32ELX0124SQ <sup>E</sup>		Reclocking Deserializer	—	1	125	312.5	3.125 Gbps	-40 to +85	LLP-48	AES-EX
DS32EL0421SQ <sup>E</sup>	5:1 DDR LVDS	Serializer	1	—	125	312.5	3.125 Gbps	-40 to +85	LLP-48	AES-EX
DS32EL0124SQ <sup>E</sup>		Deserializer	—	1	125	312.5	3.125 Gbps	-40 to +85	LLP-48	AES-EX
<b>Embedded Clock : 8b/10b</b>										
SCAN25100TYA <sup>E</sup>	10:1	SerDes	1	1	30.72	122.16	2456	-40 to +85	TQFP-100	SCAN25100EVK
SCAN12100TYA <sup>E</sup>	10:1	SerDes	1	1	30.72	61.44	1228.8	-40 to +85	TQFP-100	SCAN25100EVK
<b>Embedded Clock : Start/Stop Bit</b>										
DS92LV1023EMQ <sup>E</sup>	10:1	Serializer	1	—	30	66	660	-40 to +85	SSOP-EIAJ 28L	—
DS92LV1224TMSA <sup>E</sup>	1:10	Deserializer	—	1	30	66	660	-40 to +85	SSOP-EIAJ 28L	—
SCAN921025HSM <sup>E</sup>	10:1	Serializer	1	—	20	80	800	-40 to +125	BGA-49	—
SCAN921226HSM <sup>E</sup>	1:10	Deserializer	—	1	20	80	800	-40 to +125	BGA-49	—
SCAN928028TUF <sup>E</sup>	10:1	Serializers	8	—	25	66	5280	-40 to +85	LBGA-196	—
SCAN926260TUF <sup>E</sup>	1:10	Deserializers	—	6	16	66	3960	-40 to +85	LBGA-196	—
DS92LV16TVHG <sup>E</sup>	16:1	SerDes	1	1	25	80	1280	-40 to +85	PQFP-80	BLVDS16EVK
DS92LV18TVV <sup>E</sup>	18:1	SerDes	1	1	15	66	1188	-40 to +85	PQFP-80	LVDS-18B-EVK
DS90UR241QVS <sup>E</sup>	24:1	Serializer	1	—	5	43	1204	-40 to +105	TQFP-48	SERDESUR-43USB
DS90UR124QVS <sup>E</sup>	1:24	Deserializer	—	1	5	43	1204	-40 to +105	TQFP-64	SERDESUR-43USB
<b>Parallel Clock : Channel Link</b>										
DS90CR217MTD <sup>E</sup>	21:3	Serializer	1	—	20	85	595/1785	-10 to +70	TSSOP-48	CLINK3V28BT-85
DS90CR218AMTD <sup>E</sup>	3:21	Deserializer	—	1	12	85	595/1785	-10 to +70	TSSOP-48	CLINK3V28BT-85
DS90CR287MTD <sup>E</sup>	28:4	Serializer	1	—	20	85	595/2380	-10 to +70	TSSOP-56	CLINK3V28BT-85
DS90CR288AMTD <sup>E</sup>	4:28	Deserializer	—	1	20	85	595/2380	-10 to +70	TSSOP-56	CLINK3V28BT-85
DS90CR483AVJD <sup>E</sup>	48:8	Serializer	1	—	33	112	672/5376	-10 to +70	TQFP-100	CLINK48BT-112
DS90CR484AVJD <sup>E</sup>	8:48	Deserializer	—	1	33	112	672/5376	-10 to +70	TQFP-100	CLINK48BT-112

Package codes: National has recently moved to 2-letter package code suffixes for new products. The new VV code refers to the same PQFP-80 package as the old VH code.

<sup>E</sup> Evaluation board



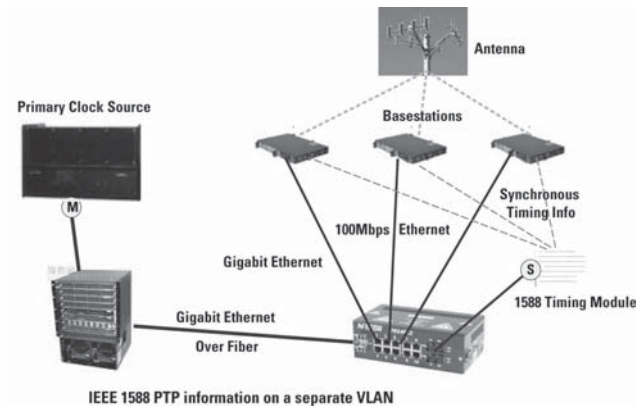
# Ethernet Backhaul and IEEE 1588 Solutions

## High-Speed Ethernet Connectivity

### Single Port PHYTER 10/100 Ethernet PHYs

- IEEE 1588(R) v1 & v2 Precision Time Protocol support (DP83640)
  - Enable IEEE 1588 with any MAC based microcontroller, FPGA or ASIC
  - Node synchronization accuracy to <10 nS
  - Replace E1/T1 lines
  - Replace expensive GPS clocks
  - Synchronized clock output
  - Synchronous Ethernet support
- Industry's lowest deterministic latency
- Selectable MII/RMII interface
- Cable health diagnostic support
- 100 BASE-FX Fiber Interface
- Reference clock output to MAC

See Power-over-Ethernet (PoE) solutions on page 39



Product ID	PHYTER (Single)				PHYTER Mini (Single, Tiny Package)	
	DP83640	DP83848C	DP83848I/E	DP83848YB	DP83848M/T/H	DP83848J/K
IEEE 1588 v1 & v2 hardware support	•					
Fiber Support	•					
Temp Range (°C)	-40 to 85	0 to 70	-40 to 85	-40 to 125	0 to 70 -40 to 85 -40 to 125	0 to 70 -40 to 85
Number of Ports	Single	Single	Single	Single	Single	Single
Interface	MII/RMII	MII/RMII/SNI	MII/RMII/SNI	MII/RMII/SNI	MII/RMII	MII/RMII
Power	280 mW	265 mW	265 mW	265 mW	265 mW	265 mW
IEEE 802.3 Compliant	•	•	•	•	•	•
UNH Interoperability Testing	•	•	•	•	•	•
Auto-MDIX	•	•	•	•	•	•
Deterministic Delay	•	•	•	•	•	•
Low Latency	•	•	•	•	•	•
LEDs	3	3	3	3	1	2
Interrupt Pin	•	•	•	•		
Cable Health Diagnostics	•					
System Diagnostics	•	•	•	•	•	•
IEEE 1149.1 (JTAG)	•		•	•		
Software Utility Support	•	•	•	•	•	•
Error-Free Operation (m typ)	150	137	150	150	137	137
Supply Voltage (V)	3.3	3.3	3.3	3.3	3.3	3.3
Package	LQFP-48	LQFP-48	LQFP-48	LQFP-48	LLP-40	LLP-40
Package Size (mm)	9 x 9 x 1.4	9 x 9 x 1.4	9 x 9 x 1.4	9 x 9 x 1.4	6 x 6 x 0.8	6 x 6 x 0.8
ESD HBM/CDE (kV)	8.0 / 2.0	4.0 / 2.0	4.0 / 2.0	4.0 / 2.0	4.0 / 2.0	4.0 / 2.0

M = Commercial Temperature (0°C +70°C)  
 E = Industrial Temperature (-40°C +85°C)  
 Specialized for ProfinetNET Applications

T = Industrial Temperature (-40°C +85°C)  
 H = Extreme Temperature (-40°C +125°C)

J = Commercial Temperature (-0°C +70°C) 2 LED's  
 K = Industrial Temperature (-40°C +85°C) 2 LED's

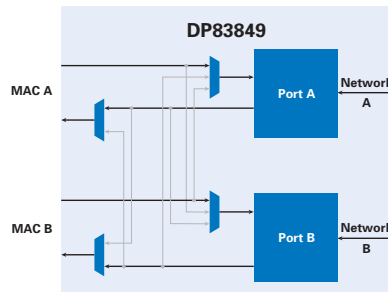
# Ethernet Backhaul and IEEE 1588 Solutions

## High-Speed Ethernet Connectivity

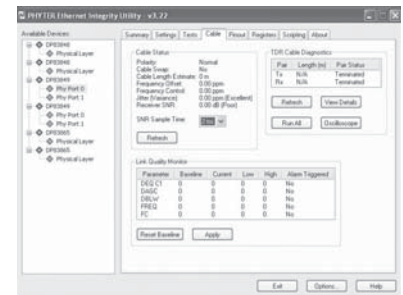
### DP83849 – Dual PHYTER 10/100 Ethernet PHY

#### Features

- Flexible port switching and chaining
  - MII port assignment
  - MDI chaining
- Industry's lowest deterministic latency
- Enhanced cable diagnostics
- Two fully independent 10/100 ports
  - Selectable 100Base-Tx/100Base-Fx
  - MII/RMII/SNI
- Controlled I/O during power up
- Built-in Self-Test (Packet BIST)
- See Power-over-Ethernet (PoE) solutions on page 39
- Available in 12 x 12 mm TQFP-80 packaging



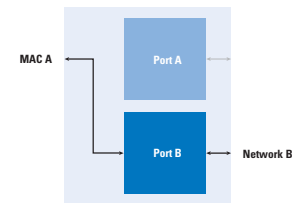
Unique Flexible Switching Capability



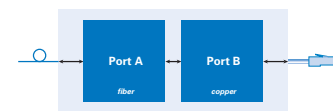
Enhanced Cable Diagnostics

Product ID	PHYTER Dual		PHYTER Dual	
	DP83849C	DP83849I	DP83849ID	DP83849IF
<b>Fiber Support</b>			•	•
<b>Flexible Port Switching</b>		•		•
<b>Temp Range (°C)</b>	0 to 70	-40 to 85	-40 to 85	-40 to 85
<b>Number of Ports</b>	Dual	Dual	Dual	Dual
<b>Interface</b>	MII/RMII	MII/RMII	MII/RMII	MII/RMII
<b>Power</b>	300 mW / Port	300 mW / Port	300 mW / Port	300 mW / Port
<b>IEEE 802.3 Compliant</b>	•	•	•	•
<b>UNH Interoperability Testing</b>	•	•	•	•
<b>Auto-MDIX</b>	•	•	•	•
<b>Deterministic Delay</b>	•	•	•	•
<b>Low Latency</b>	•	•	•	•
<b>LEDs</b>	3	3	3	3
<b>Interrupt Pin</b>	•	•	•	•
<b>Cable Health Diagnostics</b>	•	•	•	•
<b>System Diagnostics</b>	•	•	•	•
<b>IEEE 1149.1 (JTAG)</b>		•	•	•
<b>Software Utility Support</b>	•	•	•	•
<b>Error-Free Operation (m typ)</b>	137	137	137	137
<b>Supply Voltage (V)</b>	3.3	3.3	3.3	3.3
<b>Package</b>	TQFP-80	TQFP-80	TQFP-80	TQFP-80
<b>Package Size (mm)</b>	12 x 12 x 1.0	12 x 12 x 1.0	12 x 12 x 1.0	12 x 12 x 1.0
<b>ESD HBM/CDE (kV)</b>	4.0 / 2.0	4.0 / 2.0	4.0 / 2.0	4.0 / 2.0

### Other Useful DP83849 Configurations



Failover Operation



Fiber-Copper Converter (MAC-less)

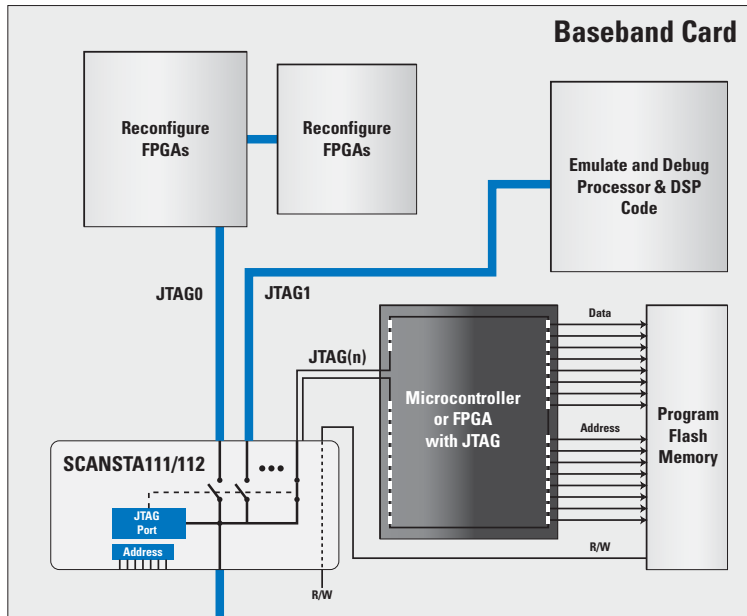


300m Repeater-Extender (MAC-less)

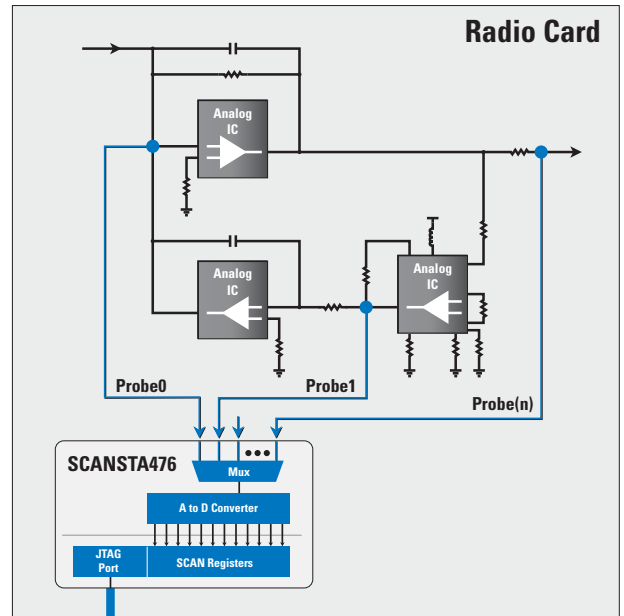
# JTAG: More Than Board Test

## Remote Diagnostic and Reconfiguration Solutions

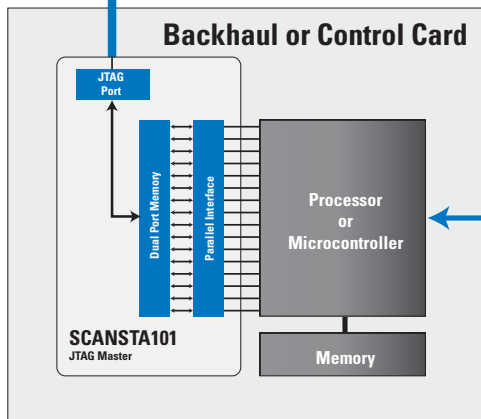
**Quickly Target and Reprogram FPGAs and Flash;  
Emulate and Debug Processor and DSP Code**



**Monitor Critical Analog Voltages**



**IEEE 1149.1 "JTAG" Bus**



**Backhaul Link**

**Vectors**

0	1	1	0	0	0	1	0	1	1	1	0	0	0	1
1	0	0	0	1	1	0	1	0	0	0	1	1	1	0
0	0	1	1	0	1	0	0	0	1	1	0	1	0	1
1	0	1	0	1	1	1	1	0	1	0	1	1	1	1
1	1	0	1	1	0	0	1	1	0	1	1	0	0	0
0	0	1	1	0	1	0	0	1	1	1	0	1	1	0
1	1	1	0	0	1	0	1	1	1	0	0	1	0	0
0	1	1	0	0	0	1	0	1	1	0	0	0	1	1
1	0	0	1	1	0	1	0	0	0	1	1	0	1	0
0	0	1	1	0	1	0	0	0	1	1	0	1	0	1
1	0	1	0	1	1	1	1	0	1	0	1	1	1	1
1	1	0	1	1	0	0	1	1	0	1	1	0	0	0
0	0	1	1	0	1	0	0	1	1	1	0	1	1	0
1	1	1	0	0	1	0	1	1	1	0	1	1	0	1

Test, Program, Emulate, Diagnose

**Remotely Manage, Diagnose, and Reconfigure Systems**

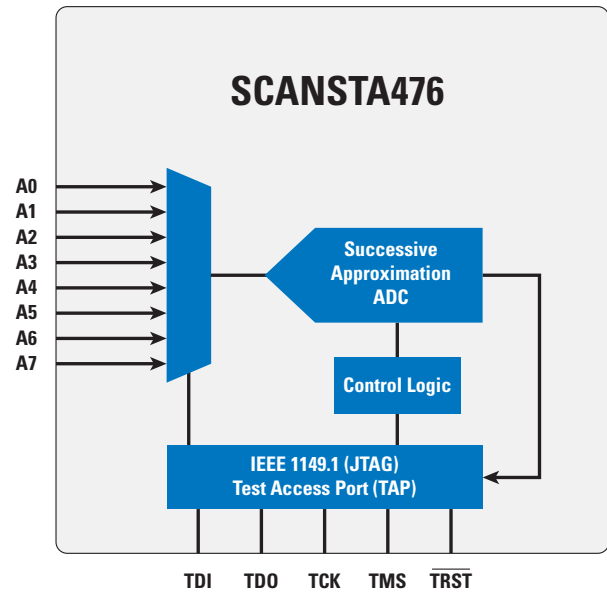
# JTAG System Products Solutions

## Description

The SCANSTA476 is a low-power, 8-channel analog voltage monitor. Useful for manufacturing or online testing, the SCANSTA476 uses the IEEE 1149.1 JTAG interface to select the analog input, initiate measurement, and access results further extending the capabilities of your JTAG infrastructure. A wide operating range makes the SCANSTA476 flexible and easy to use.

## Features

- 8 selectable full-scale (0 to  $V_{DD}$ ) analog inputs
- 2 mV typ input accuracy at max  $V_{DD}$
- Single 2.7V to 5.5V supply
- IEEE 1149.1 (JTAG) compliant interface
- Very low power
- Industrial -40°C to +85°C temperature range
- Available in tiny 5 x 5 mm LLP-16 packaging



## JTAG System Management Products

Product ID	Description	Supply Voltage (V)	Features	Packaging
SCANSTA111MT/SM <sup>Ⓔ</sup>	3-port multidrop IEEE 1149.1 JTAG bus multiplexer	3.3	7 address inputs, 3 local scan ports, transparent mode	TSSOP-48, BGA-49
SCANSTA112VS/SM	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
SCANSTA101SM <sup>Ⓔ</sup>	IEEE 1149.1 JTAG system test master	3.3	Parallel 16-bit interface to IEEE 1149.1 master device	BGA-49
SCANSTA476TSD <sup>Ⓔ</sup>	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

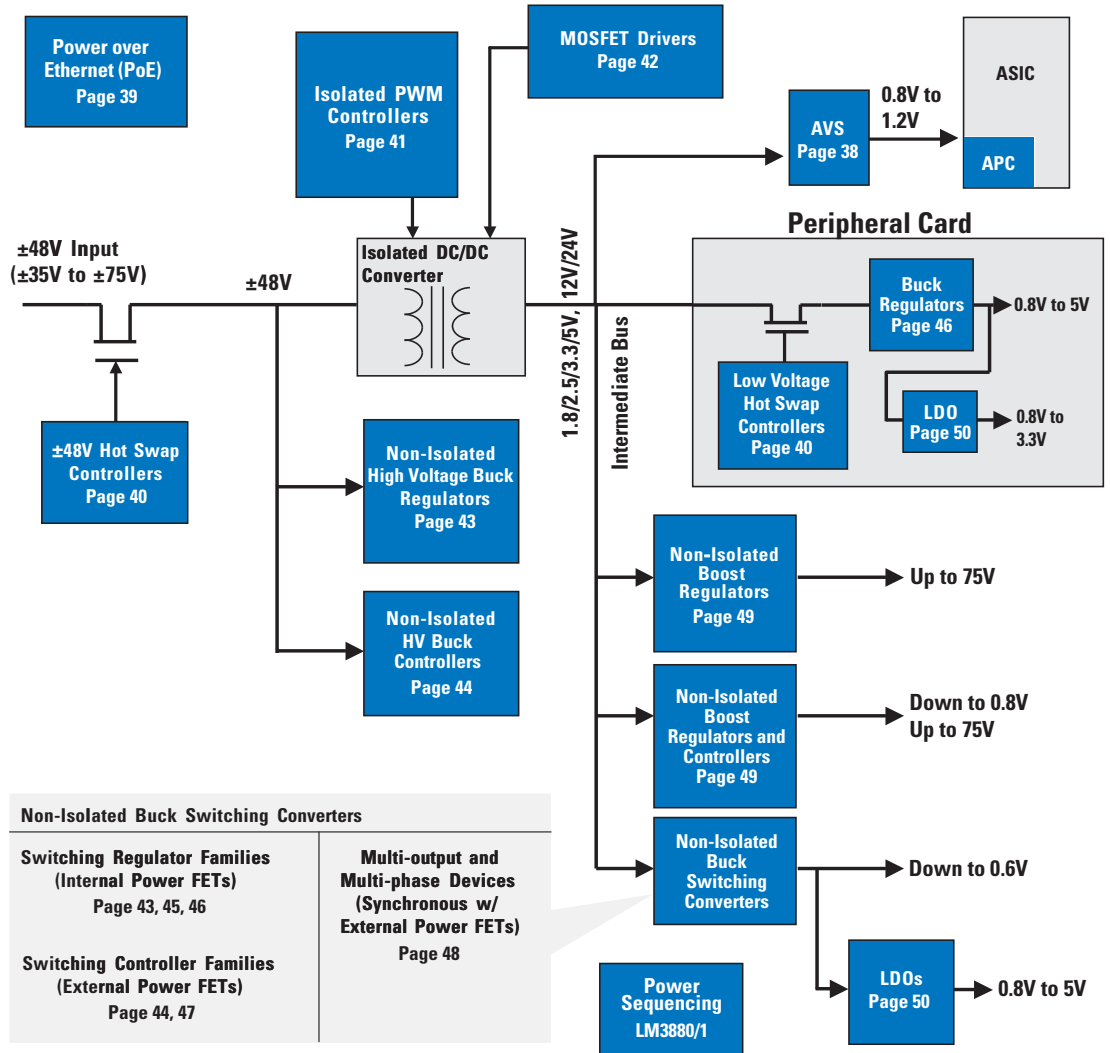
<sup>Ⓔ</sup> Evaluation board

# Power Solutions for Networking Infrastructure

## Networking Infrastructure Power Solutions

### Features

- Power rail integrity
  - Hot swap
- Thermal management
  - High efficiency
  - High integration
- Reliability
  - N+1 redundancy
- Load complexity
  - Sequencing
  - Broad solutions



# PowerWise® Adaptive Voltage Scaling (AVS)

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

AVS technology is ideal for data centers, cellular basestations and anywhere an ASIC, processor, or SoC is used.

## LM10500: 5A Integrated AVS EMU

- Closed-loop Adaptive Voltage Scaling (AVS)
- 40% typical power saving compared to fixed voltage scheme
- AVS  $V_{OUT}$  range: 0.6V to 1.0V or 0.72V to 1.2V
- $V_{OUT}$  range (resistor feedback): 0.6V to 5V
- PWI 1.0/PWI 2.0 compatible
- 1% output voltage accuracy
- 300 kHz to 1.5 MHz switching frequency
- Frequency synchronization
- Cycle-by-cycle current limiting
- Internal soft-start to reduce in-rush current
- Power GOOD/PWROK
- Available in LLP-28 packaging

### Applications

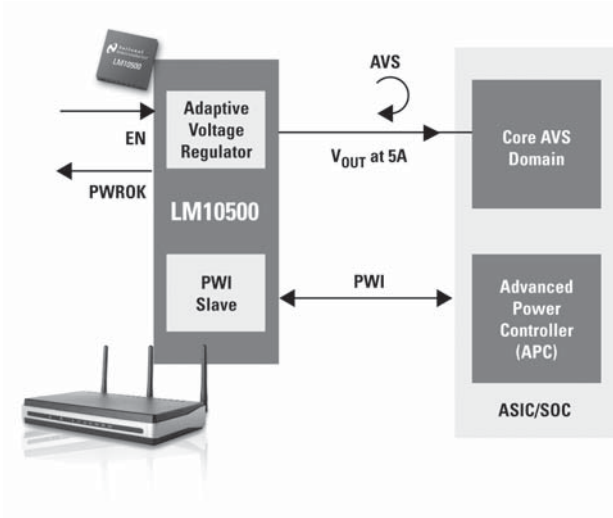
- Servers and network ASICs
- Set-top-box processors
- Storage devices ASICs

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

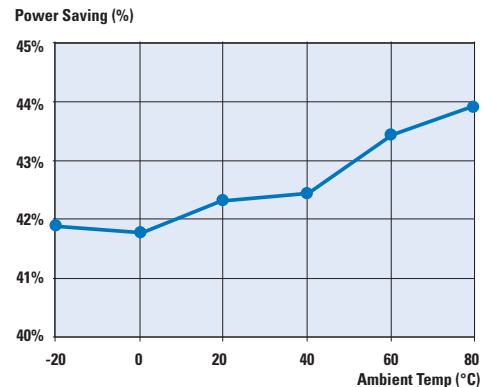
### AVS Energy Management Unit

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

For more information about high-current AVS Energy Management Units, visit us at: [www.national.com/avs](http://www.national.com/avs)



LM10500 Typical Power Savings with AVS

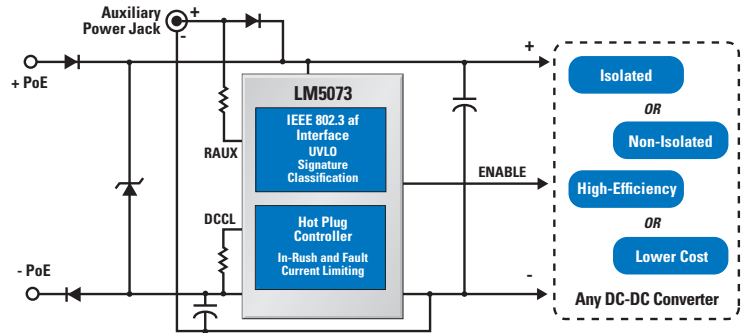


# Power-over-Ethernet Solutions

## 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



### Applications

Ideal for use in VoIP telephony, wireless access points, gate access control (card readers), Bluetooth access points, surveillance cameras and building control

Optimized for:	Pair LM5073 with:
High efficiency	LM5025/26/27 active clamp PWM controller (PowerWise®)
Low cost	LM5020 flyback controller (PowerWise)
Non-Isolated and/or Ease of Design – Regulator with Integrated MOSFET	LM557x SIMPLE SWITCHER® regulator (PowerWise)
Isolated	LM5015 2-switch forward flyback regulator

## Power-over-Ethernet Powered Device Interface with Integrated DC-DC Regulator

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	60	1.8	1	✓	13	48V Front only	2	0.7	LLP-16, TSSOP-16
LM5071	75	1.8	1	✓	13	48V Front only	2	0.7	TSSOP-16
LM5072	100	9	0.7	✓	25	Fully configurable front/rear	2	0.7	eTSSOP-16

PowerWise product

## 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	Packaging
LM5073	100	9	0.7	—	25	Fully configurable front/rear	eTSSOP-14

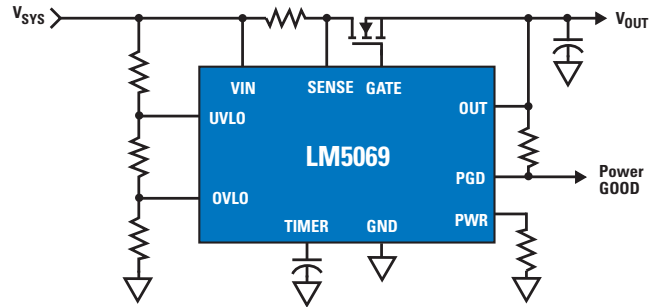
See also: Ethernet Backhaul and IEEE 1588 Solutions on pages 33 and 34

# Hot Swap/In-Rush Current Controllers

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

### Features

- Adjustable in-rush current limit and circuit breaker protect system from over-current/short-circuit events and module insertion/removal from live power sources
- Adjustable power limit sets maximum power dissipation in the external pass device
  - Ensures MOSFET stays in Safe Operating Area (SOA)
  - Reduces MOSFET size
- Adjustable features for design flexibility:
  - Input UVLO/OVLO and hysteresis
  - Multifunction timer to prevent nuisance trips
  - Power GOOD flag output using FB pin (LM25061)
- Internal high-side charge pump and gate driver for external N-channel MOSFET
- Available in latched fault and automatic restart versions

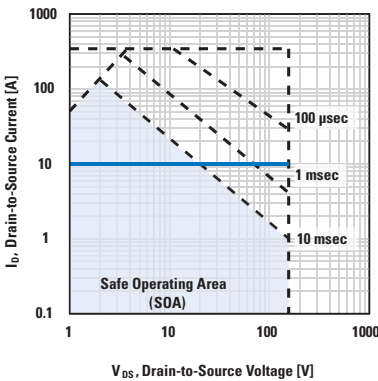


## Power Limiting Protects External Pass Device for Improved System Reliability

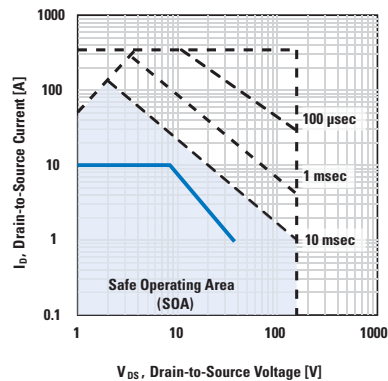
To ensure system reliability, any MOSFET must operate within its SOA in order to avoid FET failure. National's LM(2)506x hot swap controllers provide both current and power limiting to

dynamically adjust the current limit at large  $V_{DS}$  and ensure the MOSFET stays in the SOA at all conditions – maximizing long-term system reliability and robustness.

**Conventional Hot Swap: Current Limit Only**  
MOSFET Out of SOA at Large  $V_{DS}$



**LM(2)506x: Current Limit AND Power Limit**  
Optimal Circuit and MOSFET Protection for All  $V_{DS}$



## Hot Swap/In-Rush Current Controllers

Product ID	$V_{IN}$ Range	Power Good	Adjustable UVLO	Adjustable OVLO	Active In-Rush Current Limit	Active Current Limiting	Active Power Limiting	Fault Latch-Off / Auto Retry	Packaging
LM5067	-9V to -80V	$V_{DS}$	✓	✓	✓	✓	✓	✓	MSOP-10, LLP-10
LM5069	+9 to +100V	$V_{DS}$	✓	✓	✓	✓	✓	✓	MSOP-10
<b>NEW</b> LM25061	+2.9V to +16V	$V_{OUT}$ (adj.)	✓	—	✓	✓	✓	✓	MSOP-10
<b>NEW</b> LM25069	+2.9V to +16V	$V_{DS}$	✓	✓	✓	✓	✓	✓	MSOP-10



# High-Voltage Isolated PWM Controllers

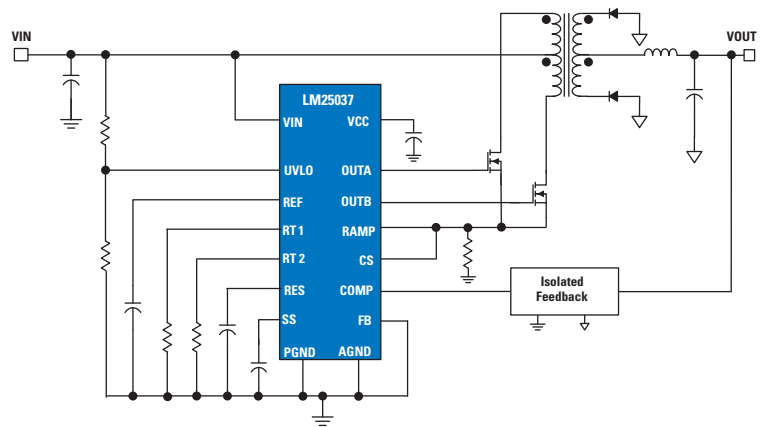
National offers isolated solutions that maximize power density and efficiency for a range merchant power module applications:

Power Module Form Factor	Power Level	Ideal Topologies	National's Solutions
1/2 Brick	> 500W	Interleaved Forward or Cascade	LM5034, LM5041A
1/4 Brick	300W – 400W	Cascade	LM5041A
1/8 Brick	100W – 150W	Active Clamp Forward	LM5025, LM5026, LM5027
1/16 Brick	< 100W	Half-Bridge	LM5030, LM5033, LM5035/A

## LM(2)5037 – Dual-Mode PWM Controller with Alternating Outputs

### Features

- Ultra-wide input operating range from 5.5V to 75V (LM25037) and 13V to 105V (LM5037)
- Alternating outputs for double-ended topologies
- Current-mode or feed-forward voltage-mode control
- Programmable maximum duty cycle limit
- Versatile dual mode over-current protection with hiccup delay timer
- Programmable soft-start
- Precision 5V reference output
- Current sense leading-edge blanking
- Programmable 1 MHz oscillator with synchronization capability



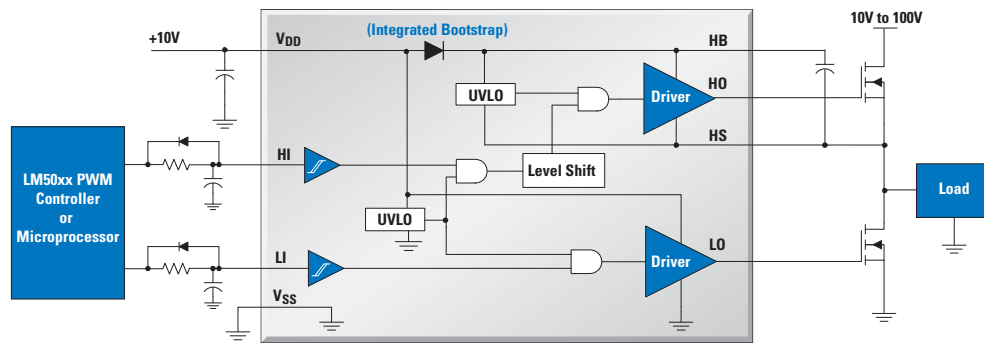
### Isolated Controllers

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

PowerWise product <sup>E</sup> Evaluation board

# MOSFET Drivers

## LM510x – Family of High-Speed FET Drivers



LM5100A and LM5101A now available in Power SOIC (PSOP) packages for maximum thermal performance.



## MOSFET Drivers

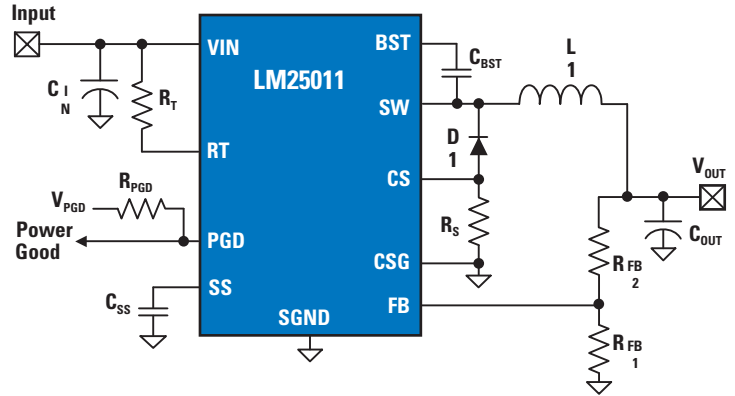
Product ID	Topology	Input Max Voltage (V)	Supply Min (V)	Supply Max (V)	Peak Sink Current (A)	Peak Source Current (A)	Bottom Driver Prop Delay (nS)	Top Driver Prop Delay (nS)	Pulse Width Min	Input Control Type	Packaging
LM5100C	Synchronous buck, bridge	100	7.5	14	1	1	25	25	50	Dual, independent	SO-8
LM5101C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

# Non-Isolated High-Voltage Buck Regulators

## LM25011 – High Frequency, 2A Constant On-Time Switching Regulator with Emulated Ripple Mode

### Features

- Wide  $V_{IN}$  range: 6V to 42V (44V Abs max)
- Adjustable current limit up to 2A
- Maximum switching frequency: 2 MHz
- Constant On-Time switching w/feed-forward
  - Ultra-fast transient response
  - Nearly constant switching frequency
  - No compensation needed
- Programmable soft-start
- Adjustable output down to 2.5V
- Power GOOD output
- Small eMSOP-10 package
- Thermal shutdown
- Precision 2% feedback reference



### 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
<b>NEW</b> LM5009/A <sup>E,W</sup>	0.15	9.5/6	95	2.5	85	50 to 600	—	Constant on-time	LLP-8, MSOP-8
<b>NEW</b> LM5008/A <sup>E,W</sup>	0.35	9.5/6	95	2.5	75	50 to 600	—	Constant on-time	LLP-8, MSOP-8
LM22671/74 <sup>E,W</sup>	0.5	4.5	42	1.285	30	500 / Adj. to 1000	—	Voltage	PSOP-8
LM25007 <sup>E,W</sup>	0.5	9	42	2.5	37	50 to 800	—	Constant on-time	MSOP-8
LM25574 <sup>E,W</sup>	0.5	6	42	1.23	40	50 to 1000, Sync	—	Current	TSSOP-16
LM5007 <sup>E,W</sup>	0.5	9	75	2.5	73	50 to 800	—	Hysteretic	LLP-8, MSOP-8
LM5574 <sup>E,W</sup>	0.5	6	75	1.23	70	500, Sync	—	Current	TSSOP-16
LM3103 <sup>E,W</sup>	0.75	4.5	42	0.6	38	1000	✓	Constant on-time	eTSSOP-16
LM22672/75 <sup>E,W</sup>	1	4.5	42	1.285	30	500 / Adj. to 1000	—	Voltage	PSOP-8
LM5010/A <sup>E,W</sup>	1	8/6	75	2.5	70	50 to 1000	—	Hysteretic	LLP-10, eTSSOP-14
LM25575 <sup>E,W</sup>	1.5	6	42	1.23	40	50 to 1000, Sync	—	Current	eTSSOP-16
LM5575 <sup>E,W</sup>	1.5	6	75	1.23	70	500, Sync	—	Current	eTSSOP-16
LM22680 <sup>E,W</sup>	2	4.5	42	1.285	30	500	—	Voltage	PSOP-8
<b>NEW</b> LM25011 <sup>E</sup>	2	6	42	2.51	40	Adj to 2000	—	Constant on-time	eMSOP-10
LM25005 <sup>E,W</sup>	2.5	7	42	1.23	40	500, Sync	—	Current mode	TSSOP-20
LM3102 <sup>E,W</sup>	2.5	4.5	42	0.8	38	1000	✓	Constant on-time	eTSSOP-20
LM5005 <sup>E,W</sup>	2.5	7	75	1.23	70	500, Sync	—	Current mode	TSSOP-20
LM22670/73/76 <sup>E,W</sup>	3	4.5	42	1.285	30	200 to 1000	—	Voltage	TO-263 THIN, PSOP-8
LM25576 <sup>E,W</sup>	3	6	42	1.23	40	50 to 1000, Sync	—	Current	eTSSOP-20
LM5576 <sup>E,W</sup>	3	6	75	1.23	70	500, Sync	—	Current	eTSSOP-20
LM22677/78/79 <sup>E,W</sup>	5	4.5	42	1.285	30	500 to 1000 adj	—	Voltage	TO-263 THIN

PowerWise product   <sup>W</sup> WEBENCH enabled   <sup>E</sup> Evaluation board

# Non-Isolated High-Voltage Buck Controllers

## LM315x SIMPLE SWITCHER® Controllers

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

### Features

#### LM315x

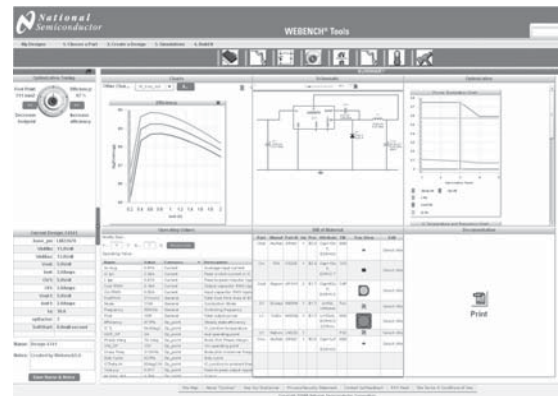
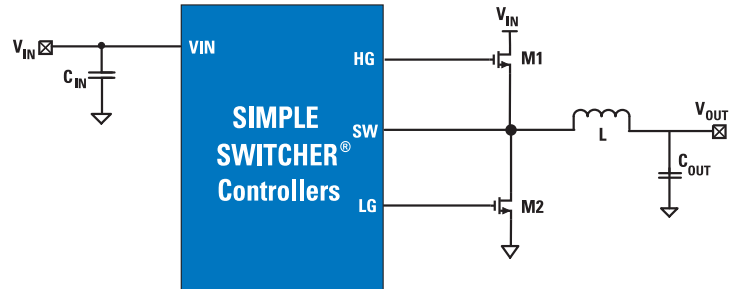
- Input voltage ranging from 6V to 42V
- Output current up to 12A
- Constant On-Time control eliminates the need for complex compensation circuitry
- Patent-pending Emulated Ripple Mode allows for the use of low ESR output capacitors for reduced solution size and reduced output voltage ripple
- Synchronous architecture for added efficiency
- Exposed pad TSSOP-14 package for enhanced thermal performance

#### LM3150

- Adjustable output voltage down to 0.6V
- Adjustable frequency up to 1 MHz

#### LM3151/52/53

- Fixed output voltages: 3.3V
- Fixed frequencies: 250 kHz, 500 kHz, 750 kHz



Features robust design tools including the enhanced WEBENCH® Power Designer online tool, external component selection, new WEBENCH MOSFET selection tool, electrical and thermal simulation, board evaluation

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

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

<sup>E</sup> PowerWise product    <sup>W</sup> WEBENCH enabled    <sup>E</sup> Evaluation board

# Non-Isolated Synchronous Regulators

## Point of Load (POL)

### LM20xxx – PowerWise® Family of High-Efficiency, Full-Featured Synchronous Buck Regulators

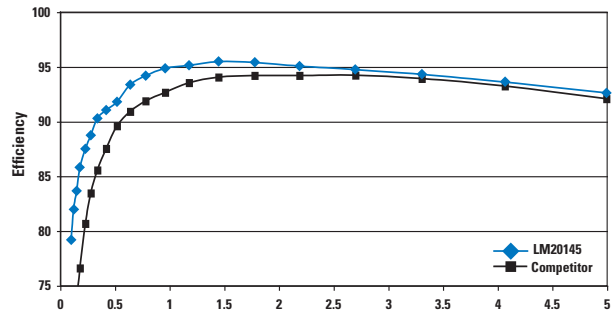
#### Features

- Tracking
- Precision enable
- Power GOOD
- Pre-biased start-up
- Available in eTSSOP-16 packaging

#### Feature Options

- Fixed and adjustable switching frequency
- Clock synchronization in
- Clock synchronization out (LM20154)

Efficiency vs Output Current ( $V_{IN} = 5.0V$ ,  $V_{OUT} = 3.3V$ ,  $f_{SW} = 500$  kHz)



### Non-Isolated PoL (<42V) Buck Regulators - Synchronous

Product ID	Output Current (A)	Input Min Voltage (V)	Input Max Voltage (V)	Output Min Voltage (V)	Output Max Voltage (V)	Frequency Range (kHz) & Sync Capability	PWM Mode	Packaging
LM3670 <sup>E,W</sup>	0.35	2.5	5.5	0.7	3.3	1000 Fixed	Voltage with input feed-forward	SOT23-5
LM3673 <sup>E,W</sup>	0.35	2.7	5.5	1.1	3.3	2000 Fixed	Voltage with input feed-forward	micro SMD-5
LM3679 <sup>E</sup>	0.35	2.5	5.5	1.8	1.8	3000 Fixed	Auto	micro SMD-5
LM3671/74 <sup>E,W</sup>	0.6	2.7	5.5	1.1	3.3	2000 Fixed	Voltage with input feed-forward	SOT23-5, LLP-6
LM3676 <sup>E</sup>	0.6	2.9	5.5	1.1	3.3	2000 Fixed	Voltage with input feed-forward	LLP-8
LM3677 <sup>E</sup>	0.6	2.7	5.5	1.2	3.3	3000 Fixed	Auto	micro SMD-5
LM3691 <sup>E</sup>	1	2.3	5.5	0.75	1.8	4000 Fixed	Auto	micro SMD-6
LM3678 <sup>E</sup>	1.5	2.5	5.5	0.8	1.2	3300 Fixed	Auto	LLP-10
LM3100 <sup>E,W</sup>	1.5	4.5	36	0.8	32	Adj. to 1000	Constant on-time	eTSSOP-20
LM2852 <sup>E,W</sup>	2	2.85	5.5	0.8	3.3	500, 1500 Fixed	Voltage	TSSOP-14
LM20242 <sup>E,W</sup>	2	4.5	36	0.8	32	Adj. to 1000	Current	eTSSOP-16
LM20123 <sup>E,W</sup>	3	2.95	5.5	0.8	5	1500 Fixed	Current	eTSSOP-16
LM20133 <sup>E,W</sup>	3	2.95	5.5	0.8	5	460 to 1500, Sync	Current	eTSSOP-16
LM20143 <sup>E,W</sup>	3	2.95	5.5	0.8	5	500 to 1500	Current	eTSSOP-16
LM2853 <sup>E,W</sup>	3	3	5.5	0.8	3.3	550 Fixed	Voltage	TSSOP-14
<b>NEW</b> LM20343	3	4.5	36	0.8	32	250 to 1000	Current	eTSSOP-16
<b>NEW</b> LM20333 <sup>E,W</sup>	3	4.5	36	0.8	32	200 to 1500, Sync	Current	eTSSOP-16
<b>NEW</b> LM20323 <sup>E,W</sup>	3	4.5	36	0.8	32	500 Fixed	Current	eTSSOP-20
LM20124 <sup>E,W</sup>	4	2.95	5.5	0.8	5	1000 Fixed	Current	eTSSOP-16
LM20134 <sup>E,W</sup>	4	2.95	5.5	0.8	5	460 to 1500, Sync	Current	eTSSOP-16
LM20144 <sup>E,W</sup>	4	2.95	5.5	0.8	5	Adj. to 1000	Current	eTSSOP-16
LM20154 <sup>E,W</sup>	4	2.95	5.5	0.8	5	1000 Fixed	Current	eTSSOP-16
LM2854 <sup>E,W</sup>	4	2.95	5.5	0.8	5	500, 1000 Fixed	Voltage	TSSOP-14
LM20125 <sup>E,W</sup>	5	2.95	5.5	0.8	5	500 Fixed	Current	eTSSOP-16
LM20145 <sup>E,W</sup>	5	2.95	5.5	0.8	5	250 to 750	Current	eTSSOP-16
<b>NEW</b> LM20136 <sup>E,W</sup>	6	2.95	5.5	0.8	5	460 to 750, Sync	Current	eTSSOP-16
<b>NEW</b> LM20146 <sup>E,W</sup>	6	2.95	5.5	0.8	5	250 to 750	Current	eTSSOP-16

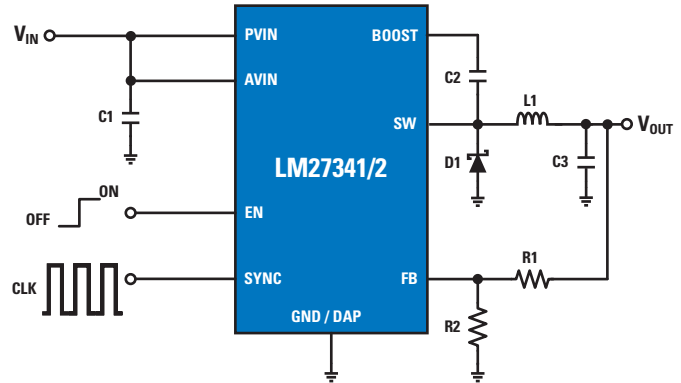
# Non-Isolated Non-Synchronous Buck Regulators

## Point of Load (POL)




### LM27341/42 – 1.5A/2A, 2 MHz Wide Input Range Buck Regulator with 1% Reference Accuracy

#### Features

- Wide input voltage range 3V to 20 V
- Wide output voltage range 1V to 18 V
- LM27341 delivers 1.5A maximum output current
- LM27342 delivers 2A maximum output current
- High switching frequency 2 MHz
- Frequency synchronization  $1.00 \text{ MHz} < f_{\text{SW}} < 2.35 \text{ MHz}$
- 70 nA shutdown current
- Space-saving 3 X 3 mm LLP-10 and eMSOP-10 package



### 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 <sup>E</sup>	0.6	8	30	2.5	24	50 to 1000	Hysteretic	LLP-10, TSSOP-14
LM34919 <sup>E</sup> 	0.6	8	40	2.5	30	2000 (max)	Constant on-time	micro SMD-10
LM2736 <sup>E,W</sup>	0.75	3	18	1.25	16	550, 1600	Current	SOT23-6
LM2830 <sup>W</sup>	1	3	5.5	0.6	4.5	1600, 3000	Current	SOT23-5
LM2734/Z <sup>E,W</sup>	1	3	20	0.8	18	550, 1600 / 3,000	Current	SOT23-6
LM34930 <sup>E</sup> 	1	8	33	2.5	30	2000 (max)	Constant on-time	micro SMD-12
LM34910 <sup>E,W</sup>	1.2	8	36	2.5	30	1000 (max)	Constant on-time	LLP-10
LM2695 <sup>E</sup>	1.25	8	30	2.5	24	50 to 800	Hysteretic	LLP-10, eTSSOP-14
LM34917A <sup>E</sup> 	1.25	8	33	2.5	30	2000 (max)	Constant on-time	micro SMD-10
LM34914 <sup>E</sup>	1.25	8	40	2.5	30	1300 (max)	Constant on-time	LLP-10
LM2831 <sup>E,W</sup>	1.5	3	5.5	0.6	4.5	550, 1600, 3000	Current	SOT23-5
LM2738 <sup>E</sup>	1.5	3	18	0.8	18	550, 1600	Current	LLP-6, eMSOP-8
LM27341	1.5	3	20	1	18	2350, Sync	Current	LLP-10, eMSOP-10
LM2832 <sup>E,W</sup>	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 <sup>E</sup>	3	3	5.5	0.6	4.5	1500, 3000	Current	LLP-10, eMSOP-10
LM2696 <sup>E,W</sup>	3	4.5	24	1.29	20	100 to 500	Constant on-time	TSSOP-16

 PowerWise product    <sup>W</sup> WEBENCH enabled    <sup>E</sup> Evaluation board

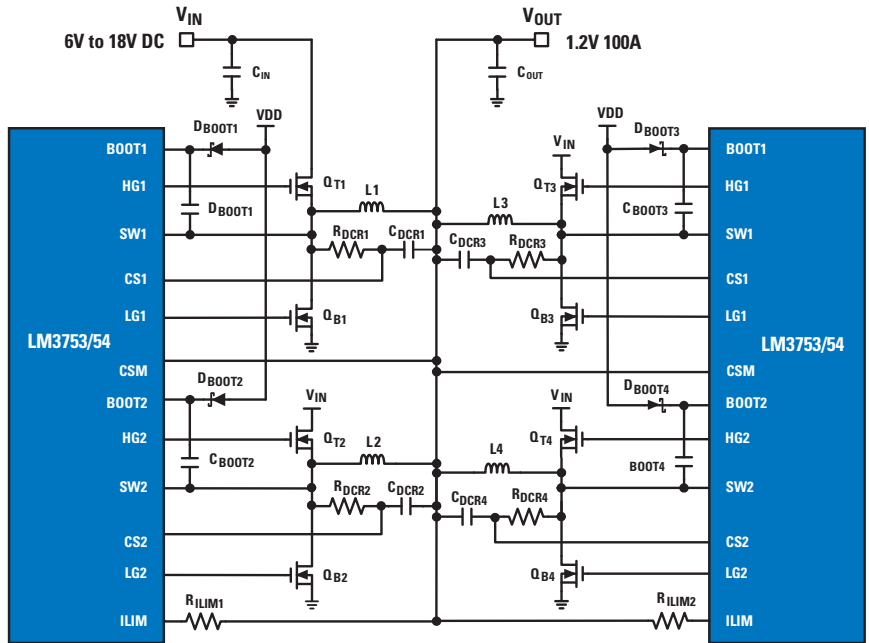
# Non-Isolated Synchronous Controllers

## Point of Load (POL)

### LM3753/54 – Stackable, Scalable Multi-Phase Controller Supports up to 300A

#### Features

- Wide input range of 4.5V to 18V
- Output voltage: 0.6V – 3.6V
- System accuracy: better than 1%
- Scalable
  - Up to 12 phases
  - Support for loads more than 300A
  - Channel-to-channel interleaving
- Channel current matching: better than 12%
- Integrated synchronous NFET drivers
- $V_{IN}$  feed-forward
- DCR or sense resistor current sensing
- Differential remote sensing
- Adjustable frequency from 200 kHz – 1 MHz
- Output current monitor pin
- Pre-biased startup (LM3754)
- Linear controller for providing VDD bias
- Soft-start and tracking versions available



### 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
LM2737	2.2	16	0.6	5	50 to 2000	Voltage	TSSOP-14
LM2727 <sup>E</sup>	2.2	16	0.6	5	50 to 2000	Voltage	TSSOP-14
LM1770 <sup>EW</sup>	2.8	5.5	0.8	4.5	300 to 1000	Constant on-time	SOT23-5
LM1771 <sup>E</sup>	2.8	5.5	0.8	4.5	300 to 1000	Constant on-time	LLP-6, MSOP-8
LM3495 <sup>E</sup>	2.9	18	0.6	5.5	200 to 1500, Sync	Emulated peak current mode (ECM)	TSSOP-16
LM3743 <sup>E</sup>	3	5.5	0.8	4.6	300 to 1000	Voltage	MSOP-10
<b>NEW</b> LM3753 <sup>E</sup>	4.5	18	0.6	3.6	200 to 1000, Sync	Voltage	LLP-32
LM2642 <sup>E</sup>	4.5	30	1.3	13.5	300	Current	TSSOP-28, eTSSOP-28
LM5642 <sup>E</sup>	4.5	36	1.3	34.5	150 to 250, Sync	Current	TSSOP-28, eTSSOP-28
LM5642X	4.5	36	1.3	34.5	200 to 500, Sync	Current	TSSOP-28, eTSSOP-28
LM2647 <sup>E</sup>	5.5	28	0.6	5	200 to 500	Voltage	LLP-28, TSSOP-28
LM3152 <sup>EW</sup>	6	33	3.3	3.3	250, 500, 750	Constant on-time	TSSOP-14
LM3153 <sup>W</sup>	8	18	3.3	3.3	250, 500, 750	Constant on-time	TSSOP-14
LM2742	1	16	0.6	13	50 to 2000	Voltage	TSSOP-14
LM2743 <sup>EW</sup>	1	16	0.6	13	50 to 1000	Voltage	TSSOP-14
LM2745 <sup>E</sup>	1	16	0.6	13	50 to 1000	Voltage	TSSOP-14
LM2748	1	16	0.6	13	50 to 1000	Voltage	TSSOP-14
LM2747 <sup>E</sup>	1	16	0.6	13	50 to 1000	Voltage	TSSOP-14

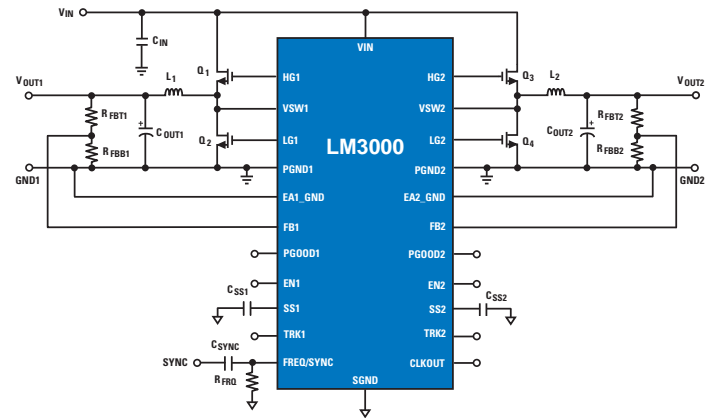
PowerWise product

# Dual Output Converters


## LM3000 – Dual-Channel Switching Controller with 0.6V, 1% Accuracy Reference

### Features

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






### 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 <sup>E</sup>	3 to 20	520 Fixed	0.6 to 16	2	0.6 to 16	2	✓	✓	eTSSOP-16, LLP-16
LM2717 <sup>E</sup>	4 to 20	300 to 600	3.3	2.2	1.265 to 18	3.2	✓	✓	TSSOP-24
LM3370 <sup>E</sup> 	2.7 to 5.5	2000 Fixed	1 to 2	0.6	1.8 to 3.3	0.6	✓	✓	LLP-16, micro SMD-20

 PowerWise product

<sup>E</sup> Evaluation board

### Dual Output Switching Controllers

Product ID	Input Voltage Range (V)	Frequency Range (kHz) & Sync Capability	$V_{OUT}$ Range (V)	Packaging	Other Features
LM2647 <sup>E</sup>	5.5 to 28	200 to 500	0.6V to 5	LLP-28, TSSOP-28	Supports dual-channel interleaved switching, Adaptive duty cycle clamping reduces peak currents
LM2657 <sup>E</sup>	4.5 to 28	200 to 500	0.6V to 5	LLP-28, TSSOP-28	Supports dual-channel interleaved switching, Adaptive duty cycle clamping reduces peak currents
LM5642 <sup>E</sup> 	4.5 to 36	150 to 500, Sync	1.3V to 34	TSSOP-28, eTSSOP-28	Configurable for single output parallel operation
 LM3000 <sup>E</sup> 	3.3 to 18.5	200 to 1000, Sync	Adj. to 0.6V	LLP-32	Features soft-start, output tracking, and output synchronization, Remote differential output voltage sensing

 PowerWise product

<sup>W</sup> WEBENCH

<sup>E</sup> Evaluation board

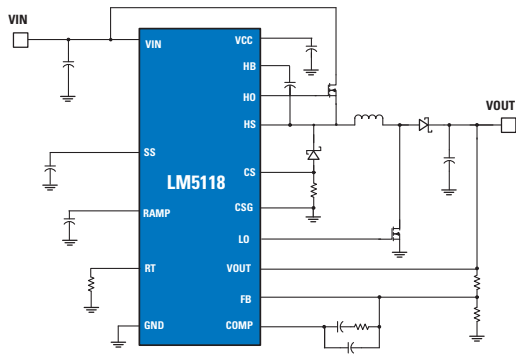


# Buck-Boost Switching Regulators and Controllers

## LM5118 – Wide-Voltage Range Buck-Boost Controller

### Features:

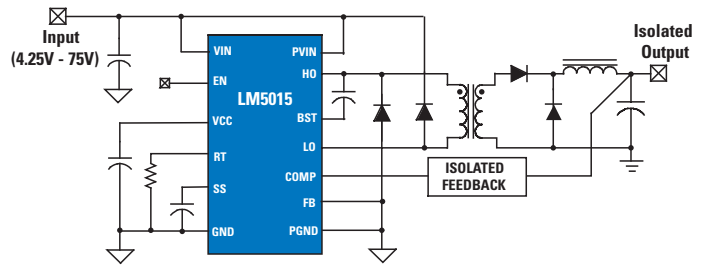
- Ultra-wide input voltage range from 3V to 75V
- Emulated peak current-mode control
- Smooth transition between step-down and step-up modes
- Switching frequency programmable to 500 kHz
- Oscillator synchronization capability
- Internal high-voltage bias regulator
- Integrated high and low-side gate drivers
- 1.5% feedback reference accuracy
- Thermal shutdown
- Available in TSSOP-20 packaging



## LM5015 – High-Voltage Monolithic Two-Switch Forward DC-DC Regulator

### Features

- Dual integrated 75V N-Channel MOSFETs
- Ultra-wide input voltage range: 4.25V to 75V
- Integrated high-voltage bias regulator
- Adjustable output voltage
- 1.5% feedback reference accuracy
- Current-mode control with selectable compensation
- Wide bandwidth error amplifier
- Integrated current sensing and limiting
- 50% maximum duty cycle limit
- Single resistor oscillator programming
- Oscillator synchronization capability
- Thermal shutdown
- Available in eTSSOP-14 packaging



## Boost and Buck-Boost Switching Regulators

Product ID	Input Min Voltage (V)	Input Max Voltage (V)	Output Current (A)	Switch 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 <sup>E</sup>	3.1	75	1.26	1000	50 to 1500, Sync	Current	Boost	SO-8, LLP-8
LM5015 <sup>EW</sup>	4.25	75	1.26	1200	25 to 750, Sync	Current	Two-Switch Forward	TSSOP-14
LM2611 <sup>E</sup>	2.7	14	-1.23	900, 1200	1400	CUK	Inverting	SOT23-5

## 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 <sup>EW</sup>	2.95	40	1.26	1000	Current	Boost, Sepic, Flyback	MSOP-8
LM3488 <sup>W</sup>	2.95	40	1.26	1000	Current	Boost, Sepic, Flyback	MSOP-8
LM3481 <sup>E</sup>	2.97	48	1.275	1000	Current	Boost, Sepic, Flyback	MSOP-10
LM5118 <sup>EW</sup>	3	75	1.23	50 to 500, Sync	Emulated peak current mode (ECM)	Two-Switch Buck-Boost	eTSSOP-20
LM5022	6	60	1.25	2000	Current	Boost, Sepic	MSOP-10
LM5021	8	30	1.25	1000, Sync	Current	Flyback, Forward	MSOP-8, MDIP-8
LM5020 <sup>E</sup>	13	100	1.25	1000, Sync	Current	Flyback, Inverting, Buck, Boost, Forward	MSOP-10, LLP-10

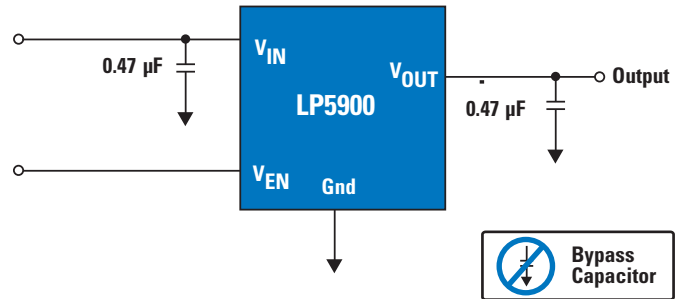
PowerWise product    <sup>W</sup> WEBENCH    <sup>E</sup> Evaluation board

# Low Dropout (LDO) Linear Regulators

## LP5900 – Low-Noise 150 mA CMOS LDO

### 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
- $25 \mu\text{A}$   $I_q$  minimizes current drain when system operates in low-power mode
- Elimination of bypass capacitor reduces BOM to only two ceramic  $0.47 \mu\text{F}$  capacitors
- Available in a micro SMD-4 and LLP-6 packaging



## Low Dropout (LDO) Linear Regulators

Product ID	Load Current (mA)	$V_{\text{IN}}$ Min (V)	$V_{\text{IN}}$ Max (V)	$V_{\text{OUT}}$ (V)	Packaging
LP8900	280	1.8	5.5	2.7 to 1.8	SMD-6
LP38511	800	2.25	5.5	1.8, adj down to 0.8	T0263-5
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	1500	2.25	5.5	1.8, adj down to 0.8	T0263, LLP-8
LP38500	1500	2.7	5.5	0.6 to 5, adj	TO-263
LP38502	1500	2.7	5.5	0.6 to 5, adj	TO-263
LP38852	1500	1.2	5.5	0.8 to 1.8, adj	T0220-7
LP38855	1500	1.38	5.5	1.2 to 1.8, adj	T0220-7
LP38858	1500	1.38	5.5	1.2 to 1.8, adj	T0220-7
LP38513	3000	2.25	5.5	1.8, adj down to 0.8	T0263-5
LP38501	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	3000	1.2	5.5	0.8 to 1.8, adj	PSOP-8
LP38856	3000	1.15	5.5	0.8 to 1.8, adj	T0263-7
LP38859	3000	1.55	5.5	1.2 to 1.8, adj	T0220-7

PowerWise product

## 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	150	5.5	2.5	0.08	1.5, 2.8, 3.3	—	0.025	75	6.5	micro SMD-4
LP5990	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	TO-263-5, SOT-223-5, TO-220-5
LP3878	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	TO-263-5, SOT-223-5
LP3876	3000	7	2.5	0.8	2.5, adj.	✓	6	73	150	TO-263-5

PowerWise product

## Wireless Basestation Solutions

Wireless basestations require the need for 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

<b>Low Intermediate Frequency Receiver</b>	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.
<b>High Intermediate Frequency Receiver</b>	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.
<b>Low Intermediate Frequency Receiver Board</b>	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

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

## Wired and Data Center Solutions

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

### Hot Swap Solutions

<b>Hot Swap Controller Evaluation Boards</b>	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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Visit [www.national.com/comms](http://www.national.com/comms) to view the Hot Swap with Confidence webinar.

### High-Voltage Solutions

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

### Power-over-Ethernet (PoE) Solutions

<b>PoE Phyter</b>	Integrates both LM5072 PoE controller and DP83848 10/100 Mb/s Ethernet physical layer transceiver for a turnkey PoE design with an output of 3.3V at 7.3A.
<b>LM5073-HE PoE Evaluation Board</b>	Implements a fully compliant IEEE 802.3af PD interface with minimal power dissipation and a measured efficiency of 98.5%.
<b>LM5072 Evaluation Board</b>	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.

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

To find more Communications Infrastructure reference designs, articles, and application notes, visit: [www.national.com/comms](http://www.national.com/comms)

# WEBENCH® Online Design Environment

## Save Development Time and Costs

WEBENCH online design and prototyping tools deliver results faster than ever. Now you have the world's most powerful and award-winning online design environment right at your

fingertips. Design, optimize, generate your prototype, and download your test vectors—all online. And do it all for free, anywhere, anytime.

### Select It

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

**Choose from only those parts that meet your specifications**

### Design It

- 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 graph for easy external component selection based on efficiency, footprint, cost or vendors

**Create your custom BOM using readily available parts**

### Analyze It

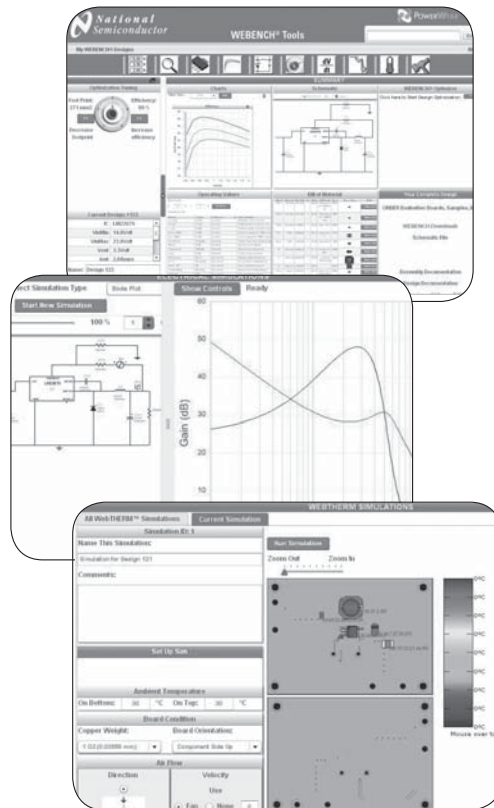
- Simulate your circuit and evaluate performance using electrical and thermal simulations
- Overlay alternate circuits and compare results to get optimal performance

**Solve your design problems before you prototype**

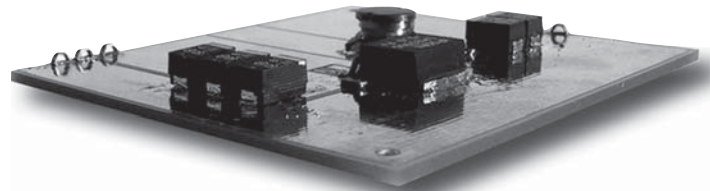
### Build It

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

**Save weeks getting your final design into production**



**24 HOUR SHIPPING!**



## Power Supply Design Tool

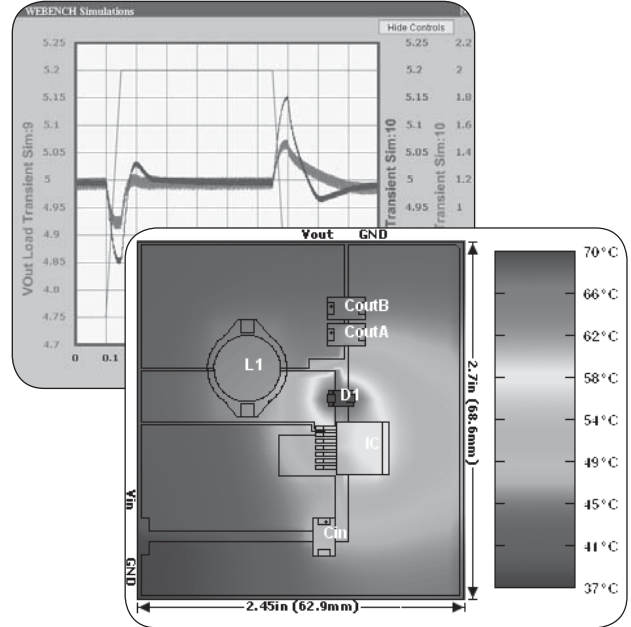
The WEBENCH environment provides the end-to-end design and prototyping tools you need to create power supplies that meet your design's requirements. WEBENCH tools let designers solve design problems before prototyping—alleviating the time and trouble associated with traditional design methods.

### WEBENCH Electrical Simulator

Use this tool to simulate your power supply circuit. Use probe points on a schematic display to examine waveforms, change component values, and view a history of simulation results to fine-tune your design.

### WebTHERM™ Thermal Simulator

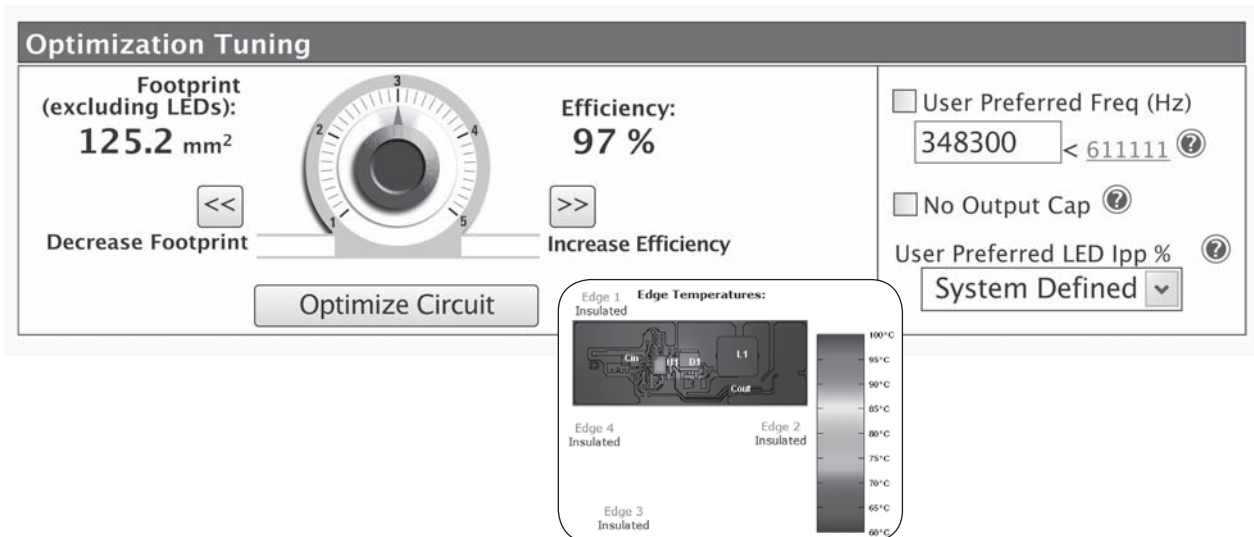
Use this tool to simulate thermal behavior of an electronic PCB. Define the environment, solve thermal problems and output a color plot of the PCB under user specified load and environmental conditions.



### Optimization Tool

Use the new WEBENCH optimization tool to quickly tune your design and balance your design objectives. By simply rotating a knob, you can achieve minimum component footprint, maximum efficiency, or a combination of both. Other key features include the ability to directly specify the switching

frequency, and, for LED designs, specifying output ripple current and eliminating the output capacitor. Use an alternate passive components list to make tradeoffs for key parameters such as voltage, current, price, size, and other electrical parameters.



# Design Tools

## Resources for Next-Generation Design



Design, build, and test analog circuits in this online design and prototyping environment.

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Published bi-monthly, the Power Designer technical articles cover key power design tips and techniques for today's design engineers.

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Published bi-monthly, the Signal Path Designer technical articles cover analog signal path tips and techniques for today's design engineers.

[national.com/spdesigner](http://national.com/spdesigner)



National's monthly analog design technical journal.

[national.com/edge](http://national.com/edge)



Easy, natural-language online search engine provides quick access to products and technical information.

[www.national.com/kbase](http://www.national.com/kbase)



Tune in to learn technical energy-saving tips, hosted by National's Chief PowerWise® Technologist, Richard Zarr, and streamed 24/7 on the web.

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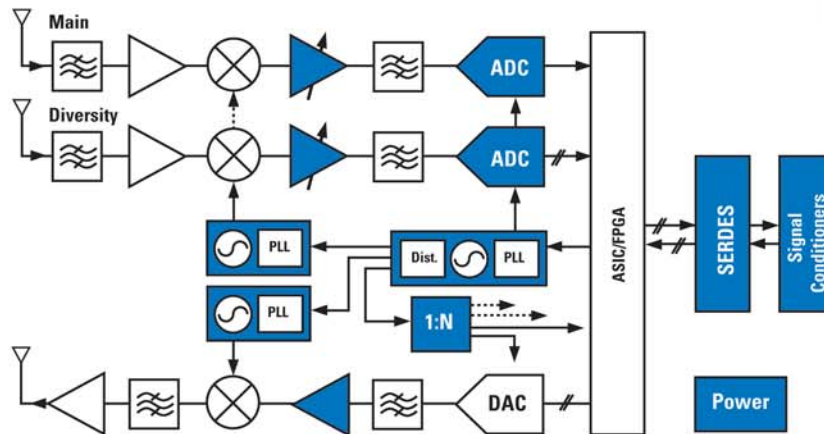
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# Maximum Efficiency. Minimum Power Loss.

## Energy-Efficient Wireless Basestation Solutions

Designing for wireless basestations poses several design challenges, including how to optimize efficiency and deliver robust system performance. These challenges need to be addressed on the receive side of a basestation when designing with amplifiers for signal conditioning, timing products for frequency translation and clock generation, ADCs for high dynamic range data conversion, and power supplies for powering signal path and digital processing systems.

- ✓ Subsystem solutions
- ✓ Reference designs
- ✓ Online design tools



Shown: Wireless Basestation Application Diagram

### Low Noise, Low Power

In high-performance basestation designs, linearity and low-noise operation are key to maximizing receiver sensitivity. National's LMH6517 DVGA, combined with the ADC16V130 16-bit ADC, LMK04000 clock jitter cleaner, and LMX2541 frequency synthesizer optimize next-generation multi-carrier GSM, LTE, UMTS, and WiMax base stations.

### High-Power Density

High-power density and efficiency are critical to reduce total power consumption, minimize heat generated by power losses, and improve system reliability and safety. National's diverse portfolio of LM5000 power management solutions maximize power density and end-to-end power chain efficiency.

### Design Flexibility

National's DS64BR401 quad 6.4 Gbps transceivers perform signal conditioning on both input (EQ) and output (De-Emphasis) stages to maximize basestation design flexibility and recover from transmission losses induced by backplane or cable interconnects.



# Worldwide Design Centers and Manufacturing Facilities



- Design Centers
- Manufacturing Facilities

## Design Centers

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Longmont, Colorado  
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Phoenix, Arizona  
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Santa Clara, California  
South Portland, Maine  
Tucson, Arizona

### EUROPE:

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Unterhaching, Germany  
Greenock, Scotland  
Milan, Italy  
Oulu, Finland  
Tallinn, Estonia

### ASIA:

Bangalore, India  
Hangzhou, China  
(joint with Zhejiang University)  
Hong Kong, China  
Tokyo, Japan

## Manufacturing Facilities

### Wafer (Die) Fabrication:

Arlington, Texas  
South Portland, Maine  
Greenock, Scotland

### Chip Test and Assembly:

Melaka, Malaysia

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