

Analog Products

Selection Guide

national.com

2011

Data Conversion

Amplifiers

Temperature Sensors

Clock and Timing

Interface

Audio

Power Management

Design Tools



National
Semiconductor

Energy-Efficient Analog Makes the Difference

national.com

With 50 years of analog innovation, National Semiconductor continues to create analog-intensive solutions that differentiate customers' products by providing greater energy efficiency, precision, portability, better audio, and sharper images in electronic systems. National's technologies address issues facing system designers in markets such as mobile handsets, communications, and industrial applications.

Proven Analog Technology Leadership

National's analog portfolio features leading-edge operational amplifiers, interface technologies, data converters, and power management solutions. These devices provide solutions for high-efficiency lighting, precision data acquisition, high-speed serial communication and highly efficient power conversion. As a recognized world leader in power management, National continues to pioneer new energy-efficient devices, subsystems, and architectures for next-generation system designs.

PowerWise® Products for Energy-Efficient Designs

For the growing number of designs where energy efficiency is a primary consideration, National has developed PowerWise® solutions. With National's PowerWise ICs, design engineers can create products and systems that consume less power, extend battery life, and generate less heat. PowerWise devices and subsystems, found in every National product family from interface products to high-speed data converters, from thermal management to power regulators, can help solve customers' design challenges.



The PowerWise portfolio includes more than 300 of National's top energy-efficient analog and mixed-signal semiconductor devices that meet or exceed a set of stringent performance-to-power metrics, making it easy for system designers to identify the most energy-efficient devices for their end products.

Personal Mobile Devices

National is focused on fully featured wireless handsets and personal mobile devices, products that enable people to search the Internet, send email, stream video, download music, and take photos. National's rich portfolio enables vibrant displays, clearer audio, better portability, and longer battery life.



Industrial Automation

Increased efficiency and lower operating costs are the driving trends in industrial automation, leading to increased modernization, as well as intelligent sensing and control. National continues to provide improved precision measurement and control, continuous-calibration capabilities, and diagnostic capabilities with reduced downtime and power usage.

LED Lighting

National's constant-current light-emitting diode (LED) drivers enable greater energy efficiency and flexibility in lighting designs. Driving numerous LEDs in one string, they provide greater than 90 percent efficiency and accurate current regulation with less power and heat dissipation. Demand is soaring as LEDs replace incandescent light bulbs in the home and HID lamps in street lights and projectors. With their energy-efficient nature, LEDs are also finding increased adoption in automotive, exterior lighting, and infotainment applications.

Communications Infrastructure

As more of the world's population shares files, photos, and video, networking and data centers are growing exponentially. Increasingly, new wireless technologies are driving higher data rates and requiring unprecedented power consumption. National's energy-efficient solutions enable routers, switches, wireless base stations, modems, and DSL equipment to consume less power and generate less heat. PowerWise solutions address rising energy costs and customer demand for "greener" operations.



Award-Winning Design Tools

National's unique WEBENCH® designer provides system engineers a competitive advantage and faster time to market. National's on-demand tools make it easy for system engineers to explore and learn, compare and select products, and then design and build their system online. National's WEBENCH design tools enable novice and experienced designers alike to easily optimize their size and efficiency requirements using online controls.

50 Years
of Industry
Leadership

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New Products

Product ID	Description	Page
Amplifiers and Comparators		
LMH6629	Ultra-low-noise, high-speed operational amplifier	31
LMP7312^E	SPI-programmable Analog Front End (AFE) with differential and single-ended input/output	39
LMP8358^E	Zero-drift, programmable instrumentation amplifier	39
LMV7231^E	Hex window comparator with 1.5% precision for hardware monitoring	51
LMP8640/HV	Precision high-voltage fixed gain current sense amplifiers	43
Audio		
LM48312/512^E	Ultra-low-EMI, mono Class D audio power amplifiers with E ² S	97
LM49155	Uplink noise reduction and downlink SNR-enhancing analog audio subsystem	92
LMV1051	Adaptive noise canceling microphone processor with microphone beamforming technology	93
LMV1100	Active noise canceling processor with integrated custom-tuned filters	93
Automotive Grade		
DAC121S101Q^E	12-bit, single-channel, automotive-grade digital-to-analog converter	27
DS90UB901/02/03/04Q	10 MHz to 43 MHz, DC-balanced FPD-Link III bidirectional control serializers and deserializers	68
DS99R124Q^E	5 MHz to 43 MHz, 18-bit color FPD-Link II to FPD-Link converter	68
LM25011Q	42V, 2A, constant on-time switching regulator with adjustable current limit	116
ADC128S052Q^E	8-channel, 200 kSPS to 500 kSPS, 12-bit A/D converter	26
DS90UR905/06/07/08^E	5 MHz to 65 MHz, 24-bit, FPD-Link II LVCMOS serializers and deserializers	68
DS90UH925/926	5 MHz to 85 MHz, 24-bit, FPD-Link III LVCMOS with HDCP serializer and deserializer	68
Clocking		
LMH1983^E	3G/HD/SD video clock and timing generator with audio clock	36
LMH2191	Dual-channel, 52 MHz clock tree driver for mobile phones	64
Data Conversion/Hardware Monitors		
ADC12D1000/1600/1800^E	12-bit 2.0/3.2/3.6 GSPS ultra high-speed ADCs	19
ADC128D818^E	12-bit, 8-channel ADC system monitor with internal/external reference	25
LM96080^E	10-bit, 7-channel system monitor with fan monitoring	59
DAC161S055^E	Precision 16-bit low-noise buffered voltage-output DAC	27

 PowerWise® product

^E Evaluation board

^W WEBENCH® enabled

Product ID	Description	Page
Interface		
DS92LX1621/1622/2121/2122	21-bit Channel Link III serializers and deserializers with embedded clock and control channel	67
DS92LV0411/0412	Channel Link II Ser/Des with embedded clock and 4-bit LVDS interface	67
DS92LV2411/2412	Channel Link II Ser/Des with embedded clock and 24-bit LVCMOS interface	67
LED Drivers		
LM3414	1A, 60W, common-anode-capable, constant-current buck LED driver	148
LM3434^E	Common-anode-capable high-brightness LED driver controller with high-frequency dimming	146
LM3444	AC-DC offline LED driver	148
LM3445	TRIAC-dimmable LED driver	148
LM3450	Power factor correction controller with phase-dimming decoder	148
LM3464	LED driver with dynamic headroom controller and thermal control interface	149
Power Management		
LM25066	Integrated system power protection and management IC with PMBus	136
LM27402	High-performance synchronous buck controller with DCR current sensing	122
LM34919B^E	Ultra-small 6V to 40V, 600 mA buck regulator	117
LMZ10503/05EXT^{E,W}	Rugged extended temperature, 5V, 20V, and 42V SIMPLE SWITCHER® power modules	111
LMZ12001/02EXT^{E,W}		
LMZ14201/02EXT^{E,W}		
LM(2)5119	42V/65V, dual-channel, dual-phase ECM buck controller	122
RF Detectors		
LMH2120	40 dB linear RMS RF power detector	52
LMH2110^E	8 GHz logarithmic RMS power detector with 45 dB dynamic range	52
Space Grade		
LM4050QML	2.5V, 5V, 10V precision shunt voltage reference	142
LM98640QML	Dual, 14-bit, 3 MSPS to 40 MSPS Analog Front End (AFE) with LVDS output	28

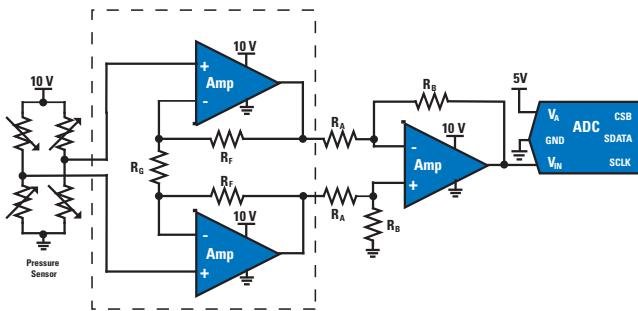
 PowerWise® product

^E Evaluation board

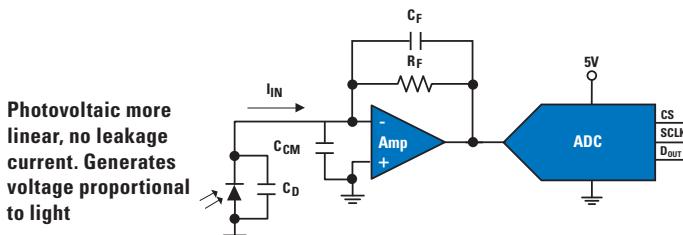
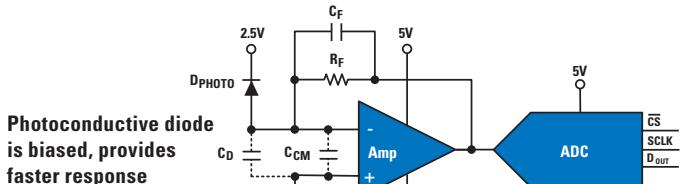
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Industrial Sensing and Control

Bridge Sensors — Pressure, Load, Force



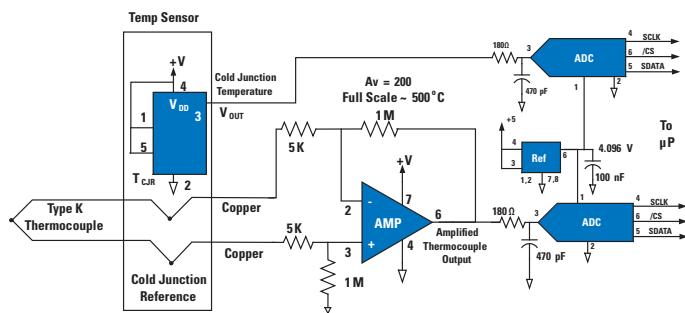
Photoconductive/Photovoltaic



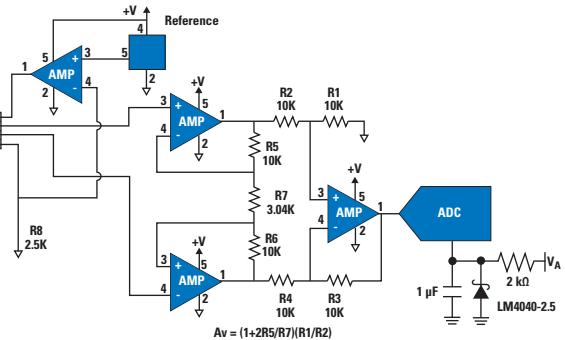
Solutions	Examples	Pages
Amplifier	LMP8358, LMP7312, LMP7704/09	39, 40
ADC	ADC121Sxx1, ADC121C02x, ADC101Sxx1, ADC101C02x	25, 26
Power	LM2267x, LM500x, LM284x	112, 116

Solutions	Examples	Pages
Amplifier	LMP7701, LMV851, LMP7715, LMV841	40, 41, 48
ADC	ADC101Sxx1, ADC101C02x, ADC121Sxx1, ADC121C02x	25, 26
Power	LM284x, LM500x	116
Reference	LM4030, LM4132/40	142

Temperature-Thermocouple Interface



Temperature-RTD

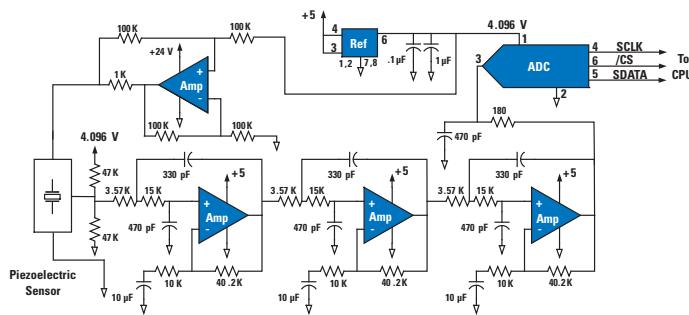


Solutions	Examples	Pages
Amplifier	LMP7701, LMP7715	41
ADC	ADC122S021, ADC121S021, ADC102S021, ADC121C02x	25, 26
Temp Sensor	LM94022	56
Reference	LM4030, LM4132/40	142

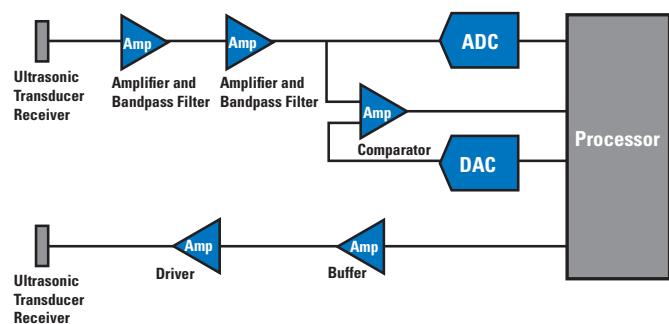
Solutions	Examples	Pages
Amplifier	LMP7704, LMP7716	41
In Amp	LMP8358	39
ADC	ADC121S021, ADC121C02x	25, 26
Reference	LM4030, LM4132/40	142
Power	LM284x, LM500x	116

For additional application information and block diagrams, visit: national.com/sensing

Vibration



Ultrasonic Speed Sensing



Solutions	Examples	Pages
Amplifier	LMP2021/22, LMP7731/32	40
ADC	ADC141S626, ADC161S626	27
Power	LM284x, LM500x	116
Voltage Reference	LM4030, LM4132/40	142

Solutions	Examples	Pages
Amplifier	LMV771/91	42
ADC	ADC121S101	26
DAC	DAC121S101	27
Comparator	LMV7219	51
Power	LM284x, LM500x	116
Reference	LM4030, LM4132/40	142

Solutions for pressure sensors, load cells, thermocouples, and optical sensors

Reduces design time — move rapidly from concept to design to prototyping

- Select a sensor
- Modify key parameters to meet specification application needs
- WEBENCH® Sensor Designer tool creates a complete design (schematic, BOM, detailed error analysis)
- Customized solution to meet specific performance needs
- A “Build It” option (PC board/components from design) expedites prototyping

The screenshot shows the WEBENCH Sensor Designer Tools interface. It features a navigation bar with links like Home, Page AtP_Sensors, PRODUCTS, DESIGN, ORDER, COMPANY, and a search bar. The main area is titled "WEBENCH SENSOR DESIGNER TOOLS". It includes sections for "About WEBENCH Sensor Designer", "Temperature Sensors", "Sensor Designer", and "WHAT'S NEW". There are also tabs for Pressure Sensor, Thermocouple Sensor, and Photodiode Sensor.

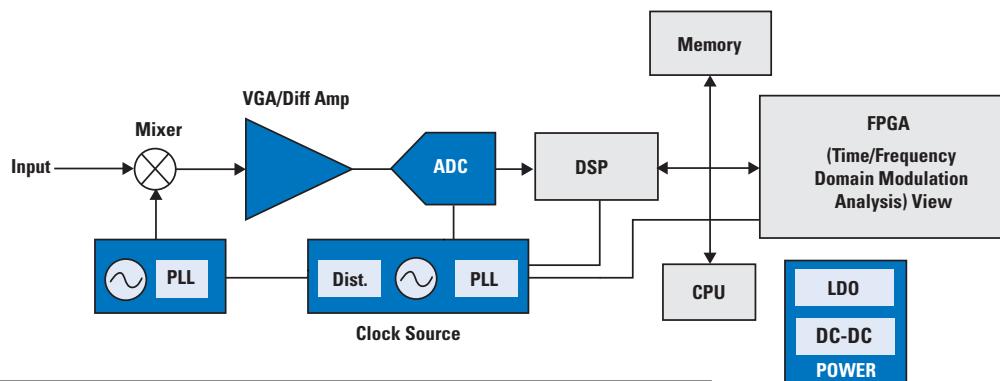
national.com/sensors

For additional application information and block diagrams, visit: national.com/sensing

national.com

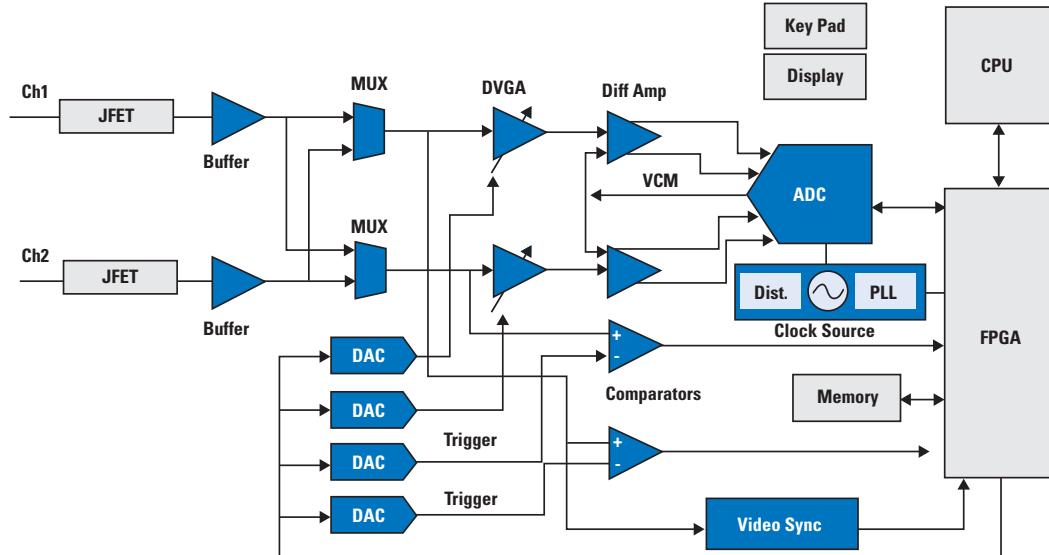
Test and Measurement

Spectrum Analyzer



Solutions	Examples	Pages
Amplifier	LMH6505, LMH6515/17/18, LMH6552/54	32, 35
ADC	ADC10D1000/1500, ADC16V130, ADC16DV160, ADC12D1000/1600/1800	19, 21, 22, 23
Clock Source	LMX2531/41, LMK040xx, LMK010xx, LMK030xx	60, 61, 62, 63
Power	LMZ1200x, LP3990, LP38511	111, 138, 141

Oscilloscope/Digitizer

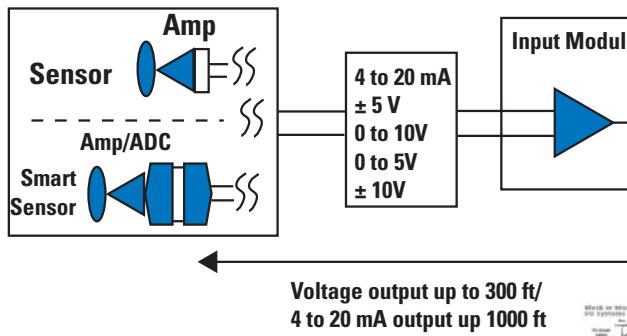


Solutions	Examples	Pages
Amplifier	LMH6702/03, LMH6552/54/55, LMH6515/17/18, LMH6570, LMH1980/81	31, 32, 34, 35, 36, 38
Comparator	LMH7220, LMH7322/24	51
ADC	ADC12D1000/1600/1800, ADC10D1000/1500, ADC08D1000/A, ADC08D1500	19, 21
DAC	DAC161S055, DAC121S101, DAC122S085, DAC121C085	27
Power	LMZ1050x, LM21305, LM2267x	111, 112, 119
Clock Source	LMX2531/41, LMK040xx, LMK010xx, LMK030xx	60, 61, 62, 63

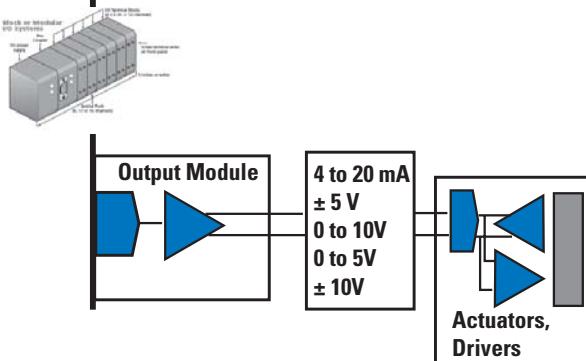


I/O Module

Input to I/O Module

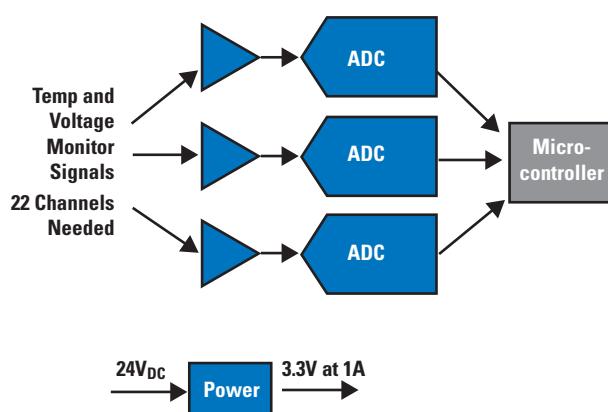


Output from I/O Module



Solutions	Examples	Pages
Amplifier	LMP7312, LMP7715/16, LMP7701, LMP2021	39, 40, 41
ADC	ADC121S021, ADC128S052, ADC121S625, ADC141S626, ADC161S626	26, 27
DAC	DAC161S055, DAC121S101, DAC122S085, DAC124S085	27
Power	LM5009A, LM5008A	116

Data Acquisition

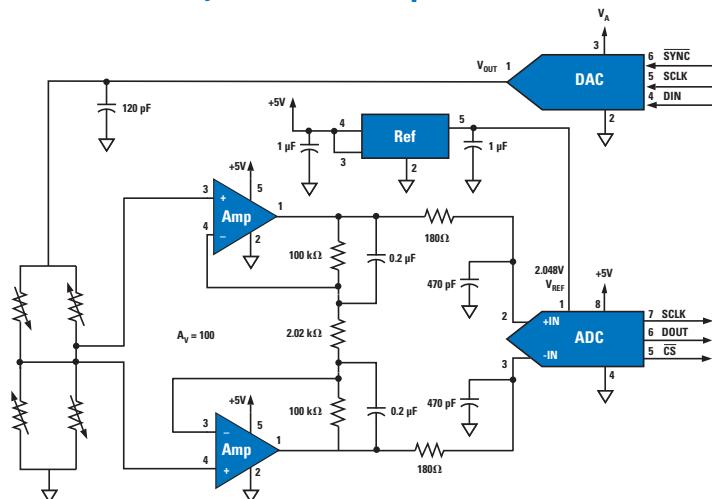


Solutions	Examples	Pages
Amplifier	LMP8358, LMP7312, LMP7704, LMP7712/15/16	40, 41
ADC	ADC128S022, ADC128S052, ADC128S102	26
Power	LM25011, LM25575	113, 116
Reference	LM4132/40	142

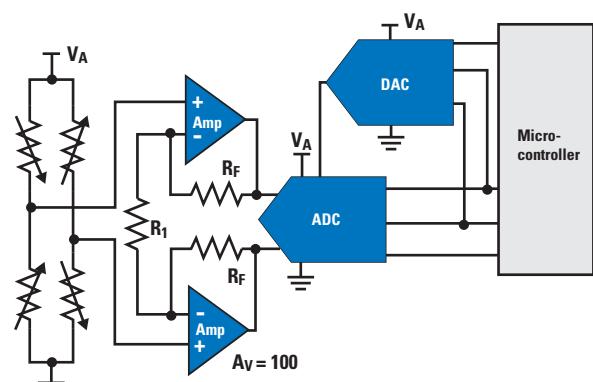
For additional application information and block diagrams, visit: national.com/industrial

Setting Control Points/Sensor Drive

**Variable Sensor Voltage Drive
(adjusts sensor output)**



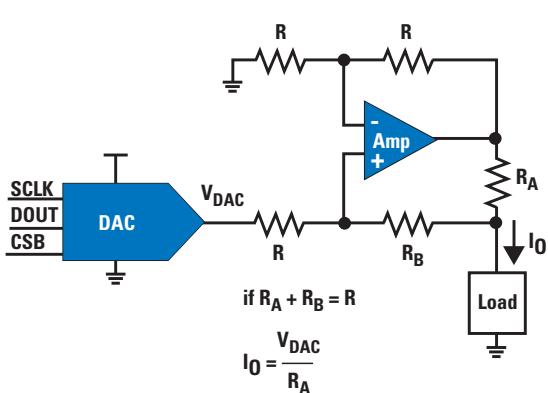
**Adjustable ADC Reference
(adjusts ADC range)**



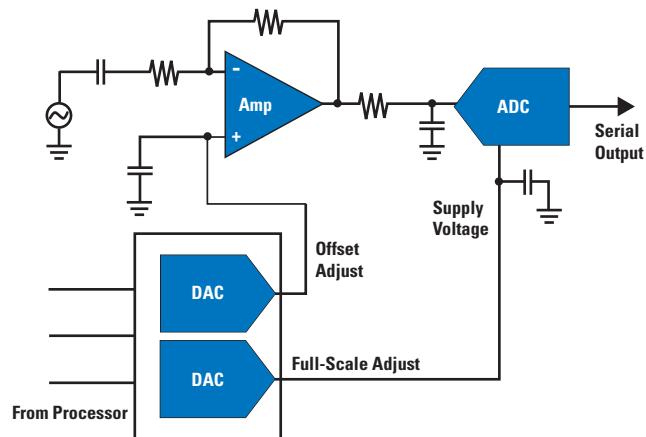
Solutions	Examples	Pages
Amplifier	LMP7701/02, LMP8358	39, 40
DAC	DAC121S101, DAC101S101, DAC161S055	27
ADC	ADC121S625	27
Reference	LM4030, LM4132/40	142

Solutions	Examples	Pages
Amplifier	LMP7701/02, LMP8358	39, 40
DAC	DAC101S101, DAC121S101, DAC161S055	27
ADC	ADC121S625	27
Reference	LM4030, LM4132/40	142

Variable Current Source



Offset and Gain Calibration



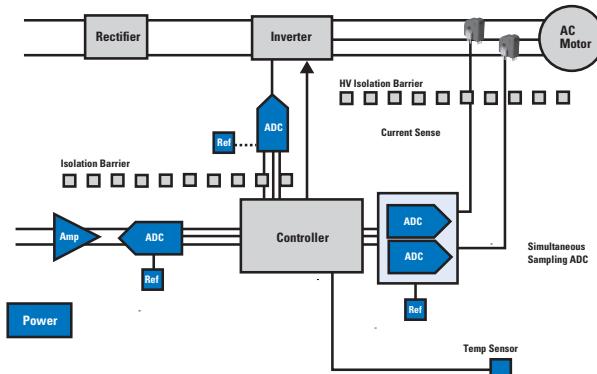
Solutions	Examples	Pages
Amplifier	LMP7711	40
DAC	DAC081S101, DAC101S101, DAC161S055	27
Reference	LM4030, LM4132/40	142

Solutions	Examples	Pages
Amplifier	LMP7701	40
ADC	ADC121S101	27
DAC	DAC122S085, DAC161S055	27
Reference	LM4030, LM4132/40	142

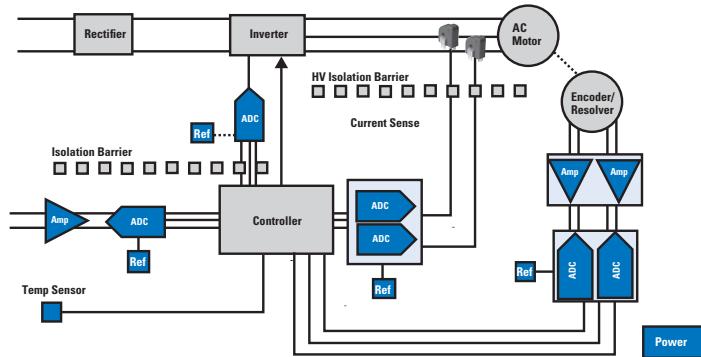
For additional application information and block diagrams, visit: national.com/sensing

Motor Control

AC Motor



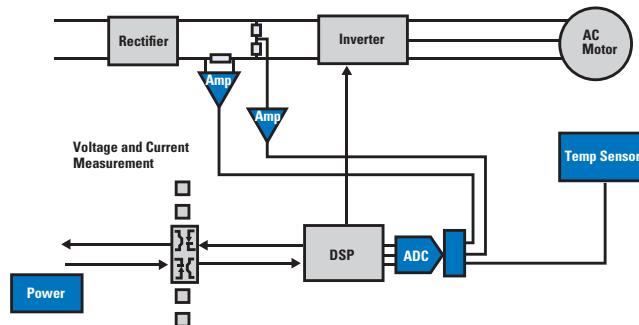
Servo Motor Control



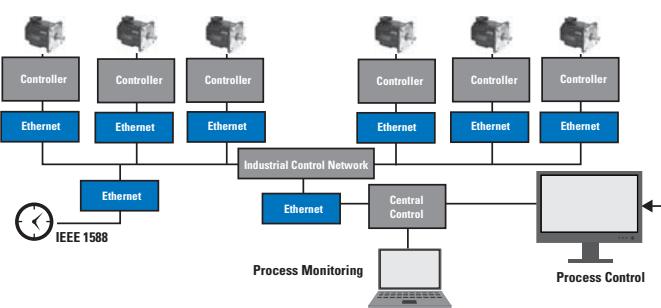
Solutions	Examples	Pages
Amplifier	LMP7712/31, LMP2015/16	40
ADC	ADC121S021/625, ADC161S626, ADC122Sxxx	25, 27
Reference	LM4030, LM4128/32	142
Ethernet	DP83640, DP83848/49	84, 85
Temp Sensor	LM73	57
Power	LM2557x, LM557x, LM500x	113, 116

Solutions	Examples	Pages
Amplifier	LMP7702, LMP7731/32, LMP2015/16	40
ADC	ADC121S021, ADC121S625, ADC122Sxxx, ADC161S626	25, 27
Ethernet	DP83640, DP83848/49	84, 85
Reference	LM4030, LM4128/32	142
Power	LM2267x, LM557x, LM5009x	112, 113, 116

Low-Side Motor Control



Multiple Motor Control Synchronization



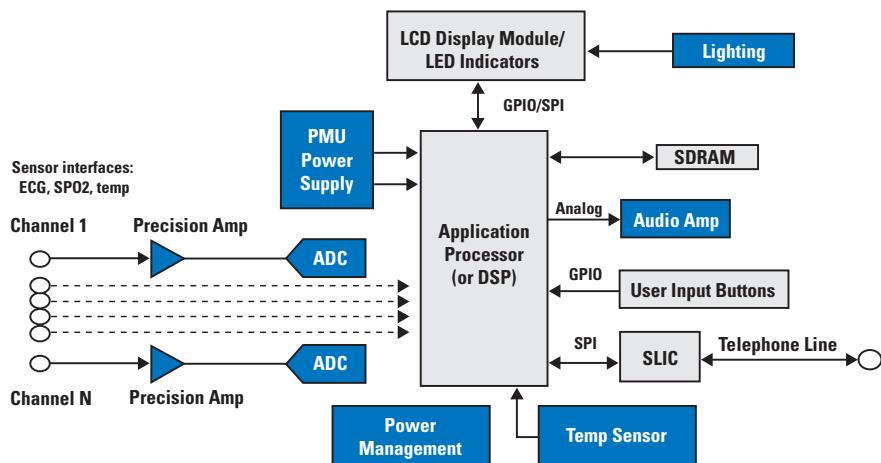
Solutions	Examples	Pages
Amplifier	LMP7707, LMP8601/02/03, LMP7711	40, 43
ADC	ADC124Sxxx	26
Temp Sensor	LM94022, LM73	56, 57
Reference	LM4030, LM4132/40	142

Solutions	Examples	Pages
Ethernet	DP83640, DP83848/49	84, 85

For additional application information and block diagrams, visit: national.com/industrial

Medical

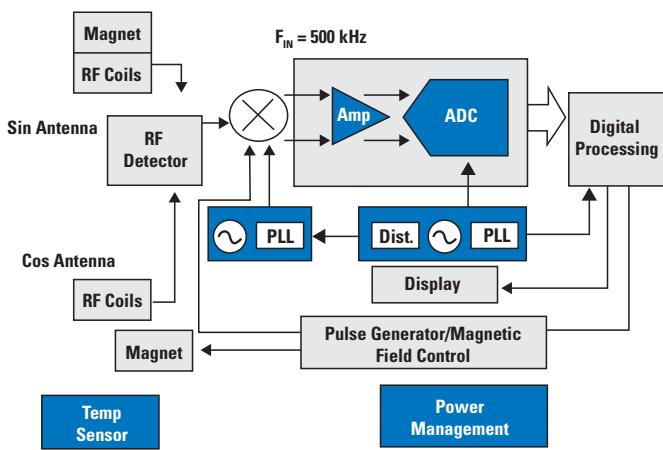
Multichannel Patient Monitor



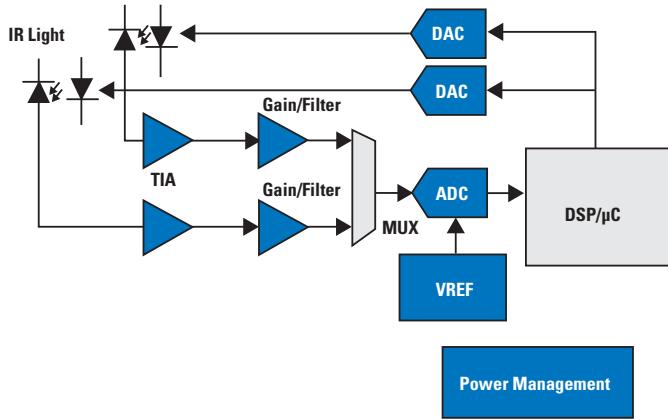
Solutions	Examples	Pages
ADC	ADC121S021, ADC121S625, ADC101S021, ADC121C021/27	25, 26, 27
Amplifier	LMP2011/12, LMP2231/32/34, LMP7701/02/04, LMP7715/16	40
Audio	LM48512, LM48557, LM48310/11/12	94, 97, 98

Solutions	Examples	Pages
Lighting	LM2795, LM27951, LM3500	147
PMU	LM26480	128
Power	LM25005, LM2696, LM2733, LM3370, LM367x, LP3906	116, 118, 124, 128
Temp Sensor	LM73, LM94022, LM95235	56, 57, 58

MRI



Pulse Oximetry



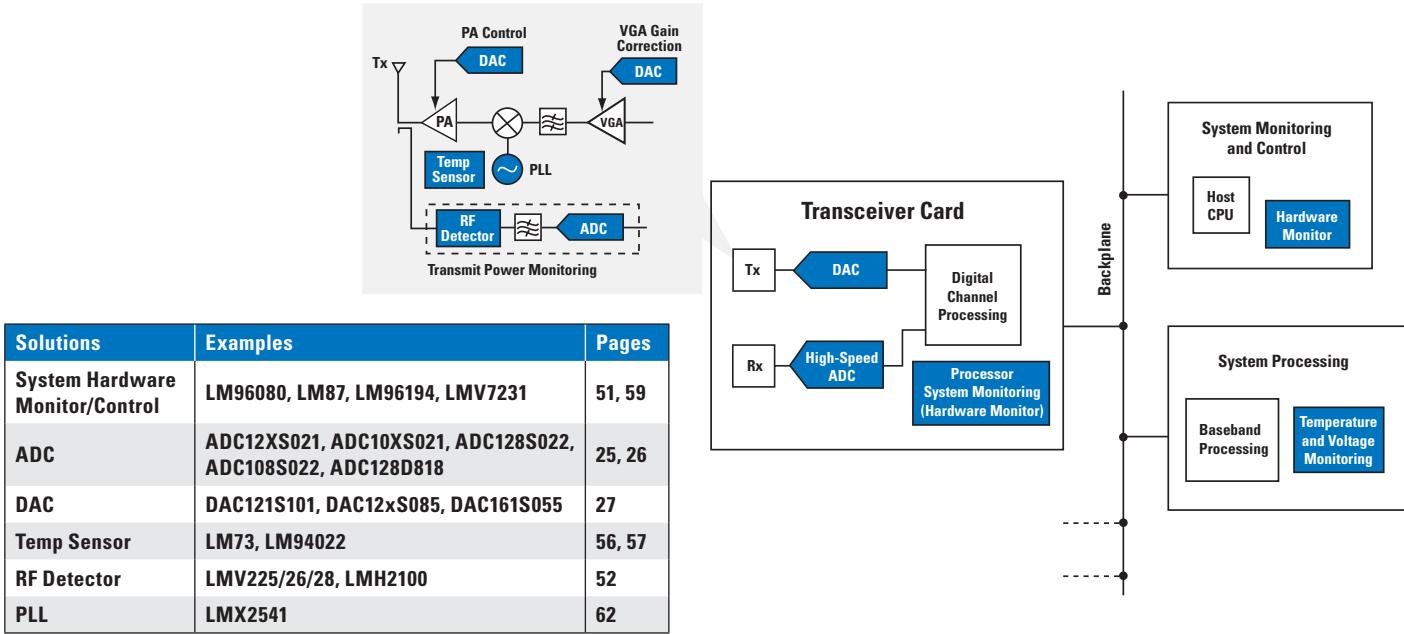
Solutions	Examples	Pages
ADC	ADC16DV160, ADC16V130	20, 22
Amplifier	LMH6550/51/52/53/54/55, LMH6622/24/26/28/29	31, 32, 34
Clock Source	LMK010xx, LMK020xx, LMK030xx, LMK040xx, LMX2531/41	60, 61, 62
Power	LM25005, LM2734, LM2830z, LM3100, LM3475, LM3489, LM4132, LP5900	114, 116, 121, 137, 142
Temp Sensor	LM57, LM94022	56

Solutions	Examples	Pages
ADC	ADC141S626, ADC161S626	27
Amplifier	LMP7711/12, LMV791/92, LMV793/94, LMV861/62	41, 42
DAC	DAC122S085	27
Power	LM4140, LM4132, LM22674, LP5900, LP2992, LP3906, LP3999	113, 128, 137, 140, 142

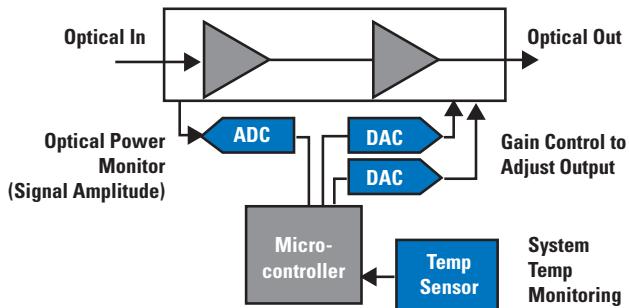
For additional application information and block diagrams, visit: national.com/medical

Communications Infrastructure

Wireless Basestation

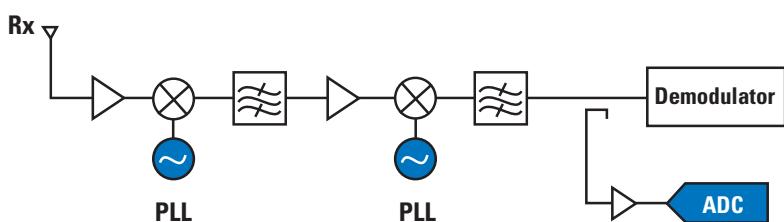


Optical Networks



Solutions	Examples	Pages
ADC	ADC12XS021	26
DAC	DAC121S101, DAC101S101, DAC12XS085, DAC10XS085, DAC161S055	27
Temp Sensor	LM73, LM57	56, 57

RSSI (Receive Signal Strength Indicator) in Channelized Communication

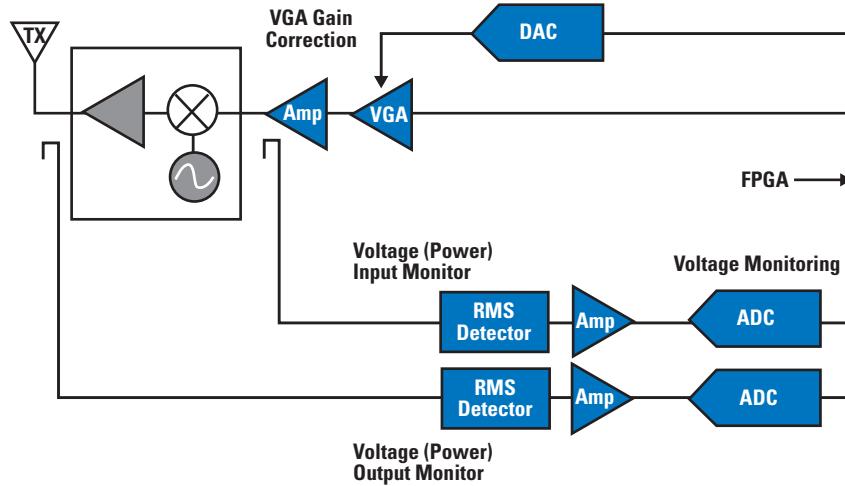


Solutions	Examples	Pages
ADC	ADC122S021	26
PLL	LMX2541	62

For additional application information and block diagrams, visit: national.com/comms

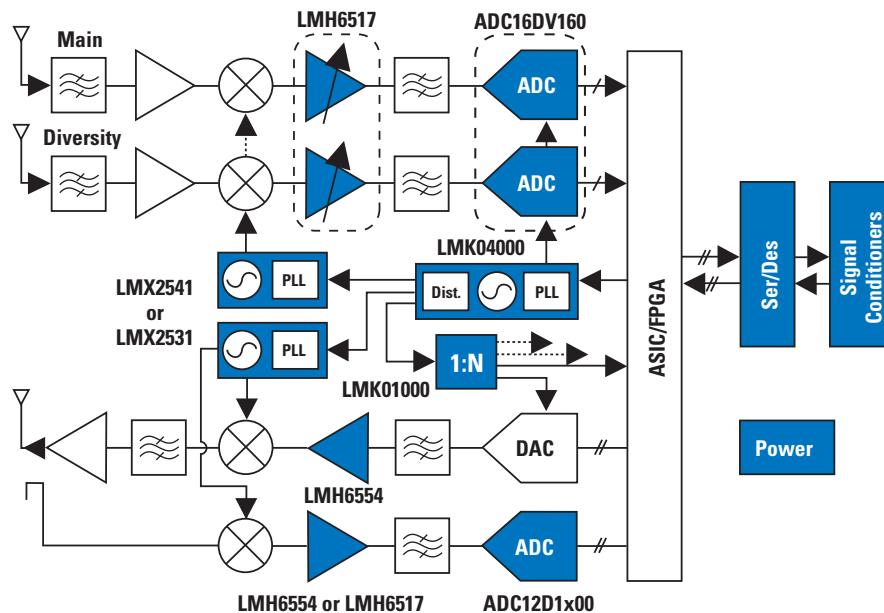
Communications Infrastructure

Radio Transmitter Power Level



Solutions	Examples	Pages
ADC	ADC12XS021, ADC102X021	26
DAC	DAC121S101, DAC12XS085, DAC10XS085	27
Amplifier	LMV771	42
RMS Detector	LMH2110	52

High-Speed Radio Signal Path for Wireless Basestations

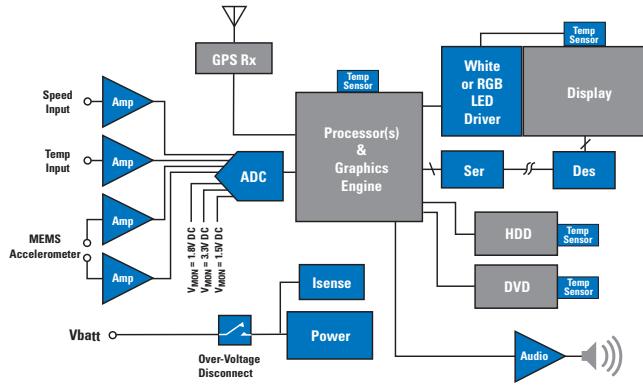


Solutions	Examples	Pages
ADC	ADC12D1000/1600/1800, ADC11DV200, ADC10DV200, ADC16DV160, ADC16V130, ADC14155	21, 22
Amplifier	LMH6515/17	35
Clock Source	LMK0400xx, LMK010xx, LMK030xx, LMK020xx	60, 61
PLL	LMX2531/41	62, 63

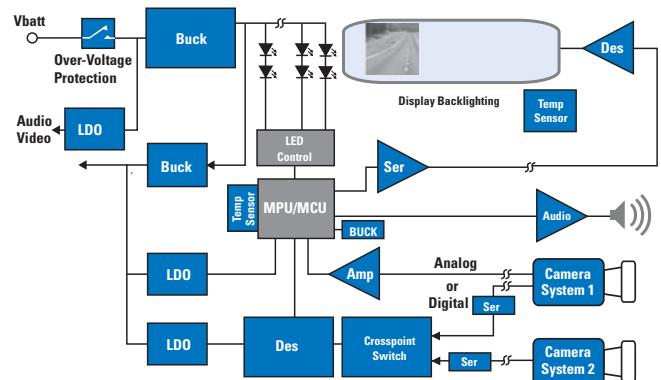
For additional application information and block diagrams, visit: national.com/comms

Automotive

Navigation System



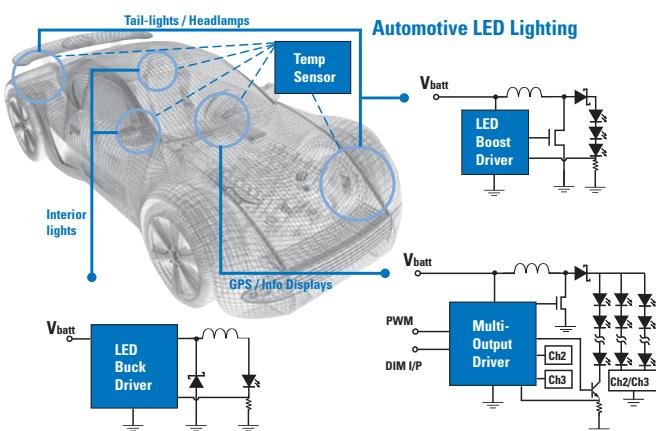
Automotive Park Assist



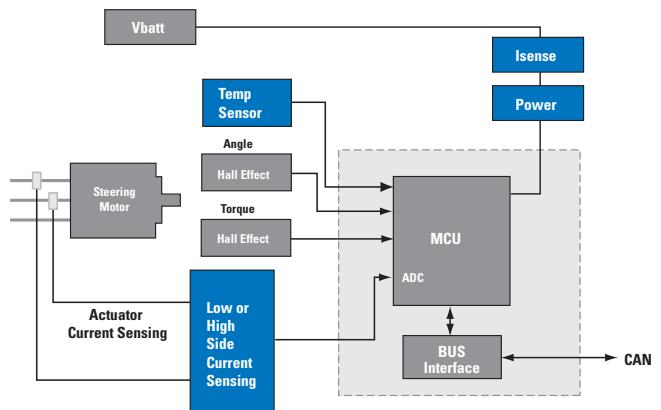
Solutions	Examples	Pages
ADC	ADC128S052Q, ADC122S051, ADC121C02x	25, 26
Temp Sensor	LM26/27/57, LM94021/22/23	56
Ser/Des	DS90UR905/06/07/08Q, DS90UR241/124Q	68
Audio	LM48100Q, LM48512, LM48557	94, 98, 99
Power	LM2600x, LM27341/42	116, 117

Solutions	Examples	Pages
Power	LM2600x, LM25011, LM34919, LP3869x	116, 117, 138
Temp Sensor	LM94021/22Q, LM71Q	56, 57
Ser/Des	DS90UB901/02, DS90UB903/04	68
Crosspoint	DS25CP104A, DS10CP152	72
Over-Voltage Disconnect	LM5060	136
Amplifier	LMV796	41

LED Lighting



Electric Power Steering



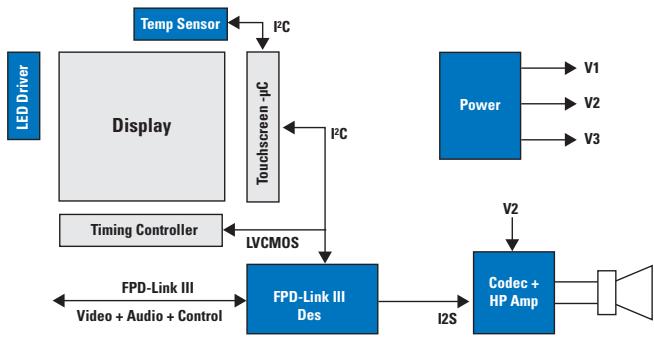
Solutions	Examples	Pages
LED Driver	LM340x, LM3421/23	146
Temp Sensor	LM94022Q	56

Solutions	Examples	Pages
Temp Sensor	LM95172Q, LM94021/22Q, LM71Q, LM57	56, 57
Power	LM2557x, LM557x, LM20xxx, LM5060	113, 119, 136
Amplifier	LMP7707/08/09, LMV796/97	40, 41

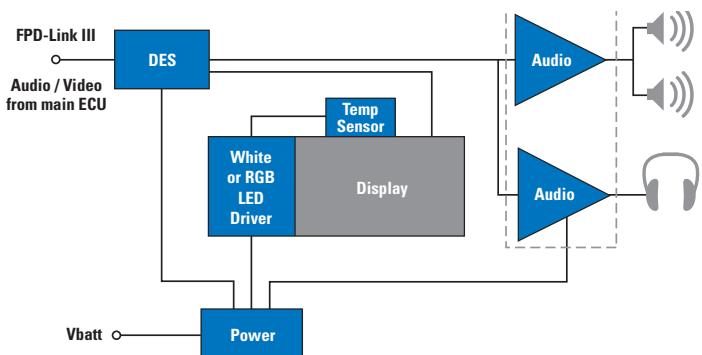
For additional application information and block diagrams, visit: national.com/automotive

Automotive

Central Information Display



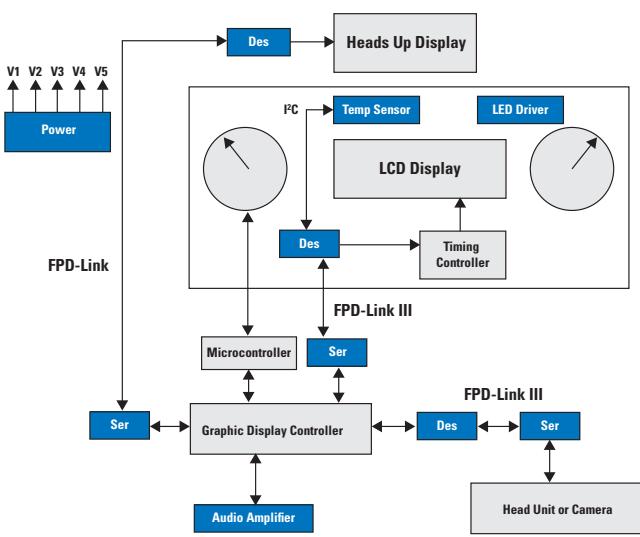
Rear Seat Entertainment Unit



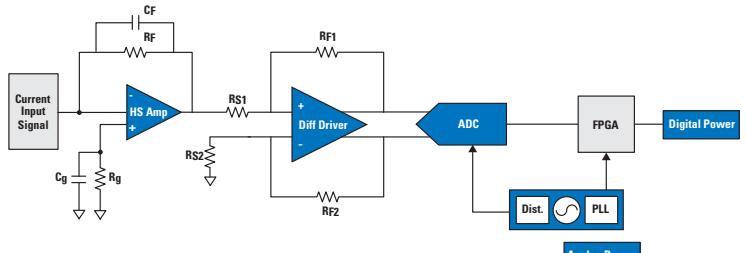
Solutions	Examples	Pages
Temp Sensor	LM57, LM94021/22Q, LM71Q, LM95235Q	56, 57, 58
Power	LM26001/03, LM25011	116, 117
LED Driver	LM3421/23	146
Ser/Des	DS90UR905/06/07/08Q, DS90UR241/124Q	68

Solutions	Examples	Pages
Ser/Des	DS90UR905/06/07/08Q, DS90UR241/124Q	68
LED Driver	LM3431	146
Temp Sensor	LM57, LM94021/22Q, LM95235Q	56, 58
Audio	LM49352, LM4911QMM	90, 96
Input Protection	LMV431/A/B	142
Power	LM25011	116

Instrument Cluster



Distance Measurement LiDAR System

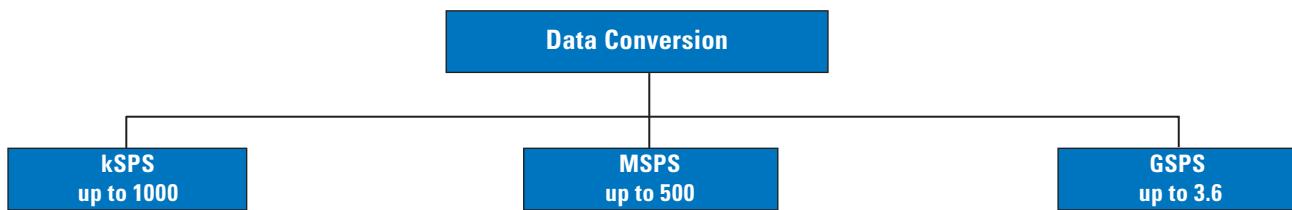


Solutions	Examples	Pages
ADC	ADC08B200, ADC08B3000, ADC12D1000/1600**/1800	19, 21
Amplifier	LMH6551/52/53/54, LMH6622/24/26/29	32
Analog Power	LP3878, LP5900	137
Clock Source	LMK010xx, LMK020xx, LMK030xx, LMK040xx	60, 61
Digital Power (PoL)	LM26480, LMZ14202EXT	111, 128
PLL	LMX2531/41	62, 63

**Space-level development in progress

For additional application information and block diagrams, visit: national.com/automotive

Data Converter Product Portfolio



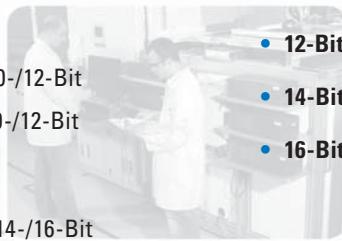
- Single-Ended Input I²C Compliant
 - A/D Converters: 8-/10-/12-Bit
 - D/A Converters: 8-/10-/12-Bit

- 8-Bit
- 10-Bit
- 11-Bit
- 12-Bit
- 14-Bit
- 16-Bit

- 8-Bit
- 10-Bit
- 12-Bit

- Single-Ended Input SPI

- A/D Converters: 8-/10-/12-Bit
- D/A Converters: 8-/10-/12-Bit



- Differential-Input SPI

- A/D Converters: 12-/14-/16-Bit



Data Conversion Solutions

ADC12D1x00 Enables SDR Architectures and Applications

The ADC12D1x00 family offers excellent dynamic performance over large input bandwidths and up to 3.6 Giga-Samples Per Second (GSPS) sampling rates, enabling a new generation of

Software-Defined Radio (SDR) architectures and applications. The 12-bit ADC family delivers unparalleled performance in a small package at the industry's lowest power.

Highest Sampling Rate

12-bits at up to 3.6 GSPS and input bandwidth of up to 2.8 GHz enable wideband sampling applications

High Energy Efficiency

50% lower power per sample rate than any competitive solution

Wide Bandwidth

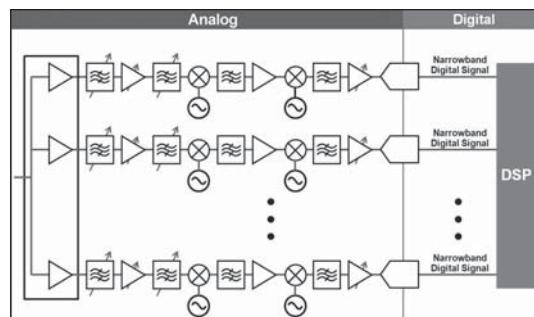
Flexibly supports everything from time-domain applications to IQ-sampling communications to high-IF and even some RF-sampling applications

Smallest Solution Size

Reduces board area and footprint providing for low-cost upgrades and weight reduction

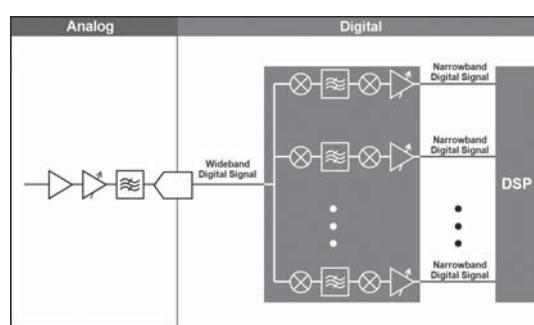
Traditional Hardware-Defined Radio Solution

- High analog complexity
- RF interference susceptibility
- Limited flexibility
- Redesign required for any additional features
- Analog power, area, and weight scales with channels



Software-Defined Radio Solution

- Low analog complexity
- Less susceptibility to RF interference
- Unlimited flexibility
- Analog power does not increase with increased Rx channels
- Low power, small size, and lighter weight
- Allows RF design reuse across platforms and generations



GSPS Ultra-High-Speed A/D Converters

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

Features

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

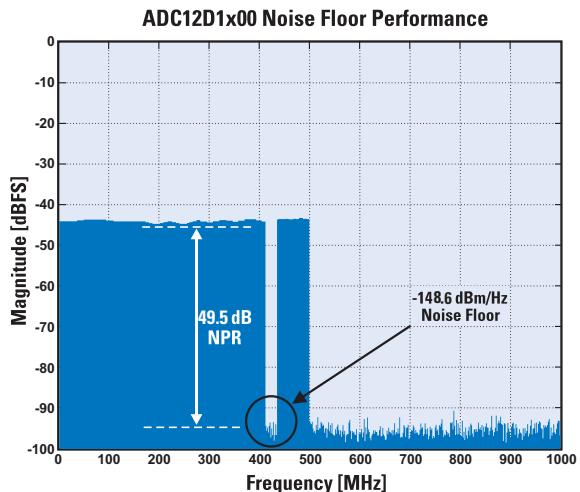
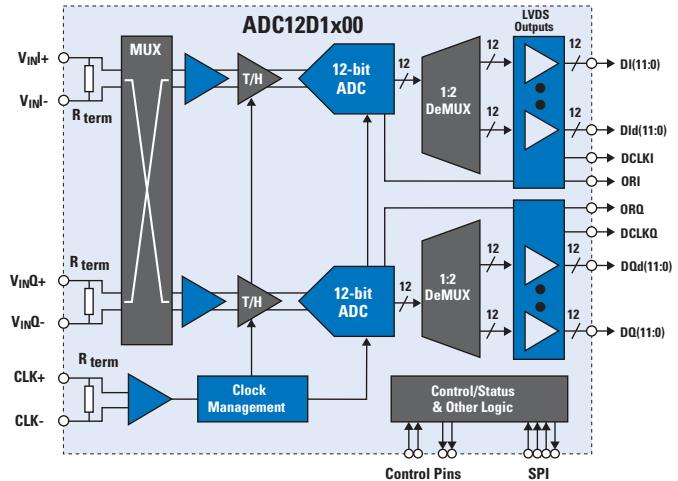
Applications

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

Optimal Performance

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

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



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)

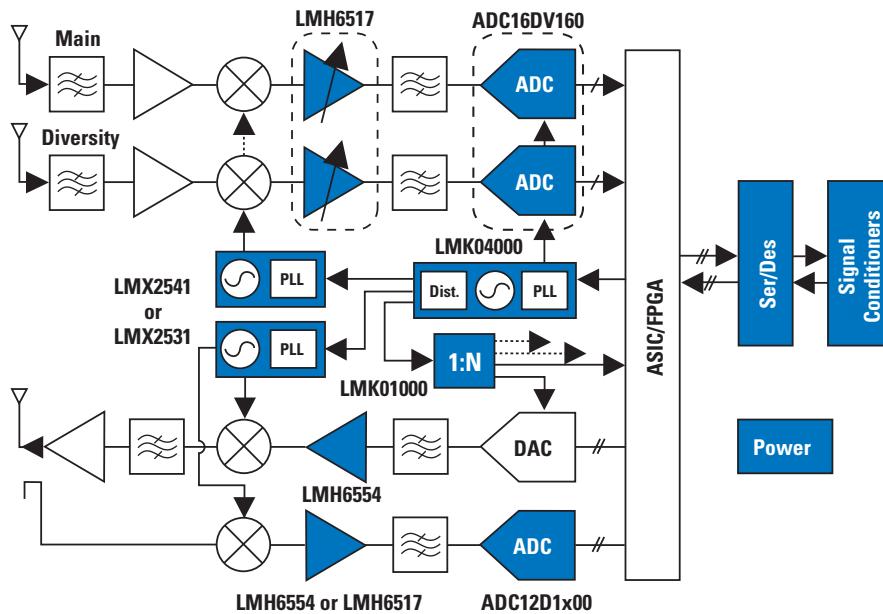
Performance (typical)

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

Applications

- 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

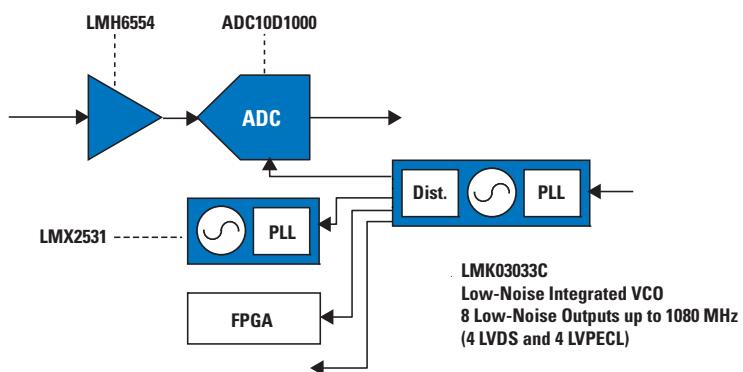


GSPS Ultra-High-Speed A/D Converters

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

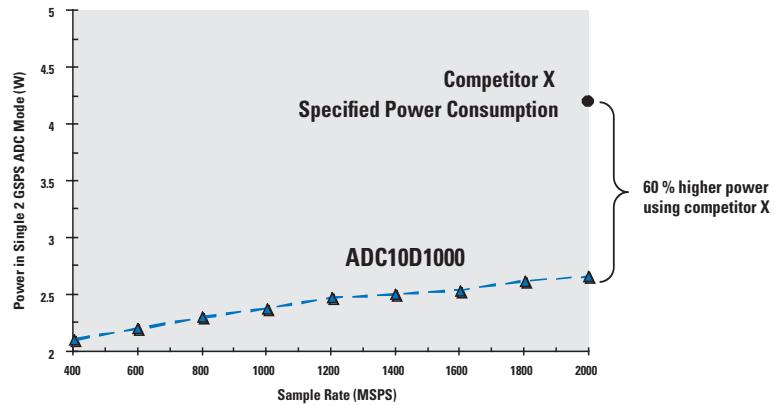
Features

- 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
- 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
- Pin-compatible with ADC12D1000/1600/1800



Performance ADC10D1000/ADC10D1500

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



Ultra-High-Speed A/D Converters

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

PowerWise product

E Evaluation board

MSPS High-Speed A/D Converters

High-Speed MSPS A/D Converters

Product ID	Channels	Speed (MSPS)	Power (mW)	SNR (dB)	SFDR (dB)	Outputs	Packaging
16-Bit							
ADC16DV160 ^E	2	160	1300	78.5	95	LVDS	LLP-68
ADC16V130 ^E	1	130	755	78.5	95.5	LVDS	LLP-64
14-Bit							
ADC14155/V155 ^E	1	155	967/951	71.3/71.7	87/86.9	CMOS/LVDS	LLP-48
ADC14DS080/105 ^E	2	80/105	800/1000	74.2/73	90	Serial LVDS	LLP-60
ADC14DC080/105 ^E	2	80/105	600/800	73/74	90	CMOS	LLP-60
ADC14C080/105 ^E	1	80/105	300/400	74.2/74	90	CMOS	LLP-32
ADC14L020/40 ^E	1	20/40	150/235	74/73	93/90	CMOS	LQFP-32
12-Bit							
ADC12C170/V170 ^E	1	170	715/781	67.2	85.4/85.8	CMOS/LVDS	LLP-48
ADC12C105 ^E	1	105	400	71	90	CMOS	LLP-32
ADC12DS080/105 ^E	2	80/105	800/1000	71	88	Serial LVDS	LLP-60
ADC12DC080/105 ^E	2	80/105	600/800	71.5/71	90	CMOS	LLP-60
ADC12C080 ^E	1	80	300	71.2	90	CMOS	LLP-32
ADC12DL080 ^E	2	80	447	69	82	CMOS	TQFP-64
ADC12L080/81 ^E	1	80	425	66	80	CMOS	LQFP-32
ADC12L066	1	66	357	66	80	CMOS	LQFP-32
ADC12QS065 ^E	4	65	800	69	83	Serial LVDS	LLP-60
ADC12DL065 ^E	2	65	360	69	86	CMOS	TQFP-64
ADC12L063	1	62	354	66	78	CMOS	LQFP-32
ADC12EU050 ^E	8	50	384	69.3	77	Serial LVDS	LLP-68
ADC12DL040 ^E	2	40	210	69	85	CMOS	TQFP-64
ADC12D040 ^E	2	40	600	68	80	CMOS	TQFP-64
ADC12040 ^E	1	40	340	69.5	84	CMOS	LQFP-32
ADC12020	1	20	185	70	86	CMOS	LQFP-32
11-Bit							
ADC11DV200 ^E	2	200	450	62.5	82	CMOS or LVDS	LLP-60
ADC11C125/70 ^E	1	125/170	608/715	65.5/65.1	88.2/85.4	CMOS	LLP-48
ADC11DL066	2	66	686	64	80	CMOS	TQFP-64
ADC11L066	1	66	357	65	78	CMOS	LQFP-32
10-Bit							
ADC10DV200 ^E	2	200	450	59.9	82	CMOS or LVDS	LLP-60
ADC10080 ^E	1	80	78.6	59.5	79	CMOS	TSSOP-28
ADC10DL065	2	65	370	61	85	CMOS	TQFP-64
ADC10065 ^E	1	65	68.4	59.6	80	CMOS	TSSOP-28
ADC10D040	2	40	267	60	72	CMOS	TQFP-48
ADC10040 ^E	1	40	55.5	59.6	80	CMOS	TSSOP-28
ADC10D020 ^E	2	20	150	59	75	CMOS	TQFP-48
8-Bit							
ADC08060	1	20 to 60	1.3	44.6	64	CMOS	TSSOP-24
ADC08L060	1	10 to 60	0.65	48	59.1	CMOS	TSSOP-24
ADC08100/200	1	100/200	1.3/1.05	47/46	60/58	CMOS	TSSOP-24

 PowerWise® product

^E Evaluation board

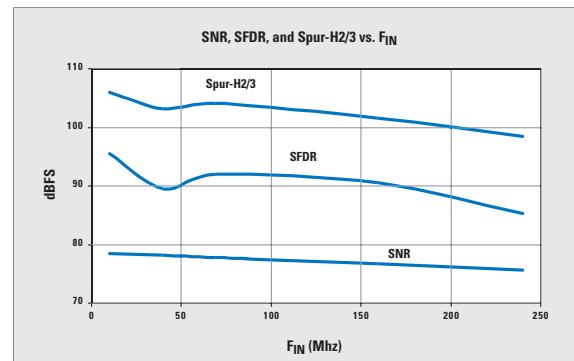
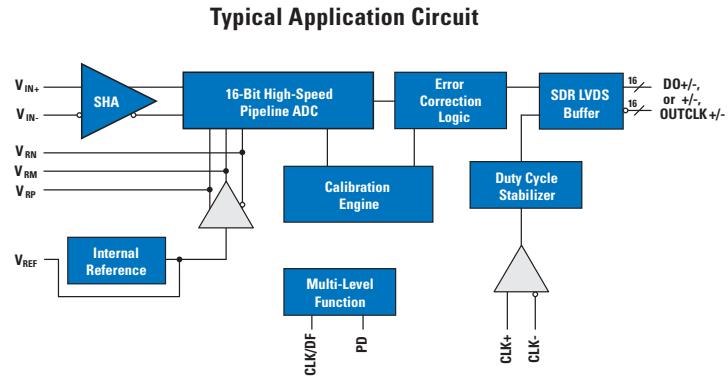
ADC16V130 – PowerWise® 16-bit, 130 MSPS ADC for High-IF, High-Dynamic Performance Applications

Features

- 1.4 GHz full power bandwidth
- Industry's best 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 and H3) at $f_{IN} = 160$ MHz
- Industry's lowest power: 755 mW
- Dual 3V/1.8V supply operation
- Parallel LVDS outputs
- Available in LLP-64 packaging (9 x 9 mm)
- Reference board available with LMK04031B clock jitter cleaner

Applications

Ideal for use in multi-carrier/multi-standard basestation receivers, repeaters, high-IF sampling systems, test and measurement equipment, communications instrumentation, radar systems, medical imaging, data acquisition, and portable instrumentation



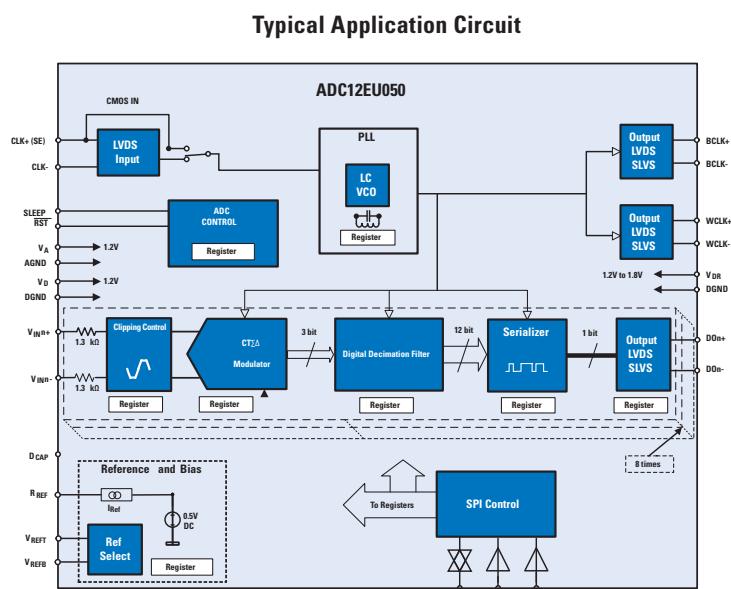
ADC12EU050 – PowerWise® High-Speed Continuous-Time Sigma-Delta ADC

Features

- Xignal™ continuous-time sigma-delta ADC technology
- 8-channel, 12-bit, 50 MSPS ADC
- Ultra-low power consumption: 384 mW
- Consumes 48 mW/channel at 50 MSPS
- Alias-free sample bandwidth up to 25 MHz
- On-chip PLL+VCO
- -76.6 dB Total Harmonic Distortion (THD)
- 69.3 dBFS Signal-to-Noise Ratio (SNR)
- Instant Overload Recovery (IOR)
- Available in LLP-68 packaging

Applications

Ideal for use in medical imaging, industrial imaging, communication, test and measurement, and portable systems



MSPS High-Speed A/D Converters

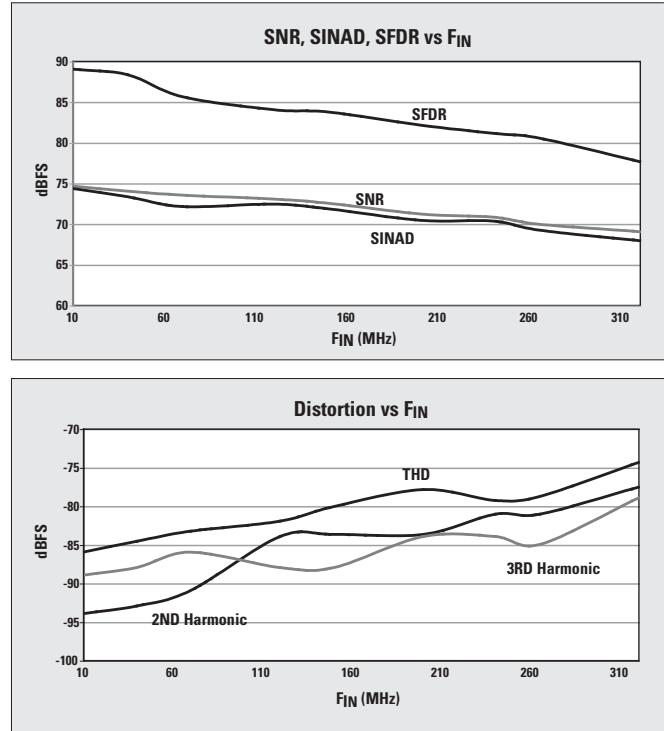
ADC14C105 – PowerWise® 14-bit, 105/95 MSPS ADC for High IF Sampling

Features

- 1 GHz full power bandwidth
- 72 dBFS SNR at 240 MHz input
- 82 dBFS SFDR at 240 MHz input
- -79.3 dBFS THD at 240 MHz input
- Power consumption: 400 mW
- Single 3.3V supply operation
- 12-bit, 105/95 MSPS ADC (ADC12C105)
- 12-bit, 80/65 MSPS ADC (ADC12C080)
- 14-bit, 80/65 MSPS ADC (ADC14C080)
- Available in LLP-32 packaging (5 x 5 x 0.8 mm)

Applications

Ideal for use in 3G wireless basestation receivers, WiMAX, power amplifier linearization, high IF sampling receivers, multi-carrier, multi-mode receivers, test and measurement equipment, communications test equipment, and radar systems

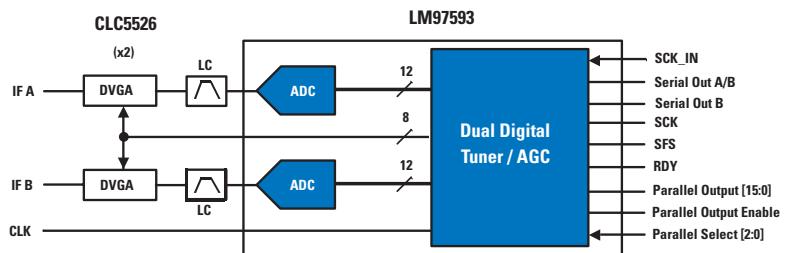


LM97593 – Integrated Dual ADC with Digital Downconverter and Automatic Gain Control for Communications Applications

Features

- 2-channel, 12-bit ADC
- 650 MHz input bandwidth allows direct IF sampling of inputs up to 300 MHz
- 83 dBFS SNR at $f_{IN}=250$ MHz, 200 kHz bandwidth
- 62 dBFS SNR at $f_{IN}=250$ MHz, Nyquist bandwidth
- 68 dBFS SFDR at $f_{IN}=250$ MHz, Nyquist bandwidth
- Digital downconverter composed of:
 - 4-stage CIC filter with programmable 8 to 2048 decimation ratio
 - 21-tap symmetric FIR filter providing decimation by 2
 - 63-tap symmetric FIR filter providing decimation by 2 or 4
- Integrated automatic gain control allows seamless integration with external DVGA
- Power consumption: 560 mW at 65 MSPS
- 3.3V analog supply, 1.8V digital
- Available in PQFP-128 packaging

Typical Application Circuit



Applications

Ideal for use in cellular basestations including GSM/GPRS/EDGE/GSM Phase 2 receivers, satellite receivers, wireless local loop receivers, digital communications, and wireless microphone mainframes

kSPS Low-Power A/D Converters

Deliver Excellent INL and ENOB in Small Pin- and Function-Compatible Packages

Single-Ended Input ADCs (1 to 8 Channels) from the PowerWise® Family

12-Bit ADC

- INL: ± 0.64 LSB
- ENOB: 11.7

10-Bit ADC

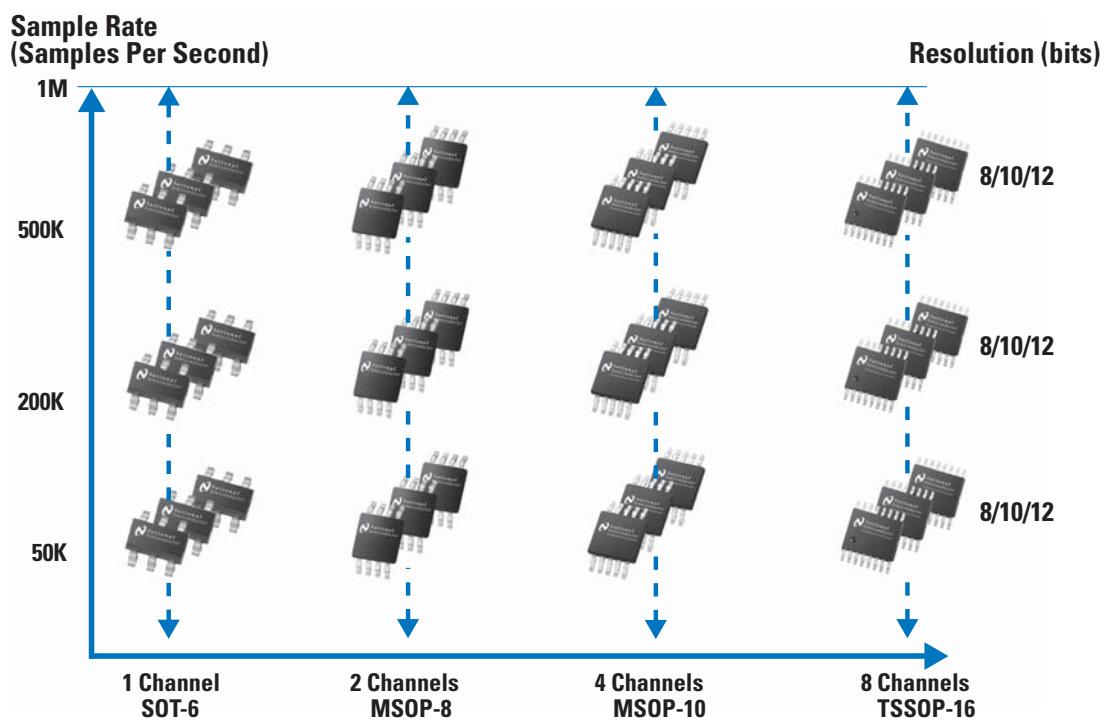
- INL: ± 0.2 LSB
- ENOB: 9.9

8-Bit ADC

- INL: ± 0.5 LSB
- ENOB: 7.8

Applications

Ideal for use in portable systems, medical instrumentation, factory automation/automatic test equipment, consumer products, mobile communications, instrumentation, and control systems



I²C Compliant 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)		INL (LSB)	Temp Range (°C)	Multi-Address	Alarm	Packaging
						3V	5V					
ADC081C021 E, W	8	1		5.5 to 189	2.7 to 5.5	0.26	0.78	± 0.2	-40 to 105	✓	✓	TSOT-6, MSOP-8
ADC101C021 E, W	10	1		5.5 to 189	2.7 to 5.5	0.26	0.78	± 0.5	-40 to 105	✓	✓	TSOT-6, MSOP-8
ADC121C021 E, W	12	1		5.56 to 189	2.7 to 5.5	0.26	0.78	± 0.5	-40 to 105	✓	✓	TSOT-6, MSOP-8
ADC081C027 E, W	8	1		5.5 to 189	2.7 to 5.5	0.26	0.78	± 0.5	-40 to 105	✓		TSOT-6
ADC101C027 E, W	10	1		5.5 to 189	2.7 to 5.5	0.26	0.78	± 0.5	-40 to 105	✓		TSOT-6
ADC121C027 E, W	12	1		5.56 to 189	2.7 to 5.5	0.26	0.78	± 0.5	-40 to 105	✓		TSOT-6
NEW! ADC128D818 E, W	12	8	—	0.01	3.0 to 5.5	2.01*	4.0*	$+2.2, -1.5$	-40 to 125	✓	✓	TSSOP-16

PowerWise® product

E Evaluation board

W WEBENCH enabled

* 3.6V, 5.5V

A/D Converters (ADCs)

SPI Interface, Single-Ended Input

SPI Interface, Single-Ended Input ADCs

Product ID	Pin/Function Comp. Family	Res. (bit)	Input Channels	Sample Rate Range (SPS)	INL (LSB)	ENOB (bit)	SINAD (dB)	Supply Voltage Range (V)	Temp Range (°C)	Packaging
ADC081S021 E,W		8	1	50K to 200K	+0.45; -0.3	7.9	49.5	2.7 to 5.25	-40 to 85	SOT23-6, LLP-6
ADC081S051 E,W		8	1	200K to 500K	+0.06; -0.04	7.9	49.5	2.7 to 5.25	-40 to 85	SOT23-6, LLP-6
ADC081S101 E,W		8	1	500K to 1M	±0.05	7.9	49.7	2.7 to 5.25	-40 to 85	SOT23-6, LLP-6
ADC101S021 E,W		10	1	50K to 200K	+0.14; -0.13	9.9	61.5	2.7 to 5.25	-40 to 85	SOT23-6, LLP-6
ADC101S101 E,W		10	1	500K to 1M	±0.2	9.9	61.7	2.7 to 5.25	-40 to 85	SOT23-6, LLP-6
ADC121S021 E,W		12	1	50K to 200K	+0.45; -0.4	11.7	72	2.7 to 5.25	-40 to 85	SOT23-6, LLP-6
ADC121S051 E,W		12	1	200K to 500K	+0.45; -0.4	11.6	72	2.7 to 5.25	-40 to 85	SOT23-6, LLP-6
ADC121S101 E,W		12	1	500K to 1M	±0.4	11.7	72	2.7 to 5.25	-40 to 125	SOT23-6, LLP-6
ADC101S051 E,W		10	1	200K to 500K	+0.15; -0.09	9.9	61.5	2.7 to 5.25	-40 to 85	SOT23-6, LLP-6
ADC082S021 E,W		8	2	50K to 200K	±0.04	7.9	49.6	2.7 to 5.25	-40 to 85	mini SOIC-8
ADC082S051 E,W		8	2	200K to 500K	+0.12; -0.06	7.9	49.5	2.7 to 5.25	-40 to 85	mini SOIC-8
ADC082S101 E,W		8	2	500K to 1M	±0.13	7.9	49.6	2.7 to 5.25	-40 to 85	mini SOIC-8
ADC102S021 E,W		10	2	50K to 200K	±0.13	9.9	61.8	2.7 to 5.25	-40 to 85	mini SOIC-8
ADC102S051 E,W		10	2	200K to 500K	+0.2; -0.1	10	61.7	2.7 to 5.25	-40 to 85	mini SOIC-8
ADC102S101 E,W		10	2	500K to 1M	+0.4; -0.1	9.9	61.6	2.7 to 5.25	-40 to 85	mini SOIC-8
ADC122S021 E,W		12	2	50K to 200K	±0.35	11.7	72	2.7 to 5.25	-40 to 85	mini SOIC-8
ADC122S051 E,W		12	2	200K to 500K	±0.5	11.7	72	2.7 to 5.25	-40 to 85	mini SOIC-8
ADC122S101 E,W		12	2	500K to 1M	±0.64	11.7	72	2.7 to 5.25	-40 to 85	mini SOIC-8
ADC084S021 E,W		8	4	50K to 200K	±0.04	7.9	49.6	2.7 to 5.25	-40 to 85	mini SOIC-10
ADC084S051 E,W		8	4	200K to 500K	+0.12; -0.06	7.9	49.5	2.7 to 5.25	-40 to 85	mini SOIC-10
ADC084S101 E,W		8	4	500K to 1M	±0.13	7.9	49.6	2.7 to 5.25	-40 to 85	mini SOIC-10
ADC104S021 E,W		10	4	50K to 200K	±0.13	9.9	61.8	2.7 to 5.25	-40 to 85	mini SOIC-10
ADC104S051 E,W		10	4	200K to 500K	+0.2; -0.1	10	61.7	2.7 to 5.25	-40 to 85	mini SOIC-10
ADC104S101 E,W		10	4	500K to 1M	+0.4; -0.1	9.9	61.6	2.7 to 5.25	-40 to 85	mini SOIC-10
ADC124S021 E,W		12	4	50K to 200K	±0.35	11.7	72	2.7 to 5.25	-40 to 85	mini SOIC-10
ADC124S051 E,W		12	4	200K to 500K	±0.5	11.7	72	2.7 to 5.25	-40 to 85	mini SOIC-10
ADC124S101 E,W		12	4	500K to 1M	±0.64	11.7	72	2.7 to 5.25	-40 to 85	mini SOIC-10
ADC088S022 E,W		8	8	50K to 200K	±0.04	7.9	49.5	2.7 to 5.25	-40 to 105	TSSOP-16
ADC088S052 E,W		8	8	200K to 500K	±0.05	7.9	49.6	2.7 to 5.25	-40 to 105	TSSOP-16
ADC088S102 E,W		8	8	500K to 1M	±0.05	7.9	49.6	2.7 to 5.25	-40 to 105	TSSOP-16
ADC108S022 E,W		10	8	50K to 200K	±0.10	10	61.8	2.7 to 5.25	-40 to 105	TSSOP-16
ADC108S052 E,W		10	8	200K to 500K	±0.10	10	61.8	2.7 to 5.25	-40 to 105	TSSOP-16
ADC108S102 E,W		10	8	500K to 1M	±0.2	10	61.8	2.7 to 5.25	-40 to 105	TSSOP-16
ADC128S022 E,W		12	8	50K to 200K	±0.4	11.8	73	2.7 to 5.25	-40 to 105	TSSOP-16
ADC128S052 E,W		12	8	200K to 500K	±0.4	11.8	73	2.7 to 5.25	-40 to 125	TSSOP-16
ADC128S102 E,W		12	8	500K to 1M	±0.5	11.8	73	2.7 to 5.25	-40 to 105	TSSOP-16

 PowerWise product

 Evaluation board

 WEBENCH® enabled

Differential-Input SPI A/D Converters

Product ID	Res (bits)	Inputs	Pin and Function Compatible	Speed Range (kSPS)	Supply Voltage Range(V)	Typ Power(mW)		Static Perform (Typ)		Typ ENOB (bits)	Temp Range (°C)	Packaging
						3V	5V	INL (LSB)	DNL (LSB)			
ADC121S625 E, W	12	1		50 to 200	4.5 to 5.5	—	2.25	- 0.5 / -0.3	±0.4	11.8	-40 to 85	MSOP-8
ADC121S655 E, W	12	1		200 to 500	4.5 to 5.5	—	9	±0.6	±0.4	11.7	-40 to 105	MSOP-8
ADC121S705 E, W	12	1		500 to 1000	4.5 to 5.5	—	11.5	±0.6	±0.4	11.7	-40 to 105	MSOP-8
ADC122S625 E, W	12	2		50 to 200	4.5 to 5.5	—	8.6	±1.0	±0.95	11.25	-40 to 105	MSOP-10
ADC122S655 E, W	12	2		200 to 500	4.5 to 5.5	—	25	±1.0	±0.95	11.25	-40 to 105	MSOP-10
ADC122S706 E, W	12	2		500 to 1000	4.5 to 5.5	20	25	±1	±0.95	11.25	-40 to 105	TSSOP-14
ADC141S626 E, W	14	1		50 to 250	2.7 to 5.5	2	4.8	±0.5	±0.5	13.7	-40 to 85	MSOP-10
ADC161S626 E, W	16	1		50 to 250	4.5 to 5.5	—	5.8	±0.8	±0.5/±0.8	14.3	-40 to 85	MSOP-10

8-/10-/12-/16-Bit DACs

Features

- Pin- and function-compatible 8-/10-/12-Bit DACs provide seamless upgradeability
- 2- and 4-channel family with smallest package outline in class (3 x 3 mm)
- Rail-to-rail output swing

Applications

Ideal for use in portable, battery-powered applications in industrial, medical, and consumer designs

Product ID	Res (bits)	# Mux Inputs	Pin and Function Comp. Family	Typ Settling Time (μs)	Supply Voltage Range (V)	Typ Current Consumption (μA)		Static Performance (Typ)		Reference	Packaging
						3V	5V	INL (LSB)	DNL (LSB)		
Single-Ended Input SPI Digital-to-Analog Converters											
DAC081S101 E	8	1		3	2.7 to 5.5	175	260	+0.16, -0.12	+0.04, -0.02	From supply	MSOP-8, TSOT-6
DAC101S101 E, A	10	1		5	2.7 to 5.5	175	260	±0.6	+0.15, -0.05	From supply	MSOP-8, TSOT-6
DAC121S101 E, A	12	1		8	2.7 to 5.5	175	260	±2.6	+0.25, -0.15	From supply	MSOP-8, TSOT-6
NEW! DAC161S055 E	16	1		5	2.7 to 5.5	620	750	±1	-1, +1.1	External	LLP-16
DAC082S085 E	8	2		3	2.7 to 5.5	210	320	±0.14	+0.04, -0.02	External	MSOP-10, LLP-10
DAC102S085 E	10	2		4.5	2.7 to 5.5	210	320	±0.7	+0.08, -0.03	External	MSOP-10, LLP-10
DAC122S085 E	12	2		6	2.7 to 5.5	210	320	±2.4	+0.2, -0.1	External	MSOP-10, LLP-10
DAC084S085 E	8	4		3	2.7 to 5.5	350	500	±0.14	+0.04, -0.02	External	MSOP-10, LLP-10
DAC104S085 E	10	4		4.5	2.7 to 5.5	350	500	±0.7	+0.08, -0.03	External	MSOP-10, LLP-10
DAC124S085 E	12	4		6	2.7 to 5.5	360	480	±2.4	+0.2, -0.1	External	MSOP-10, LLP-10
DAC088S085 E	8	8		3	2.7 to 5.5	650	970	±0.125	±0.03	Dual external	TSSOP-16, LLP-16
DAC108S085 E	10	8		4.5	2.7 to 5.5	650	970	±0.5	+0.08, -0.04	Dual external	TSSOP-16, LLP-16
DAC128S085 E	12	8		6	2.7 to 5.5	650	970	±2.0	+0.15, -0.09	Dual external	TSSOP-16, LLP-16
Single-Ended Input I^C Compliant Digital-to-Analog Converters											
DAC081C081 E	8	1		6	2.7 to 5.5	0.38	0.73	±0.1	±0.08	Supply	TSOT-6, LLP-6
DAC101C081 E	10	1		6	2.7 to 5.5	0.38	0.73	+0.21, -0.16	+0.25, -0.16	Supply	TSOT-6, LLP-6
DAC121C081 E	12	1		6	2.7 to 5.5	0.38	0.73	+2.2, -1.5	+0.18, -0.12	Supply	TSOT-6, LLP-6
DAC081C085 E	8	1		6	2.7 to 5.5	0.38	0.73	±0.1	±0.08	External	MSOP-8
DAC101C085 E	10	1		6	2.7 to 5.5	0.38	0.73	+0.21, -0.16	+0.25, -0.16	External	MSOP-8
DAC121C085 E	12	1		6	2.7 to 5.5	0.38	0.73	+2.2, -1.5	+0.18, -0.12	External	MSOP-8

Analog Front Ends (AFE)

LM98725 – 3-Channel, 16-Bit, 81 MSPS Analog Front End with LVDS/CMOS Output and Integrated CCD/CIS Sensor Timing Generator

Features

- LVDS/CMOS outputs
- LVDS/CMOS/Crystal clock source with PLL multiplication
- Integrated flexible spread-spectrum clock generation
- CDS or S/H processing for CCD or CIS sensors
- Independent gain/offset correction for each channel
- Automatic per-channel gain and offset calibration
- Programmable input clamp voltage
- Flexible CCD/CIS sensor timing generator
- Maximum input level selectable between 1.2V and 2.4V
- Input polarity selectable as + or – for use with CIS or CCD sensors
- Channel sampling rate: 30/30/27 MSPS in 3/2/1 channel mode
- INL: +17/-28 LSB (typ)
- Operating temperature: 0°C to 70°C

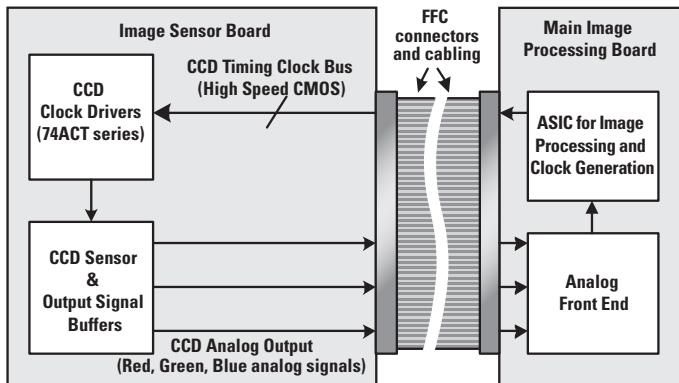
Applications

Ideal for use in multi-function peripherals, high-speed currency/check scanners, flatbed or handheld color scanners, and high-speed document scanners

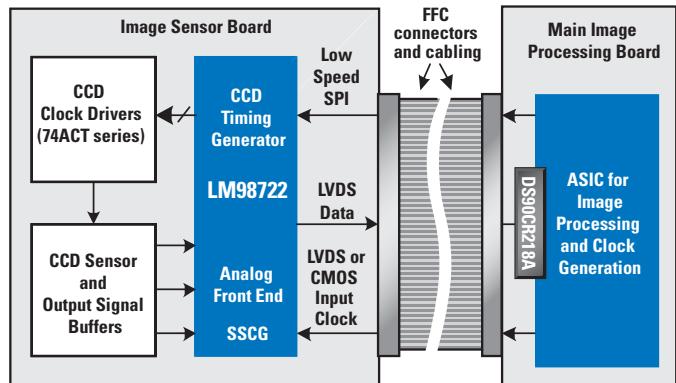
Analog Front End

Product ID	Input Channels	Sampling Rate (MSPS)	Resolution (bits)	Timing Generator	Output Type	PGA Gain (Min) (dB)	PGA Gain (Max) (dB)	DAC Offset Resolution (+/-) (bits)	DAC Offset Range (+/-) (mV)	Power Dissipation (W)
LM98519	6	65	10	—	CMOS	0	26	14	337	1.04
LM98620	6	70	10	—	LVDS	0	26	14	340	1.02
NEW! LM98640QML	2	5 to 40	14	—	LVDS	-3	18	8	250	0.356
LM98714	3	45	16	✓	Both LVDS, CMOS	-3	17.9	9	600	0.505
LM98725	3	81	16	✓	Both LVDS, CMOS	-4.2	18.4	9	307	0.755
LM98722	3	45	16	✓	Both LVDS, CMOS	-4.2	18.4	9	307	0.63

Legacy MFP Image Sensor Block Diagram

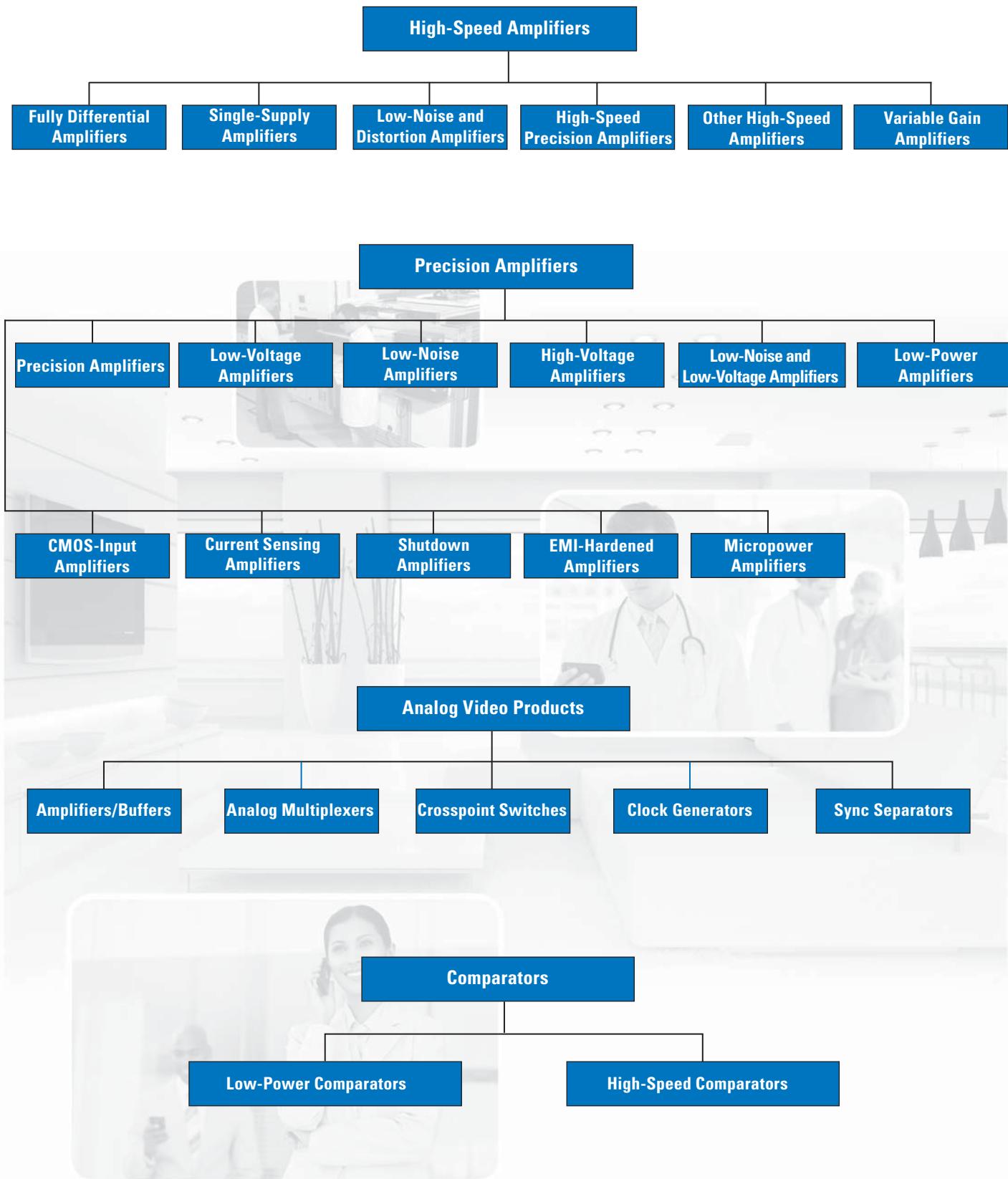


New MFP Image Sensor Block Diagram Partitioning



Read Analog Edge AN-1583. Topic:
“Simplifying CCD/CIS Image Capturing with a 3-Channel 16-Bit AFE/Timing Generator”
national.com/edge

Amplifier Product Portfolio

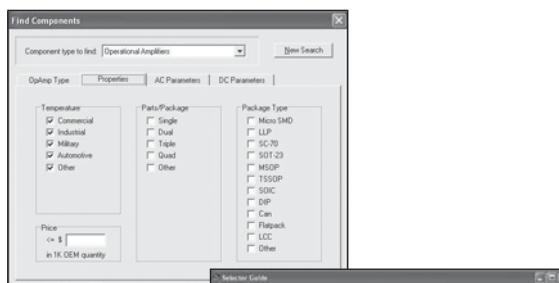


Amplifier Selection Tool

National's Amplifier Selection Tool

The Amplifier Selection Tool is a Windows software tool designed to guide the user in selecting our operational amplifiers, buffers, and comparators by enabling the user to enter in a few key parameters and have a list of devices meeting those parameters returned to them.

Set your parameters



Compare devices

Visit chosen product folder

Includes:

- Summary of key device parameters and pricing information
- Links to product folders for chosen devices (you must have a Web browser and live Internet connection to view the Web pages)

Installation of the software is simple. This selection tool does not add to or modify your system files at all and is completely self contained within one folder. It fits nicely in the corner of your desktop or notebook PC for easy future reference.

national.com/selguide

High-Speed Amplifiers

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

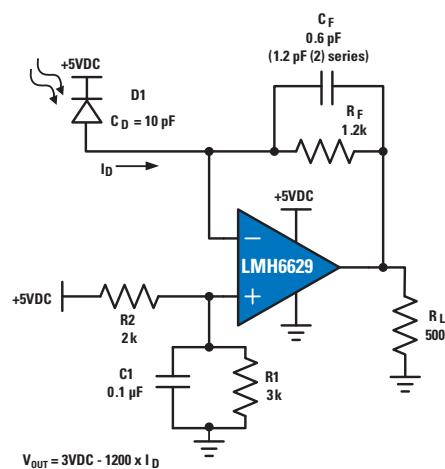
Features

- -3 dB bandwidth 900 MHz at a gain of 10V/V
- 0.69 nV/ $\sqrt{\text{Hz}}$ input voltage noise
- $\pm 780 \mu\text{V}$ input $V_{\text{OS-MAX}}$ at 25°C
- 1600 V/ μs slew rate and 15.5 mA supply current
- -90/-94 dBc (HD2/HD3) at $f = 1 \text{ MHz}$, 2V_{PP}
- 2.7V to 5.5V operation; selectable gain ≥ 4 or ≥ 10
- Available in SOT23-5 and LLP-8 packaging

Applications

Ideal for data acquisition, scopes, ultrasound imaging, active filters, lidar, and radar

Typical Application Circuit



LMH6554 – 2.5 GHz Ultra-Linear Fully-Differential Amplifier

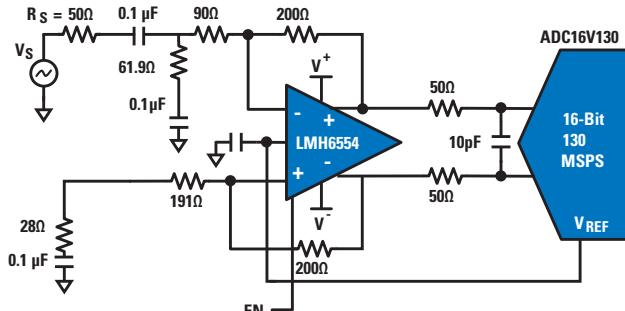
Features

- 2.5 GHz SSBW/1.8 LSBW at gain of 1
- 800 MHz 0.1 dB gain flatness
- -99 dBc IMD3 at $f = 150 \text{ MHz}$
- 72 dBc SFDR at $f = 250 \text{ MHz}$
- 0.9 nV/ $\sqrt{\text{Hz}}$ input noise voltage
- 11 pA/ $\sqrt{\text{Hz}}$ input noise current
- 4.7V to 5.3V operation
- Available in quad FCOL-14 packaging

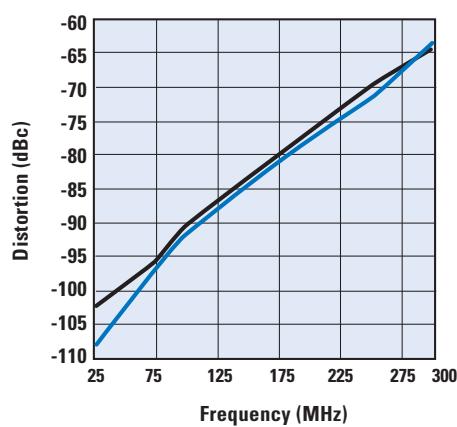
Applications

Ideal for single-ended to differential conversion driving 8- to 16-bit ADCs (including ADC16DV160 and National's GSPS ADCs), wireless basestations, oscilloscopes, spectral analyzers, automotive lidar, and military communications

AC Coupled, Single-to-Differential ADC Driver



Distortion vs Frequency Single-Ended Input



High-Speed Amplifiers

High-Speed Fully Differential Amplifiers

Product ID	Unity Gain BW (MHz) at AVCL (V/V)	Slew Rate (V/μs)	Supply Voltage Range (V)	Supply Current per Channel (mA)	Channels	Voltage Noise (nV/√Hz)	2nd/3rd HD (dBc)	Packaging
LMH6550 E	400 at 1	3000	5 to 12	20	1	6.0	-92/-103 at $V_{OUT} = 2 V_{PP}$, f = 5 MHz, RL = 800Ω	SOIC-8, MSOP-8
LMH6551 E	370 at 1	2400	3 to 12	12.5	1	6.0	-94/-96 at $V_{OUT} = 2 V_{PP}$, f = 5 MHz, RL = 800Ω	SOIC-8, MSOP-8
LMH6552 E	1500 at 1	3800	4.5 to 12	19	1	1.1	-92/-93 at $V_{OUT} = 2 V_{PP}$, f = 20 MHz, RL = 800Ω	SOIC-8, LLP-8
LMH6553 E	900 at 1	2300	4.5 to 12	29.5	1	1.1	-79/-90 at $V_{OUT} = 2 V_{PP}$, f = 20 MHz, RL = 800Ω	PSOP-8, LLP-8
LMH6554 E	2500 at 1	6200	4.7 to 5.3	52	1	0.9	-68/-70 at $V_{OUT} = 2 V_{PP}$, f = 250 MHz, RL = 200Ω	FCOL-14
LMH6555 E	1200 at 13.6 dB	1300	3 to 3.6	120	1	19	-60/-67 at $V_{OUT} = 0.8 V_{PP}$, f = 250 MHz, RL = 100Ω	LLP-16

 PowerWise® product  Evaluation board

High-Speed, Low-Noise and Distortion Amplifiers

Product ID	Unity Gain BW (MHz) at AVCL (V/V)	Slew Rate (V/μs)	Supply Voltage Range (V)	Supply Current/Channel (mA)	Channels	Voltage Noise (nV/√Hz)	Current Noise (pA/√Hz)	2nd/3rd HD (dBc)	Packaging
LMH6672 E, W	90 at 2	170	3 to 12	6.2	2	4.5	1.8	-90/-97 at $V_{OUT}=8.4 V_{PP}$, f=1 MHz, RL=100Ω	SOIC-8, PSOP-8
LMH6618/19 E, W	140 at 1	57	2.7 to 10/11	1.6/1.3	1/2	10	1.0	-102/-102 at $V_{OUT}=2 V_{PP}$, f=100 kHz, RL=1KΩ	TSOT-6/SOIC-8
LMH6622 E, W	160 at 2	80	5 to 12	4.3	2	1.6	1.5	-90/-94 at $V_{OUT}=2 V_{PP}$, f=1 MHz, RL=100Ω	SOIC-8
LMH6626 E, W	160 at 10	360	5 to 12	12	2	1.0	1.8	-63/-80 at $V_{OUT}=1 V_{PP}$, f=5 MHz, RL=100Ω	SOIC-8
LMH6624 E, W	180 at 10	400	5 to 12	12	1	0.92	2.3	-63/-80 at $V_{OUT}=1 V_{PP}$, f=5 MHz, RL=100Ω	SOIC-8, SOT23-5
LMH6628 E, W	300 at 1	550	5 to 12	9.0	2	2.0	2.0	-65/-74 at $V_{OUT}=1 V_{PP}$, f=10 MHz, RL=100Ω	SOIC-8
LMH6654/55 E, W	250 at 1	200	4.5 to 12	4.5	1/2	4.5	1.7	-80/-85 at $V_{OUT}=2 V_{PP}$, f=5 MHz, RL=100Ω	SOIC-8, SOT23-5
LMH6611/12 E, W	365 at 1	460	2.7 to 11	3.3/3.45	1/2	10	2.0	-83/-100 at $V_{OUT}=2 V_{PP}$, f=1 MHz, RL=150Ω	TSOT23-6/ SOIC-8
LMH6550 E	400 at 1	3000	5 to 12	20	1	6.0	1.5	-92/-103 at $V_{OUT}=2 V_{PP}$, f=5 MHz, RL=800Ω	SOIC-8
 LMH6629 E, W	900 at 10	1600	2.7 to 5.5	15.5	1	0.69	2.6	-84/-92 at $V_{OUT}=1 V_{PP}$, f=1 MHz, RL=100Ω	LLP-8, SOT23-5
	750 at 1	3300	10 to 12	10.5	3	2.2	3.0 (non-inverting)	-80/-90 at $V_{OUT}=2 V_{PP}$, f=5 MHz, RL=100Ω	SSOP-16
LMH6738 E	1500 at 1	3800	4.5 to 12	19	1	1.1	19.5	-92/-93 at $V_{OUT}=2 V_{PP}$, f=20 MHz, RL=800Ω	SOIC-8, LLP-8
LMH6702 E, W	1700 at 2	3100	10 to 12	12.5	1	1.83	3.0 (non-inverting)	-100/-96 at $V_{OUT}=2 V_{PP}$, f=5 MHz, RL=100Ω	SOIC-8, SOT23-5
LMH6703 E	1200 at 2	4200	8 to 12	11	1	2.3	3.0 (non-inverting)	-87/-100 at $V_{OUT}=2 V_{PP}$, f=5 MHz, RL=100Ω	SOIC-8, SOT23-6
LMH6554	2500 at 1	6200	4.7 to 5.3	52	1	0.9	11	-68/-70 at $V_{OUT}=2 V_{PP}$, f=250 MHz, RL=200Ω	LLP-14

 PowerWise® product

 Evaluation board

 WEBENCH enabled

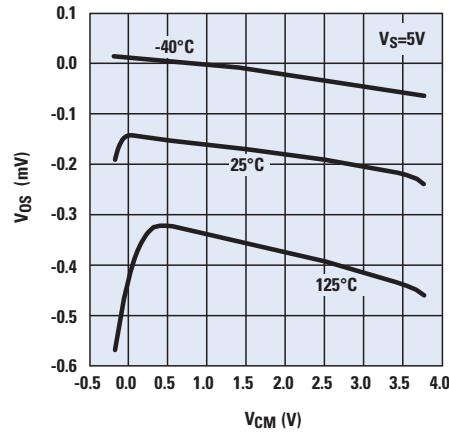
LMH6611/12 – 345 MHz Rail-to-Rail Output Single/Dual Amplifiers

Features

- 345 MHz small signal gain of 1 bandwidth
- 85 MHz large signal gain in 2 bandwidth
- 1 mV max input voltage offset over full temp on LMH6611 (1.3 mV for LMH6612)
- 102 dBc SFDR at 100 kHz
- 3.2 mA/ch supply current at $V_{CC} = 5V$
- -40°C to +125°C operating temperature range

Applications

Ideal for use in ADC and DAC buffering, high-speed filter design, and 1080i and 720p video amps



High-Speed Single-Supply Optimized Amplifiers

Product ID	Unity Gain BW (MHz) at AVCL (V/V)	Slew Rate (V/ μ s)	Supply Voltage Range (V)	Supply Current per Channel (mA)	Channels	Voltage Noise (nV/ $\sqrt{\text{Hz}}$)	Packaging
Low-Power, Rail-to-Rail Input and Output Amplifiers							
LMH6645/46/47 E,W	55 at 1	22	2.5 to 12	0.725	1/2/4	17	SOIC-8, SOT23-5
LMH6618/19 E,W	140 at 1	57	2.7 to 11	1.35	1/2	10	TSOT-6, SOIC-8
Low-Power, Rail-to-Rail Output Amplifiers							
LMH6642/43 E,W	130 at 1	135	2.7 to 12.8	2.7	1/2	17	SOIC-8, SOT23-5/SOIC-8
LMH6644 E,W	130 at 1	135	2.7 to 12.8	2.7	4	17	SOIC-14, TSSOP-14
LMH6601 E,W	250 at 1	275	2.4 to 5.5	9.6	1	7.0	SC70-6
LMH6611/12 E,W	365 at 1	460	2.7 to 11	3.3/3.45	1/2	10	TSOT-6/SOIC-8

PowerWise® product

Evaluation board

WEBENCH enabled

High-Speed Precision (Offset Voltage $\leq 0.8 \text{ mV}$)

Product ID	Channels	Offset Voltage Max, 25°C (mV)	TCVOS ($\mu\text{V}/^\circ\text{C}$)	CMRR (dB)	PSRR (dB)	Voltage Noise nV/ $\sqrt{\text{Hz}}$	-3 dB SSBW (MHz)	AVCL for -3 dB SSBW (V/V)	Slew Rate (V/ μ s)	Supply Voltage Range (V)	Packaging
LMH6611 E,W	1	0.6	0.1	98	96	10	365	1.0	460	2.7 to 11	TSOT-6
LMH6612 E,W	2	0.75	0.1	98	96	10	365	1.0	460	2.7 to 11	TSOT-6
LMH6618 E,W	1	0.6	0.8	98	104	10	140	1.0	57	2.7 to 11	TSOT-6
LMH6619 E,W	2	0.6	0.8	98	104	10	140	1.0	57	2.7 to 11	SOIC-8
LMH6624 E,W	1	0.5	0.2	95	88	0.92	180	10	400	5 to 12	SOIC-8, SOT23-5
LMH6626 E,W	2	0.5	0.2	95	88	1.0	160	10	360	5 to 12	SOIC-8
LMH6629 E	1	0.78	1	87	83	0.69	900	10	1600	2.7 to 5.5	LLP-8, SOT23-5

PowerWise® product

Evaluation board

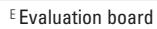
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High-Speed Amplifiers

High-Speed Amplifiers (Unity Gain Bandwidth >50 MHz)

Product ID	Unity Gain BW (MHz) at A_{VCL} (V/V)	Slew Rate (V/ μ s)	Supply Voltage Range (V)	Supply Current/Channel (mA)	Channels	Offset Voltage Max, 25°C (mV)	Voltage Noise (nV/ $\sqrt{\text{Hz}}$)	Packaging
LMH6645 E, W	55 at 1	22	2.5 to 12	0.725	1	3.0	17	SOIC-8, SOT23-5
LMH6646 E, W	55 at 1	22	2.5 to 12	0.725	2	3.0	17	SOIC-8
LMH6647 E, W	55 at 1	22	2.5 to 12	0.725	1	3.0	17	SOIC-8, SOT23-6
LMH6672 E, W	90 at 2	170	3 to 12	6.2	2	5.5	4.5	SOIC-8, PSOP-8
LMH6642 E, W	130 at 1	135	2.7 to 12.8	2.7	1	5.0	17	SOIC-8, SOT23-5
LMH6643 E, W	130 at 1	135	2.7 to 12.8	2.7	2	5.0	17	SOIC-8
LMH6644 E, W	130 at 1	135	2.7 to 12.8	2.7	4	5.0	17	SOIC-14, TSSOP-14
LMH6619 E, W	140 at 1	57	2.7 to 11	1.3	2	0.6	10	SOIC-8
LMH6618 E, W	140 at 1	57	2.7 to 10	1.6	1	0.6	10	TSOT-6
LMH6622 E, W	160 at 2	80	5 to 12	4.3	2	1.2	1.6	SOIC-8
LMH6626 E, W	160 at 10	360	5 to 12	12	2	0.5	1	SOIC-8
LMH6640	190 at 1	170	4.5 to 16	4.0	1	1.0	15	SOT23-5
LMH6682 E	190 at 2	940	3 to 12	6.5	2	5.0	12	SOIC-8
LMH6639	228 at 1	172	3 to 12	3.6	1	5.0	12	SOIC-8, SOT23-6
LMH6601 E, W	250 at 1	275	2.4 to 5.5	9.6	1	2.4	10	SC70-6
LMH6654 E	250 at 1	200	4.5 to 12	4.5	1	3.0	4.5	SOIC-8, SOT23-5
LMH6655 E	250 at 1	200	4.5 to 12	4.5	2	3.0	4.5	SOIC-8
LMH6657 E	270 at 1	700	3 to 12	6.0	1	5.0	11	SC70-5, SOT23-5
LMH6658 E	270 at 1	700	3 to 12	6.0	2	5.0	11	SOIC-8
LMH6628 E, W	300 at 1	550	5 to 12	9.0	2	2.0	2	SOIC-8
LMH6611 E, W	365 at 1	460	2.7 to 11	3.3	1	0.6	10	TSOT23-6
LMH6612 E, W	365 at 1	460	2.7 to 11	3.45	2	0.75	10	SOIC-8
LMH6551 E	370 at 1	2400	3 to 12	12.5	1	5.0	6	SOIC-8
LMH6723 E	370 at 1	600	5 to 12	1.0	1	3.0	4.3	SOIC-8, SOT23-5
LMH6724 E	370 at 1	600	5 to 12	1.0	2	3.0	4.3	SOIC-8
LMH6725 E	370 at 1	600	5 to 12	1.0	4	3.0	4.3	SOIC-14, TSSOP-14
LMH6550 E	400 at 1	3000	5 to 12	20	1	5.0	6	SOIC-8
LMH6722 E	400 at 2	1800	10 to 12	5.6	4	6.0	3.4	SOIC-14, TSSOP-14
LMH6714/20 E	400 at 2	1800	10 to 12	5.6	1	6.0	3.4	SOIC-8, SOT23-5
LMH6715 E, W	480 at 2	1300	10 to 12	5.0	2	6.0	3.4	SOIC-8
LMH6732 E	540 at 2	2700	9 to 12	9.0	1	8.0	2.5	SOIC-8, SOT23-6
LMH6738 E	750 at 1	3300	10 to 12	10.5	3	2.5	2.2	SSOP-16
LMH6553 E	900 at 1	2300	4.5 to 12	29.5	1	—	1.1	PSOP-8, LLP-8
LMH6609 E	900 at 1	1400	6 to 12	7.0	1	2.5	3.1	SOIC-8, SOT23-5
LMH6629 E	900 at 10	1600	2.7 to 5.5	15.5	1	0.78	0.69	LLP-8, SOT23-5
LMH6733 E, W	1000 at 1	3750	3 to 12	6.5	3	2.2	2.1	SSOP-16
LMH6703 E	1200 at 2	4200	8 to 12	11	1	7.0	2.3	SOIC-8, SOT23-6
LMH6552 E	1500 at 1	3800	4.5 to 12	19	1	—	1.1	SOIC-8, LLP-8
LMH6624 E, W	1500 at 10	400	5 to 12	12	1	0.5	0.92	SOIC-8, SOT23-5
LMH6702 E, W	1700 at 2	3100	10 to 12	12.5	1	4.5	1.83	SOIC-8, SOT23-5
LMH6554	2500 at 1	6200	4.7 to 5.3	52	1	—	0.9	FCOL-14

 PowerWise® product

 Evaluation board

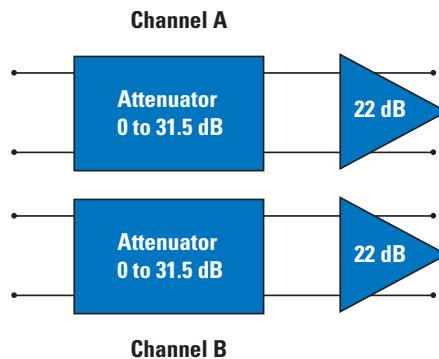
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High-Speed Variable Gain Amplifiers

LMH6517 – Low-Noise High-Linearity Digital Variable Gain Amplifier

Features

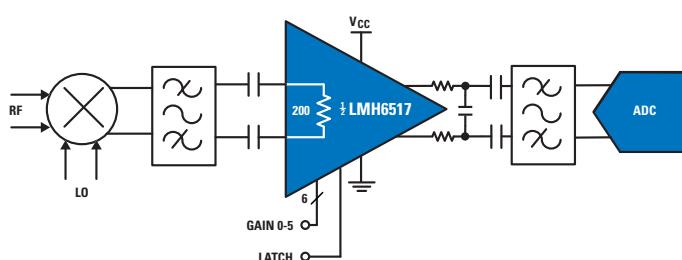
- 1.2 GHz bandwidth
- 45 dBm OIP3
- 65 dBm OIP2
- 22 dB maximum gain
- 31.5 dB in 0.5 dB gain adjustment
- 6 dB noise figure (at maximum gain)
- 1.1 nV/ $\sqrt{\text{Hz}}$ input noise voltage
- 80 mA/channel current at 5V supply
- Reference board available with ADC16DV160 and LMK04031B
- Ideal match for 14- and 16-bit ADCs such as ADC16DV160
- Available in small LLP-32 packaging (5 x 5 mm)



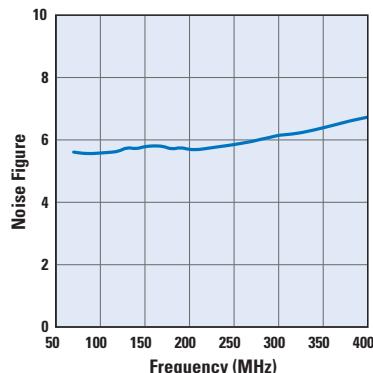
Applications

Ideal for cellular base stations, repeaters, point-to-point RF, microwave link, microwave backhaul, repeaters, and test and measurement

Typical Application Circuit



Noise Figure vs Frequency



High-Speed Variable Gain Amplifiers

Product ID	Gain Control	-3dB Bandwidth (MHz)	Gain Adj Range (dB)	Gain Step Size (dB)	Supply Voltage Range (V)	Supply Current/Channel (mA)	Channels	Voltage Noise (nV/ $\sqrt{\text{Hz}}$)	Configuration (input/ output)	2nd/3rd HD (dB)	Packaging
LMH6502 E	Analog	130	72	—	5 to 12	27	1	7.7	Diff/single	HD2/HD3= -55/ -57 (2 V _{P-P} , 20 MHz)	SOIC-14, TSSOP-14
LMH6503 E	Analog	135	70	—	5 to 12	37	1	6.6	Diff/single	HD2/HD3= -60/ -61 (2 V _{P-P} , 20 MHz)	SOIC-14, TSSOP-14
LMH6505 E	Analog	150	80	—	7 to 12	11	1	4.4	Single/single	HD2/HD3= -47/ -61 (2 V _{P-P} , 20 MHz)	SOIC-8, MSOP-8
LMH6514 E	Digital	600	42	6	4 to 5.25	107	1	1.8	Diff/diff	OIP3= 40 dBm at 70 MHz	LLP-16
LMH6515	Digital	600	31	1	4 to 5.25	107	1	1.8	Diff/diff	OIP3= 40 dBm at 70 MHz	LLP-16
LMH6517 E	Digital	1200	31.5	0.5	4.5 to 5.25	80	2	1.1	Diff/diff	OIP3= 45 dBm at 200 MHz	LLP-32
LMH6518 E	Digital	900	40	2/8.5m	4.75 to 5.25	210/150	1	0.98	Diff/diff	HD2/HD3= -50/ -53 all gains, 100 MHz	LLP-16

PowerWise® product

Evaluation board

Analog Video Products

Sync Separators

Product ID	Type	Features	Supported Video Formats	Inputs	Outputs	Spec Supply Range (V)	Packaging
LMH1981	50% slicing	Auto-video format detection, 50% sync slicing, low H sync jitter	NTSC, PAL, SECAM, 480i/p, 576i/p, 720p, 1080i/p	0.5 to 2.0 V _{p-p}	H sync, V sync, C sync, odd/even, burst/clamp, video format	3.3 to 5	TSSOP-14
LMH1980	70 mV fixed	Auto-video format detection	NTSC, PAL, SECAM, 480i/p, 576i/p, 720p, 1080i/p, PC Sync on Green	0.5 to 2.0 V _{p-p}	H sync, V sync, C sync, odd/even, burst/clamp, HD detect flag	3.3 to 5	MSOP-10

Clock Generators

Product ID	Features	Number of Inputs	Inputs Reference	Number of Outputs	Output Clock Frequencies (MHz)	Supply (V)	Packaging
LMH1982	Simultaneous SD and 3G/HD clock outputs, exceeds SMPTE jitter spec, Genlock and free-run modes, programmable output top-of-frame pulse generator	2	H/V sync, and/or 27 MHz	2	SD: Clock 27 or 67.5 MHz 3G/HD Clock: 74.25, 74.25/1.001, 148.5 or 148.5/1.001 MHz	3.3 and 2.5	LLP-32
LMH1983 E	Simultaneous SD, dual 3G/HD and audio clock outputs, low output jitter, Genlock and free-run modes	1	H/V sync and/or 27 MHz	4	CLK 1: 13.5 or 27 MHz CLK2 and 3: 27, 74.25, 74.25/1.001, 148.5 or 148.5/1.001 MHz CLK4: 98.304/2 ⁿ (n=0 to 15)	3.3	LLP-40

E Evaluation board

LMH1981 Lowest Jitter Sync Separator for HD Video Formats Featuring 50% Sync Slicing

Features

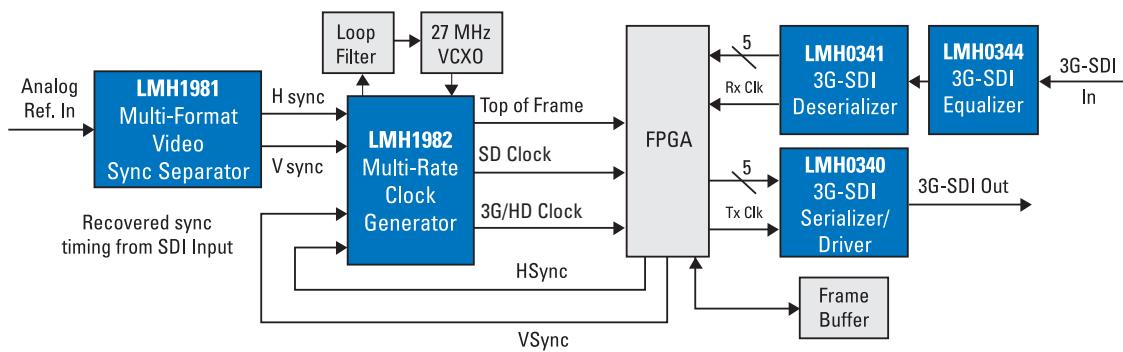
- 50% sync slicing
- Low-jitter horizontal sync outputs
- Supports NTSC, PAL, SECAM, 480i/p, 576i/p, 720p, 1080i/p
- Accepts video signals from 0.5 V_{p-p} to 2.0 V_{p-p}
- No external programming with µC required
- Horizontal sync output propagation delay < 50 ns
- 3.3V or 5V single supply operation
- 31 mW typical power dissipation

LMH1982 – 3G/HD/SD Video Clock Generator with Genlock

Features

- Two reference ports for genlocking the outputs
 - H and V sync inputs for NTSC/525i, PAL/625i, 525p, 625p, 720p, 1080i, 1080p video timing
- Simultaneous SD and 3G/HD LVDS-compatible clock outputs
- Achieves low jitter output clocks capable of directly driving FPGA serializers with no additional clock cleansing required
- Genlock or free run mode operation
- Programmable output top-of-frame pulse
- Supports cross locking

Genlock and Video Timing Interface



LMH6583 – Industry's Fastest Analog Crosspoint Switches for High-Resolution Video Applications

Features

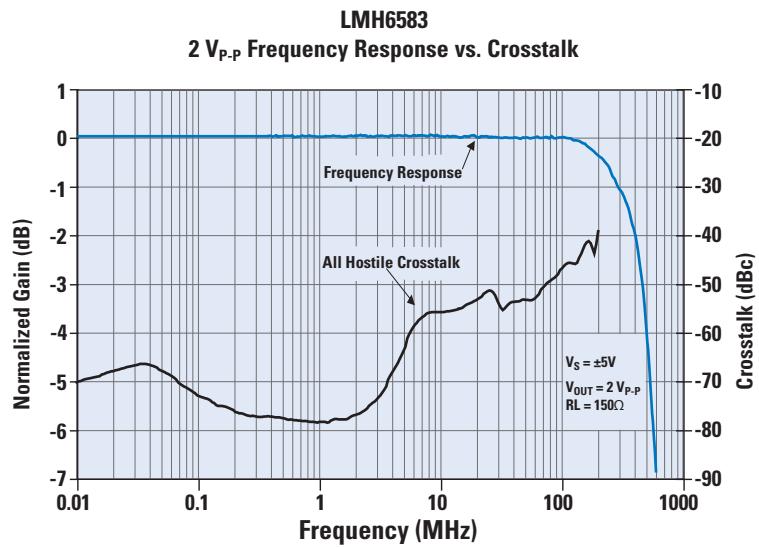
- 550 MHz, -3 dB bandwidth
- Fast slew rate: 1900 V/ μ s
- 100 MHz, 0.1 dB gain flatness
- Low crosstalk:
 - -70 dBc at 10 MHz (channel-to-channel)
 - -45 dBc at 100 MHz (all hostile)
- Gain of 2
- Diagonally symmetrical pin configuration
- Ease of control: 4-pin serial interface
- Available in eTQFP-64 packaging

Expansion Options

- One-chip solution:
16 inputs, 8 outputs
- Two-chip solution:
16 inputs, 16 outputs or 32 inputs, 8 outputs

Applications

Ideal for use in conference room systems, Keyboard, Video, and Mouse (KVM) systems, security and surveillance systems, multimedia video systems, and professional A/V systems



Product ID	Channels	Key Features	SSBW (MHz)	Slew Rate (V/ μ s)	Crosstalk Rejection (dB)	Settling Time	Diff. G/P %/deg. into RL=150Ω	2nd/3rd HD into RL=100Ω (dBc)	IOUT (mA) (typ.)	Temp. Range (°C)	Supply Range (V)	Packaging
High-Performance Crosspoint Switch												
LMH6585 E	32 x 16	2x gain, serial prog.	400	1200	-43 at 100 MHz	15 ns 2V step at 0.5%	0.04/0.03 at 3.58 MHz and 4.43 MHz	-70 at 10 MHz/-75 at 10 MHz	±45	-40 to 85	±3.0 to ±5.5	TQFP-144
LMH6583 E	16 x 8	2x gain, serial prog.	550	1900	-70/-45 at 10 MHz/100 MHz	18 ns 2V step at 0.1%	0.04/0.04 at 3.58 MHz and 4.43 MHz	-74 at 20 MHz/-77 at 5 MHz	±60	-40 to 85	±3.0 to ±5.5	eTQFP-64
LMH6580 E	8 x 4	1x gain, serial prog.	450	1200	-45	6 ns	0.05/0.05 at 3.58 MHz and 4.43 MHz	-80 at 5 MHz/-70 at 5 MHz	±70	-40 to 85	±3.0 to ±5.5	TQFP-48

Product ID	Channels	Features	SSBW (MHz)	LSBW (MHz)	Crosstalk Rejection (dB)	Diff. G/P %/deg. into RL=150Ω	Temp. Range (°C)	Spec. Supply (V)	Packaging
Composite Video Crosspoint Switch									
LMH6586 E	32 x 16	Video clamps, loss of video det., I ² C compliant prog.	66	29	-58 db at 6 MHz	0.05/0.05 at 3.58 MHz	-40 to 85	5	TQFP-80

E Evaluation board

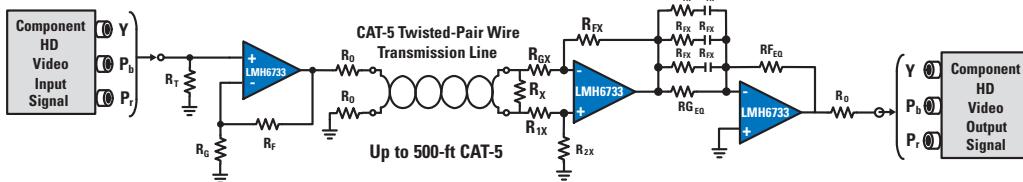
Analog Video Products

LMH6733 – Triple Amplifier with Industry's Best Bandwidth-to-Power Ratio

Features

- 1.0 GHz -3 dB small signal bandwidth ($A_V = +1, V_S = \pm 5V$)
- 600 MHz -3 dB large signal bandwidth ($A_V = +2, V_S = \pm 5V$)
- 350 MHz 0.1 dB gain flatness
- -80 dB crosstalk at 10 MHz
- 5.5 mA/channel supply current
- Single supply operation: 3V to 12V

LMH6733 Typical Application



Analog Multiplexers

Product ID	SSBW (MHz)	Mux Ratio	Channels	Switching Speed (ns)	Crosstalk Rejection (dB)	Settling Time (ns)	Tsettling Conditions	2nd/3rd HD (dB)	Supply Voltage Range (V)	Temperature Range (°C)	Packaging
LMH6570	500	2:1	1	8	70	17	to 0.05%	-68/-84	± 3.3 to ± 6.0	-40 to 85	SOIC-8
LMH6572	350	2:1	3	10	90	17	to 0.05%	-78/-75	± 3.3 to ± 6.0	-40 to 85	SSOP-16
LMH6574	500	4:1	1	8	85	17	to 0.05%	-68/-84	± 3.3 to ± 6.0	-40 to 85	SOIC-14

Video Amplifiers/Buffers

Product ID	Unity Gain BW (MHz) at A_{VCL} (V/V)	Differential Gain (dB)	Differential Phase (%)	-3 dB LSBW at $A=2$ (MHz)	Slew Rate (V/ μ s)	Supply Voltage Range (V)	Supply Current Per Channel (mA)	Channels	Voltage Noise nV/ \sqrt{Hz}	Packaging
LMH6321 E	110 at 1	—	—	—	1800	5.0 to 30	10	1	2.8	PSOP-8, T0263-7
LMH6559	1750 at 1	0.06	0.02	—	4580	3.0 to 10	10	1	2.8	SOIC-8, SOT23-5
LMH6702 E, W	1700 at 2	0.024	0.004	720	3100	10 to 12	12.5	1	1.83	SOIC-8, SOT23-5
LMH6703 E	1800 at 1	0.01	0.02	750	4200	8.0 to 12	11	1	2.3	SOIC-8, SOT23-6
LMH6704 E	650 at 1	0.01	0.02	400	3000	8.0 to 12	11.5	1	2.3	SOIC-8, SOT23-6
LMH6733 E, W	1000 at 1	0.03	0.03	600	3750	3.0 to 12	6.5	3	2.1	SSOP-16
LMH6738 E	750 at 1	0.02	0.01	750	3300	10 to 12	10.5	3	2.2	SSOP-16
LMH6739 E	750 at 1	0.02	0.01	400	3300	8.0 to 12	10.6	3	2.3	SSOP-16
LMH6611 E, W	365 at 1	0.05	0.05	87	460	2.7 to 11	3.3	1	10	TSOT23-6
LMH6612 E, W	365 at 1	0.05	0.05	87	460	2.7 to 11	3.45	2	10	SOIC-8
LMH6601 E, W	250 at 1	0.25	0.25	81	275	2.4 to 5.5	9.6	1	10	SC70-6
LMH6657 E, W	270 at 1	0.03	0.1	100	700	3.0 to 12	6.0	1	11	SC70-5, SOT23-5
LMH6658 E, W	270 at 1	0.03	0.1	100	700	3.0 to 12	6.0	2	11	SOIC-8, Mini SOIC-8
LMH6682 E	180 at 2	0.01	0.08	110	940	3.0 to 12	6.5	2	12	SOIC-8, Mini SOIC-8
LMH6683 E, W	190 at 2	0.01	0.08	110	940	3.0 to 12	6.5	3	12	SOIC-14, TSSOP-14

PowerWise® product

E Evaluation board

WEBENCH enabled

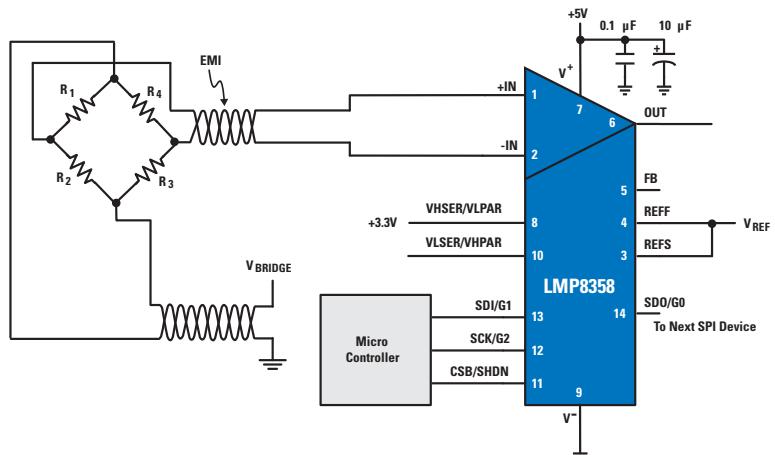
Operational Amplifiers

Instrumentation and Precision Level Shifter

LMP8358 – Industry's First Zero-Drift, Programmable Instrumentation Amplifier with On-Chip Diagnostics

Features

- $V_{OS} < 10 \mu\text{V}$, CMRR > 125 dB
- Programmable gain: 10x, 20x, 50x, 100x, 200x, 500x, 1000x
- Optional filtering
- Input fault detection to detect shorted, open, and degraded source connections
- On-chip EMI filter for RF rejection
- Below-ground sensing
- Available in SOIC-14 and TSSOP-14 packaging



Applications

Ideal for bridge sensor and thermocouple amplifiers, portable and medical instrumentation, and precision low-side current sensing

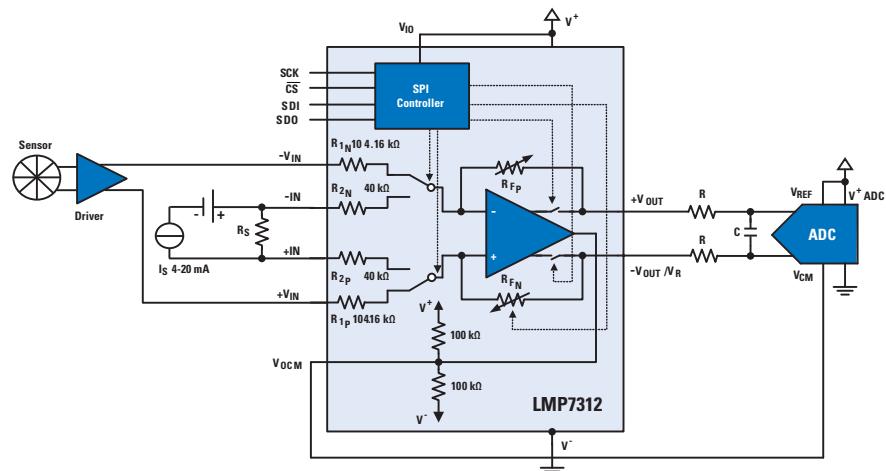
Instrumentation Amplifier

Product ID	Offset Voltage, Max, 25°C (mV)	TCVOS (µV/°C)	CMRR (dB)	PSRR (dB)	Avol (dB)	Voltage Noise (nV/√Hz)	Channels	Max Input Bias Current (nA)	Supply Current Per Channel (mA)	Supply Voltage Range (V)	Packaging
LMP8358	0.01	0.05	142	138	—	25	1	1.2	1.8	2.7 to 5.5	SOIC-14, TSSOP-14

LMP7312 – Precision SPI-Programmable Analog Front End (AFE)

Features

- Wide input voltage range of $\pm 15\text{V}$
- Current loops of 0 mA to 20 mA
- Bus programmability eliminates manual selection and wiring of input ranges
- Single-ended/differential output
- Input offset null switch
- Available in SOIC-14 packaging



Applications

Ideal for I/O modules, motor control, remote sensing, programmable automation control, and signal conditioning AFE

Precision Level Shifter

Product ID	Offset Voltage, Max, 25°C (mV)	TCVOS (µV/°C)	CMRR (dB)	PSRR (dB)	Avol (dB)	Voltage Noise (nV/√Hz)	Channels	Supply Current Per Channel (mA)	Supply Voltage Range (V)	Packaging
LMP7312	0.1	1.5	80	90	—	7.25	1	2	4.5 to 5.5	SOIC-14

Precision Amplifiers

LMP2021/22 – Single/Dual, Zero-Drift, Low-Noise, EMI-Hardened Op Amp

Features

- 5 μ V low guaranteed V_{OS}
- TCVOS guaranteed: 20 nV/ $^{\circ}$ C (max)
- Low noise with no 1/f, 11 nV/ \sqrt{Hz} at 1000V/V
- High CMRR (139 dB) and PSRR (130 dB)
- High Avol 160 dB
- 5 MHz wide gain bandwidth product
- 2.6 V/ μ s high slew rate
- 1.10 mA low supply current
- Available in SOIC-8, SOT23-5, and MSOP-8 packaging

Applications

Ideal for use in medical, industrial, test and measurement, scales and weigh stations, PC, automotive, and telecommunications

Precision Operational Amplifiers (Offset Voltage <0.5 mV)

Product ID	Avol (dB)	Offset Voltage Max, 25 $^{\circ}$ C (mV)	TCVOS (μ V/ $^{\circ}$ C)	CMRR (dB)	PSRR (dB)	Voltage Noise (nV/ \sqrt{Hz}) @kHz	Channels	Supply Current Per Channel (mA)	Supply Range (V)	Packaging
LMP2015 ^W	130	0.005	0.015	130	120	35	1	0.93	2.7 to 5.25	SOIC-8, SOT23-5
LMP2016 ^W	130	0.005	0.015	130	120	35	2	0.93	2.7 to 5.25	SOIC-8, MSOP-8
LMP2021 ^{E, W}	160	0.005	0.020 (max)	139	130	11 (Av = 1000V/V)	1	1.1	2.2 to 5.5	SOIC-8, SOT23-5
LMP2022 ^W	160	0.005	0.020 (max)	139	130	11 (Av = 1000V/V)	2	1.1	2.2 to 5.5	SOIC-8, MSOP-8
LMP2011 ^W	130	0.025	0.015	130	120	35	1	0.93	2.7 to 5.25	SOIC-8, SOT23-5
LMP2014 ^W	130	0.025	0.015	130	120	35	4	0.93	2.7 to 5.25	TSSOP-14
LMP2012 ^W	130	0.025	0.015	130	120	35	2	0.93	2.7 to 5	SOIC-8, MSOP-8
LMP7731/32 ^W 	130	0.04	0.5	120	129	2.9	1/2	2.2	2.5 to 5	SOT23-5, SOIC-8
LMP2231/32 ^{E, W} 	120	0.15	0.4/0.5 (max)	97	120	60	1/2	0.01	1.6 to 5.5	SOIC-8, SOT23-5
LMP2234 ^{E, W} 	120	0.15	0.3	97	120	60	4	0.009	1.6 to 5.5	SOIC-14, TSSOP-14
LMP7711 ^W 	110	0.15	1.0	100	100	5.8	1	1.15	1.8 to 5.5	TSOT-6
LMP7712 ^W 	95	0.15	1.75	100	100	5.8	2	1.3	1.8 to 5.5	MSOP-10
LMP7715 ^W 	110	0.15	1.0	100	98	5.8	1	1.15	1.8 to 5.5	SOT23-5
LMP7716 ^W 	110	0.15	1.8	100	98	5.8	2	1.3	1.8 to 5.5	MSOP-8
LMP7717 ^W 	110	0.15	1.0	100	98	5.8	1	1.15	1.8 to 5.5	SOIC-8, SOT23-5
LMP7718 ^{E, W} 	110	0.15	1.8	100	95	5.8	2	1.3	1.8 to 5.5	SOIC-8, MSOP-8
LMP7721 ^{E, W} 	111	0.15	1.5	100	96	6.5	1	1.3	1.8 to 5.5	SOIC-8
LMP7701 ^W	119	0.2	1.0	130	100	9.0	1	0.715	2.7 to 12	SOIC-8, SOT23-5
LMP7707 ^W 	119	0.2	1.0	138	98	9.0	1	0.715	2.7 to 12	SOT23-5
LMP7708 ^{E, W} 	119	0.22	1.0	138	98	9.0	2	0.715	2.7 to 12	MSOP-8
LMP7709 ^W 	119	0.22	1.0	138	98	9.0	4	0.715	2.7 to 12	TSSOP-14
LMP7702 ^W	119	0.22	1.0	130	100	9.0	2	0.75	2.7 to 12	SOIC-8, MSOP-8
LMP7704 ^W	119	0.22	1.0	130	100	9.0	4	0.725	2.7 to 12	TSSOP-14
LMV841 ^E	133	0.5	0.35	112	108	20	1	1.0	2.7 to 12	SC70-5
LMV842	133	0.5	0.35	112	108	20	2	1.0	2.7 to 12	MSOP-8, SOIC-8
LMV844	133	0.5	0.35	112	108	20	2	1.0	2.7 to 12	TSSOP-14, SOIC-14

 PowerWise® product

^E Evaluation board

^W WEBENCH enabled

LMP7715/7716/Q – 17 MHz, Low-Noise, CMOS Input Amplifier

Features

- 5.8V/ $\sqrt{\text{Hz}}$ input voltage noise
- $\pm 150 \mu\text{V}$ (max) input offset voltage
- 100 fA input bias current
- 17 MHz gain bandwidth product
- Supply current per channel 1.15 mA (LMP7715), 1.30 mA (LMP7716)
- CMRR 100 dB, PSRR 98 db

Applications

Ideal for use in active filters and buffers, sensor interface, transimpedance, and automotive

Low-Noise Operational Amplifiers (Noise <13 nV $\sqrt{\text{Hz}}$)

Product ID	Channels	Voltage Noise (nV/ $\sqrt{\text{Hz}}$)	Offset Voltage Max, 25°C (mV)	Max Input Bias Current (nA)	Supply Current Per Channel (mA)	Gain Bandwidth (MHz)	Supply Range (V)	Temp. Range (°C)	Packaging
LMH6629 	1	0.69	0.78	2300	15.5	4000	2.7 to 5.5	-40 to 125	LLP-8, SOT23-5
LMH6624 E, W 	1	0.92	0.5	25000	12	1500	5.0 to 12	-40 to 125	SOIC-8, SOT23-5
LMH6626 E, W 	2	1.0	0.5	25000	12	1300	5.0 to 12	-40 to 125	SOIC-8, MSOP-8
LMH6622 E, W 	2	1.6	1.2	15000	4.3	160	5.0 to 12	-40 to 85	SOIC-8, MSOP-8
LMH6702 E, W 	1	1.83	4.5	34000	12.5	1700	10 to 12	-40 to 85	SOIC-8, SOT23-5
LMH6628 E, W 	2	2.0	2.0	20000	9.0	300	5.0 to 12	-55 to 125	SOIC-8
LMP7731/32 W	1/2	2.9	0.04	30	2.2	22	1.8 to 5.5	-40 to 125	SOT23-5, SOIC-8
LMP7717/18 E, W	1	5.8	0.15	0.05	1.15	88	1.8 to 5.5	-40 to 125	SOIC-8, SOT23-5
LMV793 W	1	5.8	1.35	0.025	1.15	88	1.8 to 5.5	-40 to 125	SOIC-8, SOT23-5
LMV794 E, W	2	5.8	1.35	0.025	1.3	88	1.8 to 5.5	-40 to 125	SOIC-8, MSOP-8
LMP7711/12 W	1/2	5.8	0.15	0.05	1.15 / 1.3	17	1.8 to 5.5	-40 to 125	TSOT-6, MSOP-10
LMP7715 W	1	5.8	0.15	0.05	1.15	17	1.8 to 5.5	-40 to 125	SOT23-5
LMP7716 W	2	5.8	0.15	0.05	1.3	17	1.8 to 5.5	-40 to 125	SOIC-8, MSOP-8
LMV791/92 W	1/2	5.8	1.35	0.025	1.15 / 1.3	17	1.8 to 5.5	-40 to 125	TSOT-6, MSOP-10
LMV796/97 W	1/2	5.8	1.35	0.025	1.15 / 1.3	17	1.8 to 5.5	-40 to 125	SOT23-5, MSOP-8
LM6211 W	1	6.0	2.5	0.01	0.96	17	5.0 to 24	-40 to 125	SOT23-5
LMV751 W	1	6.5	1.0	0.1	0.6	5.0	2.7 to 5.5	-40 to 85	SOT23-5
LMP7721 E, W	1	6.5	0.15	0.00002	1.3	15	1.8 to 5.5	-40 to 125	SOIC-8
LMV861 E, W	1	8.0	1.0	0.01	2.6	30	2.7 to 5.5	-40 to 125	SC70-5
LMV862 E, W	2	8.0	1.0	0.01	2.6	30	2.7 to 5.5	-40 to 125	MSOP-8
LMP7701 W	1	9.0	0.2	0.05	0.715	2.5	2.7 to 12	-40 to 125	SOIC-8, SOT23-5
LMP7702 W	2	9.0	0.22	0.05	0.75	2.5	2.7 to 12	-40 to 125	SOIC-8, MSOP-8
LMP7704 W	4	9.0	0.22	0.05	0.725	2.5	2.7 to 12	-40 to 125	TSSOP-14
LMP7707 W	1	9.0	0.2	0.05	0.715	14	2.7 to 12	-40 to 125	SOIC-8, SOT23-5
LMP7708 E, W	2	9.0	0.22	0.05	0.75	14	2.7 to 12	-40 to 125	SOIC-8, MSOP-8
LMP7709 W	4	9.0	0.22	0.05	0.725	14	2.7 to 12	-40 to 125	TSSOP-14
LMP2021/22 E	1/2	11 (Av=1000V/V)	0.005	25	1.1	5.0	2.2 to 5.5	-40 to 125	SOIC-8, SOT23-5, MSOP-8
LMV772 W	2	12	1.0	0.1	0.6	3.5	2.7 to 5.5	-40 to 125	SOIC-8, MSOP-8
LMV774 W	4	12	1.0	0.1	0.6	3.5	2.7 to 5.5	-40 to 125	TSSOP-14
LMV716 W	2	12.8	5.0	0.115	1.6	5.0	2.7 to 5.5	-40 to 85	MSOP-8

 PowerWise® product

 Evaluation board

 WEBENCH enabled

CMOS-Input Amplifiers

CMOS-Input Operational Amplifiers

Product ID	Description	V _{DS} (mV) (Max)	T _{CVOS} Typ (µV/°C)	I _S Typ (mA/Ch)	CMRR (dB)	PSRR (dB)	Temperature Range (°C)	Packaging
LMP7711/12 ^W	17 MHz, single/dual precision, low-noise CMOS input op amp	0.15	1.0/1.75	1.15	100	100	-40 to 125	TSOT-6
LMP7715/16 ^W	17 MHz, single/dual precision, low-noise CMOS input, 1.8V op amp	0.15	1.0/1.75	1.15 / 1.3	100	98	-40 to 125	SOT23-5, MSOP-8
LMP7701/02/04 ^W	Precision, single/dual/quad CMOS input RRIO, wide supply range op amp	0.2/0.22/ 0.22	1.0	0.715/0.75/ 0.725	130	100	-40 to 125	SOT23-5, SOIC-8, MSOP-8, SOIC-8, TSSOP-14
LMC6001 ^W	Ultra-low input bias current op amp	0.35	2.5	0.45	83	83	-40 to 85	Plastic DIP-8
LMC6061/62/64 ^W	Micropower, single precision CMOS RRO op amp	0.35	1.0	0.02/0.016/ 0.016	85	85	-40 to 85	SOIC-8, SOIC-8, SOIC-14
LMV771/72 ^{E,W}	Low-offset, low-noise single/dual RRO op amp	0.85/1.0	0.35	0.6	90	90	-40 to 125	SC70-5, SOIC-8, MSOP-8
LMV751 ^W	Low-offset, low-noise single CMOS input op amp	1.0	1.0	0.6	103	107	-40 to 85	SOT23-5
LMV791/92 ^W	17 MHz, single/dual low-noise, CMOS input, 1.8V op amp with shutdown	1.35	1.0/1.8	1.15/1.3	100	98	-40 to 125	TSOT-6, MSOP-10
LMV796/97 ^W	17 MHz, single/dual low-noise, CMOS input, 1.8V op amp	1.35	1.0/1.8	1.15/1.3	100	98	-40 to 125	SOT23-5, MSOP-8
LMV716 ^W	5 MHz, low-noise, CMOS input RRO op amp	5.0	5.0	1.6	80	82	-40 to 85	MSOP-8
LMV861/62 ^{E,W}	30 MHz low power op amp	1.0	2.6	2.59	93	93	-40 to 125	SOIC-8, SC-70
LM6211 ^W	Low-noise, CMOS input RRO op amp with 24V operation	2.5	2.0	0.96	98	98	-40 to 125	SOT23-5
LMP2021/22 ^{E,W}	Zero-drift, EMI-hardened RR op amp	0.005	0.02 max	1.10	139	130	-40 to 125	SOT23-5, SOIC-8, MSOP-8
LMP7707/08/09 ^{E,W}	14 MHz, single/dual/quad 12V CMOS input RRIO op amp	0.2/0.22/ 0.22	1.0	0.715/0.75/ 0.725	130	100	-40 to 125	SOT23-5, SOIC-8, MSOP-8, SOIC-8, TSSOP-14
LMP7712 ^W	17 MHz, single precision, low-noise CMOS input op amp	0.15	1.75	1.15	100	100	-40 to 125	TSOT-6
LMP7717/18 ^{E,W}	88 MHz, single/dual precision, low-noise, CMOS input 1.8V op amp	0.15	1.0/1.8	1.15/1.3	100	98	-40 to 125	SOT23-5, SOIC-8, MSOP-8, SOIC-8
LMP2231/32/34 ^{E,W}	Micropower, single/dual/quad precision, 1.6V CMOS input op amp	0.15	0.4/0.5/0.75 (max)	0.01/0.009/ 0.009	92	97	-40 to 125	SOIC-8, SOT23-5, SOIC-8, MSOP-8, SOIC-14, TSSOP-14
LMP7721 ^{E,W}	3 femtoampere input bias current precision amplifier	0.15	1.5	1.1	100	96	-40 to 125	SOIC-8
LMV831/32/34 ^E	Low-power CMOS, EMI-hardened op amp	1.0	1.7	0.24	93	93	-40 to 125	SC70-5, MSOP-8, TSSOP-14
LMV851/52/54 ^{E,W}	Low-power CMOS, EMI-hardened op amp	1.0	2.0	0.43	94	93	-40 to 125	SC70-5, MSOP-8, TSSOP-14

 PowerWise® product

^E Evaluation board

^W WEBENCH enabled

Current Sensing Amplifiers

Current Sense Amplifiers¹

Product ID	Description	V _{CM} Range (V)	V _{OS} (mV) (Max)	Max TCVOS (μ V/°C)	Gain Output (V/V)	Supply Voltage Range (V)	Supply Current (mA)	PSRR (dB)	Packaging
LMP8601/Q ^E	High common-mode, AV = 20, bidirectional	-22 to 60	1.0	10	20	3.0 to 5.5	1.1	90	SOIC-8
LMP8602/Q ^E	High common-mode, AV = 50, bidirectional	-22 to 60	1.0	10	50	3.0 to 5.5	1.1	90	SOIC-8, MSOP-8
LMP8603/Q ^E	High common-mode, AV = 100, bidirectional	-22 to 60	1.0	10	100	3.0 to 5.5	1.1	90	SOIC-8, MSOP-8
LMP8645HV	Precision high-voltage configurable gain	-2.0 to 76	1.0	7.0	1 to 100	2.7 to 12	0.61	90	TSOT-6
LMP8645	Precision high-voltage configurable gain	-2.0 to 42	1.0	7.0	1 to 100	2.7 to 12	0.61	90	TSOT-6
^{NEW!} LMP8640HV	Precision high-voltage fixed gain	-2.0 to 76	0.9	2.6	20, 50, 100	2.7 to 12	0.722	85	TSOT-6
^{NEW!} LMP8640	Precision high-voltage fixed gain	-2.0 to 42	0.9	2.6	20, 50, 100	2.7 to 12	0.722	85	TSOT-6

^E Evaluation board

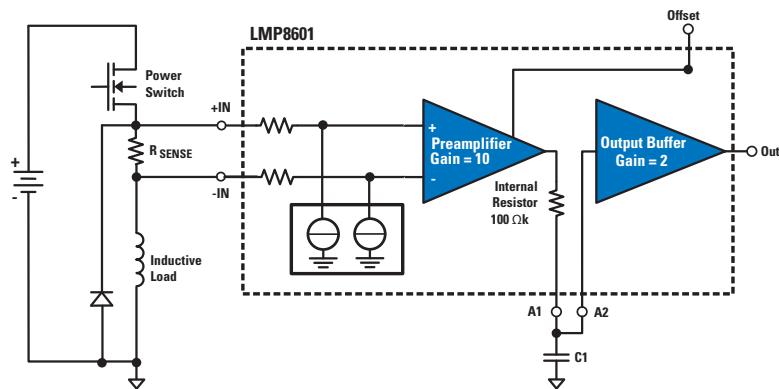
¹National's current sense amplifiers are 100% production tested at -40 to +125° C, TCVOS is guaranteed by test

LMP8601/02/03 – High Common-Mode, 60V, Current Sensing Precision Difference Amplifier

Features

- CMVR at
 - 4V to 27V at V_S = 3.3V
 - 2.2V to 60V at V_S = 5.0V
- Bidirectional current sense capability
- 3.0V to 5.5V supply voltage
- 1 mA supply current
- 1 mV max input offset voltage
- TCVOS 10 μ V/°C max, by test
- 80 dB min CMRR
- Output voltage swing rail to rail
- 60 kHz bandwidth
- Operating temperature range ambient -40°C to 125°C
 - LMP8601/Q - gain of 20 V/V
 - LMP8602/Q - gain of 50 V/V
 - LMP8603/Q - gain of 100 V/V

High-Side Current Sensing Application



Applications

Ideal for use in automotive fuel injection control, transmission control, accelerometers, high-side and low-side drivers, configuration current sensing, power management systems, and current loop to voltage conversion applications

Low-Voltage Amplifiers

Low-Voltage Operational Amplifiers (Minimum Supply Voltage ≤2.7V)

Product ID	Chan.	Supply Voltage Range (V)	Supply Current Per Channel (mA)	Gain Bandwidth (MHz)	Slew Rate (V/µs)	Offset Voltage Max, 25°C (mV)	Max Input Bias Current (nA)	Voltage Noise (nV/√Hz)	Packaging
LMV951 ^W	1	0.9 to 3	0.57	2.8	1.4	2.8	80	25	TSOT-6
LPV521	1	1.6 to 5.5	0.4	0.062	2.7	1.0	0.001	255	SC70-5
LMP2231 ^{E W}	1	1.6 to 5.5	0.016	0.13	0.058	0.015	0.001	60	SOIC-8, SOT23-5
LMP2232/34 ^{E W}	2/4	1.6 to 5.5	0.0135/0.012	0.13	0.058	0.015	0.001	60	SOIC-8, MSOP-8 / SOIC-14, TSSOP-14
LMV301 ^E	1	1.8 to 5	0.163	1.0	0.66	8.0	0.05	40	SC70-5
LMV791/92 ^W	1/2	1.8 to 5	1.15/1.3	17	9.5	1.35	0.01	5.8	TSOT-6, MSOP-10
LMV793/94 ^W	1/2	1.8 to 5	1.15	88	28	1.35	0.01	5.8	SOIC-8, SOT23-5, MSOP-8
LMV796/97 ^W	1/2	1.8 to 5	1.15/1.3	17	9.5	1.35	0.01	5.8	SOT23-5, MSOP-8
LMV931/32/34 ^E	1/2/4	1.8 to 5	0.116	1.5	0.42	4.0/5.5/5.5	35	50	SC70-5, SOT23-5, MSOP-8, SOIC-8/ TSSOP-14
LMV981 ^{E W}	1	1.8 to 5	0.116	1.5	0.42	4.0	35	50	micro SMD-6, SC70-6, SOT23-6
LMP7721 ^{E W}	1	1.8 to 5.5	1.3	15	9.3	0.15	0.00002	6.5	SOIC-8
LM6142/44	2/4	1.8 to 24	0.65	17	25	1, 2.5	526	16	CDIP-8, SOIC-8, MDIP-8/SOIC-14, MDIP-14
LM7301	1	2.2 to 30	0.6	4	1.25	6	250	36	SOIC-8, SOT23-5
LM8261/62/72 ^{E E W}	1/2/2	2.5 to 30/22/24	0.97/1.05/0.09	21/21/13	12	5.0	2000	15	SOT23-5/MSOP-8
LM7332/22 ^{E W}	2	2.5 to 32	1.2/1	19/21	15 / 18	5.0	2500/2000	15	SOIC-8, MSOP-8
LM7321 ^{E W}	1	2.5 to 32	1.1	21	18	5.0	2000	15	SOIC-8, SOT23-5
LM7341 ^W	1	2.5 to 32	0.6	4.0	1.25	4.0	250	36	SOT23-5
LMV821 ^{E W}	1	2.5 to 5.5	0.3	5.6	2.0	3.5	100	24	SC70-5, SOT23-5
LMV822/24 ^{E W}	2/4	2.5 to 5.5	0.25	5.6/5.6/6.5	2.0	3.5	100	24	SOIC-8, MSOP-8/SOIC-14, TSSOP-14
LMV116/18	1	2.7 to 12	0.6	45	40	5.0	90	40	SOT23-5, SOT23-6
LMV641 ^E	1	2.7 to 12	0.158	10	1.6	0.5	0.01	14	SOIC-8, SC70-5
LMV841/42/44 ^E	1/2/4	2.7 to 12	1.02	4.5	2.5	0.5	0.01/0.01/1.9	20	SC70-5, SOIC-8, MSOP-8, TSSOP-14
LM6132/34	2/4	2.7 to 24	0.36	10	14	2, 6	300, 350	27	SOIC-8, MDIP-8/SOIC-14, MDIP-14
LPV511 ^{E W}	1	2.7 to 12	0.00097	0.027	0.0077	3.0	0.8	320	SC70-5
LM6152/54	2/4	2.7 to 24	1.4	75	30	2, 5/5	1500	9	SOIC-8, SOIC-14
LMV341 ^{E W}	1	2.7 to 5	0.107	1.0	1.0	4.0	0.115	39	SC70-6
LMV712 ^W	2	2.7 to 5	1.17	5.0	5.0	3.0	0.115	20	micro SMD-10, LLP-10, SOIC-10
LMV716 ^W	1/2	2.7 to 5	1.17/1.6	5.0	5/5.8	3.0	260	20/12.8	SOT23-6, MSOP-8
LMV721/22 ^{E W}	1/2	2.7 to 5	1.03/0.9	10	5.25	3.0	260/0.1	8.5	SC70-5, SOT23-5, LLP-8, SOIC-8
LMV771/72 ^{E W}	1/2	2.7 to 5	0.6	3.5	1.4	0.85/1.0	0.1	12	SC70-5, SOIC-8, MSOP-8
LMV774 ^W	4	2.7 to 5	0.6	3.5	1.4	1.0	0.01	12	TSSOP-14
LMV851/52/54 ^{E W}	1/2/4	2.7 to 5	0.41	8.0	4.5	1.0	0.01	11	SC70-5, MSOP-8, TSSOP-14
LPV531	1	2.7 to 5	0.425	4.6	2.5	4.5	0.05	25	TSOT-6
LMV861/62 ^{E W}	1	2.7 to 5.5	2.59	30	18	1.0	0.01	5	SC-70, MSOP-8
LMV422	2	2.7 to 5.5	0.4	8.0	3.8	4.0	120	25	MSOP-10
LMV651/52 ^{E W}	1/2	2.7 to 5.5	0.116	12	0.83	1.5	120	17	SC70-5, MSOP-8
LMV654 ^W	4	2.7 to 5.5	0.116	12	0.83	1.5	120	17	TSSOP-14
LMV751 ^W	1	2.7 to 5.5	0.6	5.0	2.3	1.0	0.1	6.5	SOT23-5
LMV831/32/34 ^E	1/2/4	2.7 to 5.6	0.24	3.3	2.0	1.0	10	12	SC70-5, MSOP-8, TSSOP-14

 PowerWise® product

 Evaluation board

 WEBENCH enabled

Micropower Amplifiers

LMP2231/32/34 – Single/Dual/Quad Micropower Precision Op Amps with CMOS Inputs

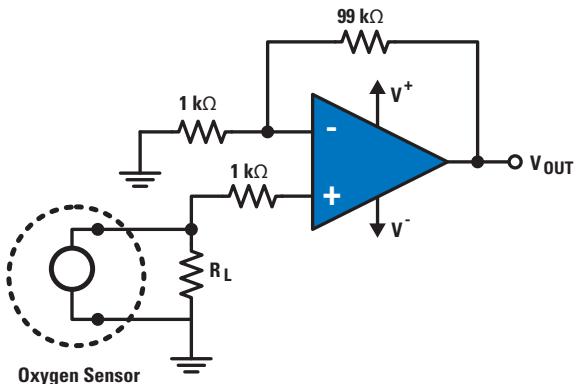
Features

- 1.6V to 5.5V operating voltage range
- 120 dB PSRR
- 97 dB CMRR
- 120 dB open loop gain
- 130 kHz gain bandwidth product
- 58 V/ μ s slew rate
- 60 nV/ $\sqrt{\text{Hz}}$ input voltage noise, $f = 1 \text{ kHz}$

Applications

Ideal for use in precision instrumentation amplifiers, battery-powered medical instrumentation, high-impedance sensors, strain gauge bridge amplifiers, and thermocouple amplifiers

Typical Application Circuit



Micropower Operational Amplifiers

Product ID	Channels	Supply Current Per Channel (μA)	Gain Bandwidth (MHz)	Offset Voltage Max, 25°C (mV)	Max Input Bias Current (nA)	CMRR (dB)	PSRR (dB)	Supply Voltage Range (V)	Slew Rate (V/ μ s)	Output Current (mA)	Voltage Noise (nV/ $\sqrt{\text{Hz}}$)	Temp Range (°C)	Packaging
LPV521	1	0.4	0.062	1.0	0.001	115	109	1.6 to 5.5	2.7	15	255	-40 to 125	SC70-5
LPV511 E, W	1	0.88	0.027	3.0	0.8	115	115	2.7 to 12	0.007	0.225	320	-40 to 85	SC70-5
LPV531	1	5 to 425	4.6	4.5	0.01	95	90	2.7 to 5	2.5	15	25	-40 to 85	TSOT-6
LMP2232 W	2	10	0.13	0.15	0.001	97	120	1.6 to 5	0.048	22	60	-40 to 125	SOIC-8, MSOP-8
LMP2231 W	1	13	0.13	0.15	0.001	97	120	1.6 to 5	0.048	22	60	-40 to 125	SOT23-5, SOIC-8
LMV831 E	1	25	3.3	1.0	.01	77	76	27.55	2.0	30	12	-40 to 125	SC70-5
LMV551/52 E, W	1/2	37	3.0	3.0	38	93	90	2.7 to 5.5	1.0	10	70	-40 to 125	SC70-5, MSOP-8
LMV554	4	37	3.0	3.0	38	93	90	2.7 to 5	1.0	10	70	-40 to 85	TSSOP-14
LMV651/52 E, W	1/2	116	12	1.5	120	100	95	2.7 to 5.5	3.0	15	17	-40 to 125	SC70-5, MSOP-8
LMV654 W	4	118	12	1.5	120	100	95	2.7 to 5.5	3.0	15	17	-40 to 125	TSSOP-14
LMV641 E	1	158	10	0.5	90	120	100	2.7 to 12	2.6	26	14	-40 to 125	SOIC-8, SC70-5

PowerWise® product

E Evaluation board

W WEBENCH enabled

Shutdown Amplifiers

LMP8100 – Programmable Gain Amplifier Delivers 0.03% Accuracy Over Temperature and Gain Settings

Features

- Unmatched gain accuracy for every gain setting enables accurate signal conditioning from -40°C to +125°C
- Gain range 1 V/V to 16 V/V in 1 V/V steps enables flexible and fine gain adjustments
- Programmable frequency compensation increases usable bandwidth for all gain settings
- Input zero calibration switch allows output offset voltage measurement and calibration
- Glitch-free transition between programmed settings eliminates errors
- 12 nV/ $\sqrt{\text{Hz}}$ input noise voltage accurately signal conditions in near DC-sensor applications
- Ideal match for 12-bit, 1-channel ADCs up to 1 MSPS
- Available in SOIC-14 packaging

Applications

Ideal for use in industrial instrumentation, sensor interface, data acquisition, test equipment, and gain control applications

Shutdown Amplifiers

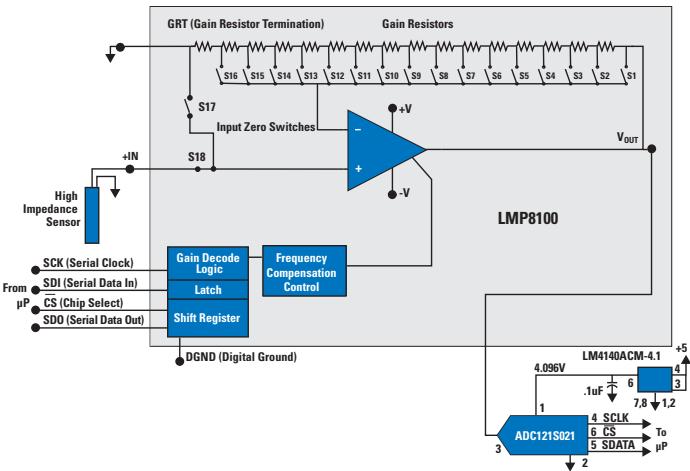
Product ID	Channels	Gain Bandwidth (MHz)	Supply Voltage Range (V)	Offset Voltage Max, 25°C (mV)	Temperature Range (°C)	Comments	Packaging
LMV341 E, W	1	1	2.7 to 5	4	-40 to 125	TRI-STATE® output	SC70-6
LMV981 E, W	1	1.4	1.8 to 5	4	-40 to 125	TRI-STATE output, RRIO	micro SMD-6, SC70-6, SOT23-6
LMV982 W	2	1.4	1.8 to 5	4	-40 to 125	TRI-STATE output, RRIO	MSOP-10
LMV951 W	1	2.8	0.9 to 3	2.8	-40 to 125	RRIO	TSOT23-6
LMV712 W	2	5	2.7 to 5	3	-40 to 85	RRIO	LLP-10, SOIC-10
LMP7711 W	1	17	1.8 to 5.5	0.15	-40 to 125	CMOS input	TSOT-6
LMP7712 W	2	17	1.8 to 5.5	0.15	-40 to 125	CMOS input	MSOP-10
LMV791 W	1	17	1.8 to 5.5	1.35	-40 to 125	TRI-STATE output	TSOT23-6
LMV792 W	2	17	1.8 to 5.5	1.35	-40 to 125	TRI-STATE output	MSOP-10
LMV118	1	45	2.7 to 12	5	-40 to 85	RRIO	SOT23-6
LMH6601 E, W	1	125	2.4 to 5.5	2.4	-40 to 85	CMOS input	SC70-6
LMH6618 E, W	1	65	2.7 to 11	0.6	-40 to 125	RRIO	TSOT23-6
LMH6611 E, W	1	135	2.7 to 11	0.6	-40 to 125	RRIO	TSOT23-6
LMH6647 E, W	1	40	2.5 to 12	3	-40 to 85	RRIO	SOIC-8, SOT23-6
LMH6703 E	1	1800*	8 to 12	7	-40 to 85	Low distortion	SOIC-8, SOT23-6
LMH6720 E	1	420*	10 to 12	6	-40 to 85	CFB	SOIC-8, SOT23-6
LMH6733 E, W	3	1000*	3 to 12	2.2	-40 to 85	CFB	SSOP-16
LMH6734 E	3	925*	3 to 12	2.4	-40 to 85	CFB	SSOP-16
LMH6738 E	3	750*	8 to 12	2.5	-40 to 85	CFB	SSOP-16
LMH6739 E	3	750*	8 to 12	2.5	-40 to 85	CFB	SSOP-16

PowerWise® product

E Evaluation board

W WEBENCH enabled

*Unity Gain Bandwidth



Low-Power Amplifiers

Low-Power Operational Amplifiers

Product ID	Channels	Supply Current Per Channel (µA)	Supply Voltage Range (V)	Offset Voltage Max, 25°C (mV)	Max Input Bias Current (nA)	Gain Bandwidth (MHz)	Slew Rate (V/µs)	Output Current (mA)	Voltage Noise (nV/√Hz)	Packaging
LPV521	1	0.4	1.6 to 5.5	1.0	0.001	0.062	2.7	15	255	SC70-5
LPV511 E, W	1	0.88	2.7 to 12	3.0	0.8	0.027	0.0077	0.225	320	SC70-5
LPV531	1	5 to 425	2.7 to 5.0	4.5	0.01	4.6	2.5	15	25	TSOT-6
LMP2232/34 E, W	2/4	9	1.6 to 5.5	0.15	0.001	0.13	0.058	30	60	SOIC-8, MSOP-8, SOIC-14, TSSOP-14
LMP2231 E, W	1	10	1.6 to 5.5	0.15	0.001	0.13	0.058	30	60	SOIC-8, SOT23-5
LMV341 E, W	1	107	2.7 to 5.0	4.0	0.12	1.0	1.0	75	39	SC70-6
LMV931 E, W	1	116	1.8 to 5.0	4.0	35	1.5	0.42	100	50	SC70-5, SOT23-5
LMV932/34	2/4	116	1.8 to 5.0	5.5	35	1.5	0.42	65	50	SOIC-8, MSOP-8, SOIC-14, TSSOP-14
LMV981 E, W	1	116	1.8 to 5.0	4.0	35	1.5	0.42	65	50	micro SMD-6, SC70-6, SOT23-6
LMV651/52 E, W	1/2	116/118	2.7 to 5.5	1.5	120	12	2.8	15	17	SC70-5, MSOP-8
LMV654 E, W	4	122	2.7 to 5.5	1.8	120	12	2.8	15	17	TSSOP-14
LMV641 E	1	158	2.7 to 12	0.5	90	10	2.6	26	14	SOIC-8, SC70-5
LMV301	1	163	1.8 to 5.0	8.0	0.035	1.0	0.66	60	40	SC70-5
LM6584/88	4/4	195/200	5.0 to 13/16	4.0	7000	15.4	15	320/230	23	SOIC-14, TSSOP-14
LMV831/32/34 E	1/2/4	240	2.7 to 5.5	1.0	10	3.3	2.0	60	12	SC70-5, MSOP-8, TSSOP-14
LMV822/24 W	2/4	250	2.7 to 5.5	3.5	100	5.6	2.0	40	24	SOIC-8, MSOP-8, TSSOP-14
LMV821 E, W	1	300	2.7 to 5.5	3.5	100	5.6	2.0	40	24	SC70-5, SOT23-5
LM6132/34	2/4	360	2.7 to 24	2, 6	300, 350	10	14	4.3	27	SOIC-8, MDIP-8/ SOIC-14, MDIP-14
LMV851/52/54 E, W	1/2/4	430	2.7 to 5.5	1.0	10	8.0	4.5	60	11	SC70-5, MSOP-8, TSSOP-14
LMV951 E, W	1	570	0.9 to 3.0	2.8	80	2.8	1.4	85	25	TSOT-6
LM7301	1	600	2.2 to 30	6	250	4	1.25	9.5	36	SOIC-8, SOT23-5
LMV116/18	1	600	2.7 to 12	5.0	0.1	45	40	15/24	40	SOT23-5, SOT23-6
LMV751 W	1	600	2.7 to 5.5	1.0	0.1	5.0	2.3	24	6.5	SOT23-5
LM7341 W	1	600	2.5 to 32	4.0	400	4.0	1.25	6.0	36	SOT23-5
LMV771/72 E, W	1/2	600/800	2.7 to 5.0	0.85/1.0	0.1/1000	3.5	1.4	66	12	SC70-5, SOIC-8, MSOP-8
LM6142/44	2/4	650	1.8 to 24	1, 2.5	526	17	25	8	16	CDIP-8, SOIC-8, MDIP-8, SOIC-14, MDIP-14
LM7321 W	1	1.0 mA	2.5 to 32	5.0	2000	16	12.3	50	14	SOT23-5, SOIC-8
LMV774 W	4	1.03 mA	2.7 to 5.0	1.0	260	3.5	1.4	24	12	TSSOP-14
LMV722 W	2	1.03 mA	2.7 to 5.0	3.0	260	10	5.25	15	8.5	LLP-8, SOIC-8
LMV2011 W	1	1.17 mA	2.7 to 5.0	0.025	0.115	3.0	4.0	35	35	SOIC-8, SOT23-5
LMV721 E, W	1	1.17 mA	2.7 to 5.0	3.0	0.115	10	5.25	40	8.5	SC70-5, SOT23-5
LMV712 W	2	1.17 mA	2.7 to 5.0	3.0	0.13	5.0	5.0	35	20	micro SMD-10, LLP-10, MSOP
LM6152/54	2/4	1.4 mA	2.7 to 24	2, 5/5	1500	75	30	6.2	9	SOIC-8, SOIC-14

E Evaluation board

W WEBENCH enabled

Precision Amplifiers and EMI-Hardened Amplifiers

LMP7721 – 3 fA Input Bias Current Precision Amplifier

Features

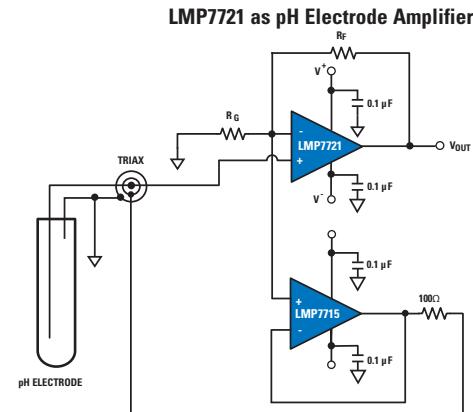
- Input bias current ($V_{CM} = 1V$)
 - $\pm 20 \text{ fA}$ at 25°C (max)
 - $\pm 900 \text{ fA}$ at 85°C (max)
- $6.5 \text{ nV}/\sqrt{\text{Hz}}$ input voltage noise, $f = 1 \text{ kHz}$
- 1.3 mA supply current
- 17 MHz gain bandwidth
- $12.76 \text{ V}/\mu\text{s}$ slew rate (falling edge)
- Supply voltage 1.8V to 5.5V
- Available in SOIC-8 packaging

Applications

Ideal for use in photodiode amplifiers, high-impedance sensor amplifiers, ion chamber amplifiers, electrometer amplifiers, pH electrode amplifiers, and transimpedance amplifiers



Read the Application Note 1798 : "Designing with Electro-Chemical Sensors"
national.com/edge



EMI-Hardened Amplifiers (EMI Rejection Ratio >80 dB at 1.8 GHz)

Product ID	EMIRR (dB)	Channels	Supply Voltage (V)	Supply Current (mA)	Offset Voltage	Input Bias Current (pA)	Packaging
LMV831/32/34 E	120	1/2/4	2.7 to 5.5	0.24	1 mV	1.0	SC70-5/MSOP-8/TSSOP-14
LMV861/62 E,W	110	1/2	2.7 to 5.5	2.25	1 mV	0.1	SC70-5/MSOP-8
LMV851/52/54 E,W	89	1/2/4	2.7 to 5.5	0.4	1 mV	0.1	SC70-5/MSOP-8/TSSOP-14
LMP2021/22 E,W	82	1/2	2.2 to 5.5	1.1	5 μV	25	SOT23-5, SOIC-8, MSOP-8

E Evaluation board

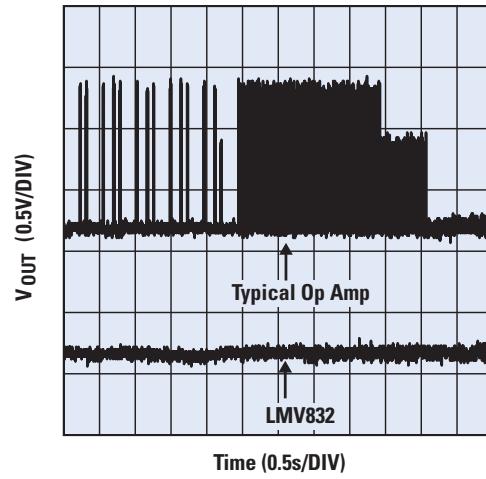
W WEBENCH enabled

LMV831/32/34 – 3 MHz Low-Power CMOS, EMI-Hardened Operational Amplifiers

Features

Unless otherwise noted, typical values at $T_A = 25^\circ\text{C}$, $V_{+} = 3.3\text{V}$

- 2.7V to 5.5V supply voltage
- $240 \mu\text{A}$ supply current (per channel)
- 1 mV max input offset voltage
- 1 pA input bias current
- 3.3 MHz GBW
- EMIRR at 1.8 GHz 120 dB
- Input noise voltage at 1 kHz $12 \text{ nV}/\sqrt{\text{Hz}}$
- $2 \text{ V}/\mu\text{s}$ slew rate
- Output voltage swing rail to rail
- 30 mA output current drive
- -40°C to 125°C operating temperature range ambient



Applications

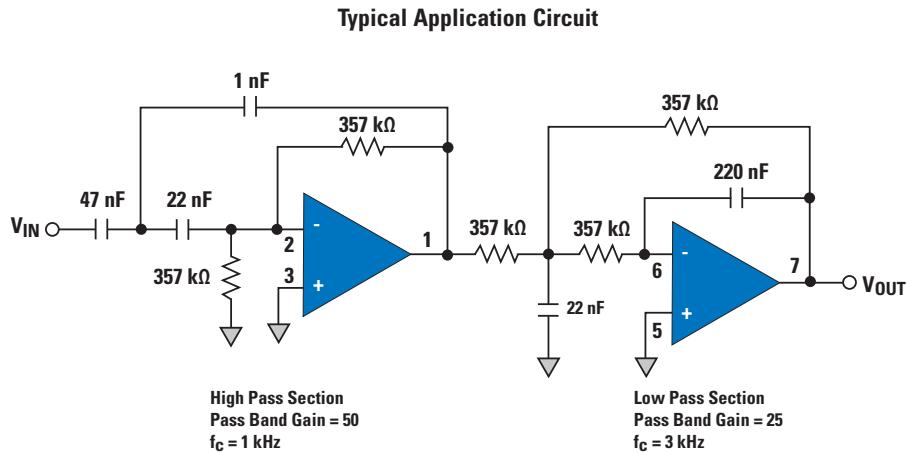
Ideal for use in photodiode preamps, piezoelectric sensors, portable/battery-powered electronic equipment, filters/buffers, and PDAs/phone accessories

Low-Voltage, Low-Noise Operational Amplifiers

LMV716 – 5 MHz, Low-Noise, Dual Op Amp with CMOS Input

Features

- 12.8 nV/ $\sqrt{\text{Hz}}$ input noise voltage
- 0.6 pA input bias current
- 1.6 mV offset voltage
- 80 dB CMRR
- 122 dB open loop gain
- Rail-to-rail output
- 5 MHz gain bandwidth
- 5.8 V/ μs slew rate
- 1.6 mA supply current
- 2.7V to 5V supply voltage range
- Available in MSOP-8 packaging



Applications

Ideal for use in active filters, transimpedance amplifiers, audio preamps, and HDD vibration cancellation circuitry

Low-Voltage, Low-Noise Operational Amplifiers (Noise \leq 12.8 nV/ $\sqrt{\text{Hz}}$, Supply Voltage \leq 2.7V)

Product ID	Channels	Voltage Noise (nV/ $\sqrt{\text{Hz}}$)	Max Input Bias Current (nA)	Offset Voltage Max, 25°C (mV)	Supply Current Per Channel (mA)	Gain Bandwidth (MHz)	Slew Rate (V/ μs)	Supply Voltage Range (V)	Output Current (mA)	Temp Range (°C)	Packaging
LMP7731	1	2.9	30	0.04	2.2	22	2.4	1.8 to 5.5	47	-40 to 125	SOT23-5
LMP7732 ^W	2	2.9	30	0.04	2.2	22	2.4	1.8 to 5.5	47	-40 to 125	SOIC-8
LMV791 ^W	1	5.8	0.025	1.35	1.15	17	9.5	1.8 to 5.0	21	-40 to 125	TSOT-6
LMV792 ^W	2	5.8	0.1	1.35	1.3	17	9.5	1.8 to 5.0	21	-40 to 125	MSOP-10
LMV796 ^W	1	5.8	0.1	1.35	1.15	17	9.5	1.8 to 5.0	21	-40 to 125	SOT23-5
LMV797 ^W	2	5.8	0.1	1.35	1.3	17	9.5	1.8 to 5.0	21	-40 to 125	MSOP-8
LMV793 ^W	1	5.8	0.1	1.35	1.15	88	28	1.8 to 5.0	21	-40 to 125	SOIC-8, SOT23-5
LMV794 ^{E,W}	2	5.8	0.1	1.35	1.3	88	28	1.8 to 5.0	21	-40 to 125	SOIC-8, MSOP-8
LMP7715 ^W	1	5.8	0.05	0.15	1.15	17	9.5	1.8 to 5.5	23	-40 to 125	SOT23-5
LMP7716 ^W	2	5.8	0.05	0.15	1.3	17	9.5	1.8 to 5.5	23	-40 to 125	MSOP-8
LMV751 ^W	1	6.5	0.1	1.0	0.6	5.0	2.3	2.7 to 5.5	15	-40 to 85	SOT23-5
LMV861/62 ^{E,W}	1/2/4	8.0	10	1.0	0.43	8.0	4.5	2.7 to 5.5	60	-40 to 85	SC70-5, MSOP-8, TSSOP-14
LMV721 ^{E,W}	1	8.5	400	3.0	1.03	10	5.25	2.7 to 5.0	24	-40 to 85	SC70-5, SOT23-5
LMV722 ^W	2	8.5	400	3.0	0.9	10	5.25	2.7 to 5.0	24	-40 to 85	LLP-8, SOIC-8
LMV771 ^{E,W}	1	12	0.1	0.85	0.6	3.5	1.4	2.7 to 5.0	66	-40 to 125	SC70-5
LMV772 ^W	2	12	0.1	1.0	0.6	3.5	1.4	2.7 to 5.0	66	-40 to 125	SOIC-8, MSOP-8
LMV774 ^W	4	12	0.1	1.0	0.6	3.5	1.4	2.7 to 5.0	66	-40 to 125	TSSOP-14
LMV716 ^W	2	12.8	0.13	5.0	1.6	5.0	5.8	2.7 to 5.0	31	-40 to 85	MSOP-8

^E Evaluation board

^W WEBENCH enabled

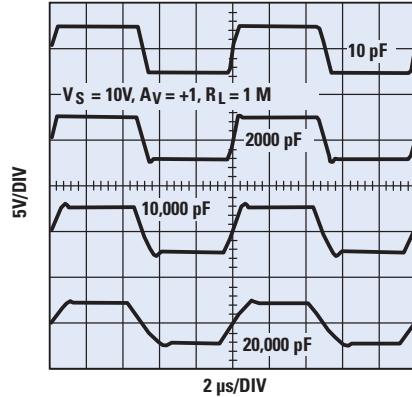
High-Voltage Supply Amplifiers

LM7332 – Dual RRIO, 30V Wide Voltage Range Operational Amplifier

Features

- 2.5V to 32V wide supply voltage range
- Wide input common-mode voltage 0.3V beyond rails
- ± 120 mA output short-circuit current
- ± 65 mA output current (1V from rails)
- 19 MHz gain bandwidth
- 15 V/ μ s slew rate
- Capacitive load tolerance unlimited
- 0.75 mA supply current/channel
- -40°C to 125°C temperature range
- Voltage offset 100% tested at 5V, ± 5 V, 30V

Large Signal Step Response for Various Capacitive Loads



High-Voltage Supply Amplifiers

Product ID	Chan.	Supply Range (V)	Voltage Noise (nV/ $\sqrt{\text{Hz}}$)	Gain BW (MHz)	Slew Rate (V/ μ s)	Output Current (mA)	V_{os} Max, 25°C (mV)	Supply Current/Channel (mA)	Comments	Packaging
LME49713 ^E	1	10 to 36	1.9	132	1900	90	1.0	8.0	Current feedback	SOIC-8
LM4562 ^E	2	5 to 34	2.7	55	20	23	0.7	6.0	High-AC accuracy	SOIC-8, PDIP-8, TO-99
LME49710 ^E	1	10 to 36	2.7	55	20	23	0.7	6.0	Can drive 600Ω loads	SOIC-8, PDIP-8, TO-99
LME49720 ^E	2	5 to 34	2.7	55	20	23	0.7	5.5	Active filters, 120 dB CMRR	SOIC-8, PDIP-8, TO-99
LME49740 ^E	4	5 to 34	2.7	55	20	23	0.7	6.0	Quad, low noise	SOIC-14, PDIP-14
LME49870	1	5 to 44	2.7	55	20	30	0.7	6.5	V_s to ±22V	SOIC-8
LME49860	2	5 to 44	2.7	55	20	30	0.7	5.5	V_s to ±22V	SOIC-8, PDIP-8
LM7372 ^W	2	9 to 36	14	120	2000	150	8.0	9.0	High output driver, xDSL	SOIC-16, PSOP-8, LLP-8
LM7332	2	2.5 to 32	15	19	15	100	6.0	1.2	Unlimited cap. load	SOIC-8, MSOP-8
LM7321 ^W	1	2.5 to 32	15	21	24	50	5.0	1.3	Unlimited cap load, RRIO	SOIC-8, SOT23-5
LM7322 ^W	2	2.5 to 32	15	21	24	50	5.0	1.3	Unlimited cap load, RRIO	SOIC-8, MSOP-8
LM7341 ^W	1	2.7 to 32	33	4.0	1.7	11	4.0	1.0	RRIO	SOT23-5
LM6171/72	1	5.5 to 34/36	12	70	3600	135/85	3, 6/1.5, 3	2.5/2.3	High slew rate	DIP-8, SOIC-8
LM7121	1	4.5 to 33	17	175	1300	52	8	4.8	High speed, high slew rate	SOIC-8, SOT23-5
LM7171	1	5.5 to 36	14	200	4100	100	3, 1	6.5	High speed, high slew rate	DIP-8, SOIC-8

^E Evaluation board

^W WEBENCH enabled

Comparators

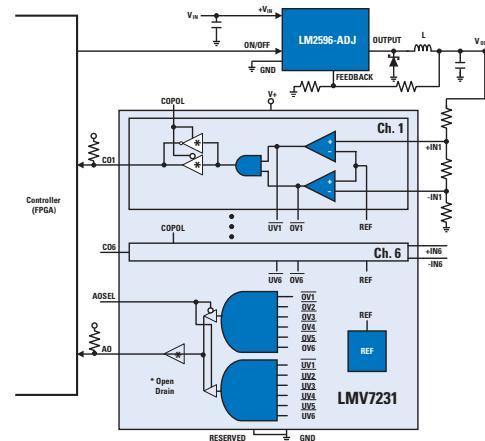
LMV7231 – Hex Window Comparator With 1.5% Precision and 400 mV Reference

Features

- 6-channel window comparator can be used to monitor multiple power supplies
- Wide supply voltage range: +2.2V to +5.5V
- $\pm 1.5\%$ (max) threshold accuracy
- High-accuracy internal reference can monitor power supply voltages down to 400 mV
- LMV7231 supply does not have to be up before other supplies are measured
- Input/output voltage range above V+
- 6 mV internal hysteresis
- 2.6 μ s to 5.6 μ s propagation delay
- Supply current 7.7 μ A per channel
- Available in LLP-24 packaging

Applications

Ideal for use in basestations, network equipment, switches/routers, storage servers, battery cell system voltage monitoring, and multiple power supply voltage detection



High-Speed Comparators (Response Time <0.05 μ s)

Product ID	Channels	Response Time (μ s)	Offset Voltage Max, 25°C (mV)	Supply Voltage Range (V)	Supply Current Per Channel (mA)	Input Bias Current (μ A)	Output Compatibility	Temperature Range (°C)	Packaging
LMH7322 E	2	0.0007	8	2.7 to 12	22.8	2.6	RS(P)ECL, LVDS	-40 to 125	LLP-24
LMH7324 E	4	0.0007	9.5	5 to 12	17.2	2.6	RS(P)ECL, LVDS	-40 to 125	LLP-32
LMH7220	1	0.0029	2.7	2.7 to 12	7.5	1.5	LVDS	-40 to 125	TSOT-6
LMV7219	1	0.007	6	2.7 to 5	1.1	0.45	Push-pull	-40 to 85	SC70-5, SOT23-5
LMV7235/39	1	0.045	6	2.7 to 5	0.065	0.03	Open drain/ Push-pull	-40 to 85	SC70-5, SOT23-5

Low-Power Comparators (Supply Current per Channel <0.28 mA)

Product ID	Channels	Response Time (μ s)	Offset Voltage Max, 25°C (mV)	Output Current (mA)	Supply Voltage Range (V)	Supply Current Per Channel (mA)	Max Input Bias Current (nA)	Temperature Range (°C)	Packaging
LPV7215	1	4.5	3	15	1.8 to 5	0.00058	0.001	-40 to 85	SC70-5, SOT23-5
LMV7231 E	6	2.6	6	10	2.2 to 5.5	0.0077	5	-40 to 125	LLP-24
LMV7271	1	0.88	4	34	1.8 to 5	0.009	100	-40 to 85	SC70-5, SOT23-5
LMV7272	2	0.88	4	34	1.8 to 5	0.009	100	-40 to 85	micro SMD-8
LMV7275	1	0.88	4	34	1.8 to 5	0.009	100	-40 to 85	SC70-5, SOT23-5
LMV7291	1	0.88	4	34	1.8 to 5	0.009	100	-40 to 85	SC70-5
LMP7300 E	1	0.3	0.3	10	2.7 to 12	0.012	3	-40 to 125	SOIC-8
LMV761	1	0.12	0.3	40	2.7 to 5	0.275	0.05	-40 to 125	SOIC-8, SOT23-6
LMV762	2	0.12	0.2	40	2.7 to 5	0.275	0.05	-40 to 125	SOIC-8

PowerWise® product

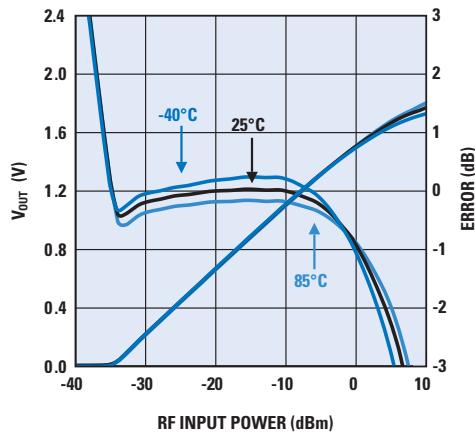
E Evaluation board

RF Power Detectors

LMH2110/20 – 8 GHz LOG/LIN RMS RF Power Detector

Features

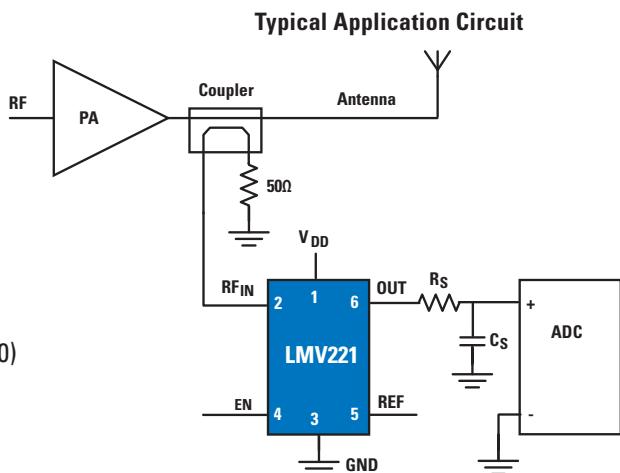
- LMH2110: 40 dB linear-in-dB power detection range
- LMH2120: 40 dB linear-in-V power detection range
- >30 dB dynamic range, 1900 MHz, n=50
 - ±0.3 dB Log conformance error
 - ±0.3 dB variation over temperature
 - 0.05 dB (typ) output variation due to modulation, WCDMA
- Shutdown pin
- Multi-band operation from 50 MHz up to 8 GHz
- Available in micro SMD-6 packaging (0.84 x 1.24 mm)



LMV221/LMH2100 – 50 MHz to 4 GHz 40 dB Logarithmic Power Detector for CDMA and WCDMA

Features

- 40 dB linear-in-dB power detection range
- 0.3V to 2V output voltage range
- Shutdown pin
- Multi-band operation from 50 MHz to 3.5 GHz
- 0.5 dB accurate temperature compensation
- External configurable output filter bandwidth
- Available in LLP-6 packaging, 2.2 x 2.5 x 0.8 mm (LMV221)
- Available in micro SMD-6 packaging, 0.85 x 1.25 x 0.6 mm (LMH2100)

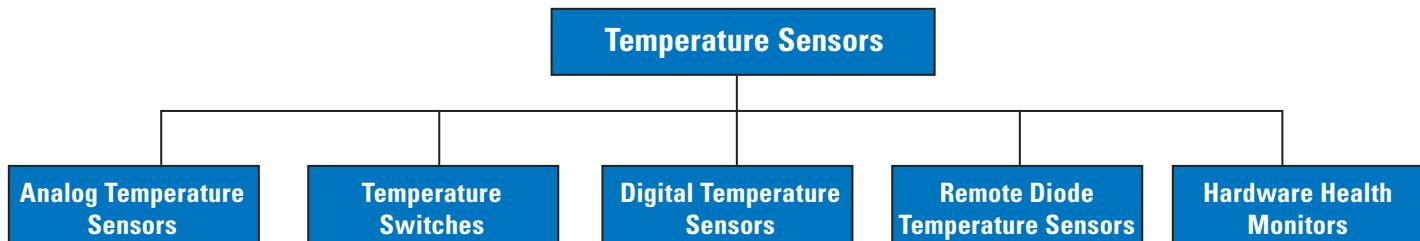


RF Detectors

Product ID	Application	Channels	Supply Voltage Range (V)	Dynamic Range (dB)	Frequency Range (MHz)	Type	Packaging
LMV221 E	CDMA, WCDMA, GSM, GPRS	1	2.7 to 3.3	40	50 to 3500	LOG Amp	LLP-6
LMV225 E	CDMA, WCDMA, GSM, EDGE, GPRS, TDMA	1	2.7 to 5.5	>30	450 to 2000	LOG Amp	micro SMD-4, LLP-6
LMV226 E	CDMA, WCDMA, GSM, EDGE, GPRS, TDMA	1	2.7 to 5.5	>30	450 to 2000	LOG Amp	micro SMD-4
LMV228 E	CDMA, WCDMA, GSM, EDGE, GPRS, TDMA	1	2.7 to 5.5	>30	450 to 2000	LOG Amp	micro SMD-4
LMV232 E	3G, UMTS, WCDMA, CDMA2000, LAN, GPS	2	2.5 to 3.3	20	50 to 2000	LIN MS Amp	micro SMD-8
LMH2100 E	CDMA, WCDMA, GSM, GPRS	1	2.7 to 3.3	40	50 to 4000	LOG Amp	micro SMD-6
LMH2110 E	LTE, UMTS, WCDMA, CDMA2000, GSM/EDGE	1	2.7 to 5	45	50 to 8000	LOG RMS	micro SMD-6
LMH2120 E	LTE, UMTS, WCDMA, CDMA2000, GSM/EDGE	1	2.7 to 5	40	50 to 6000	LIN RMS	micro SMD-6
LMV242 E	GSM, GPRS, TDMA, LAN	2	2.6 to 5.5	50	450 to 2000	LOG Amp	LLP-10

E Evaluation board

Temperature Sensors



Analog Temperature Sensor

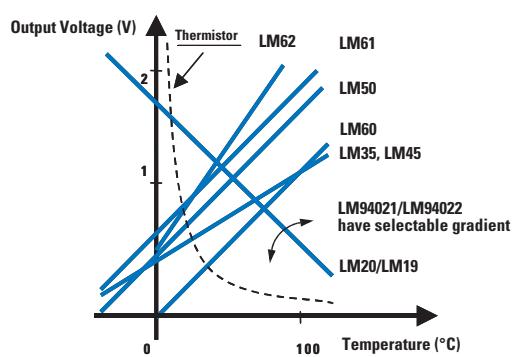
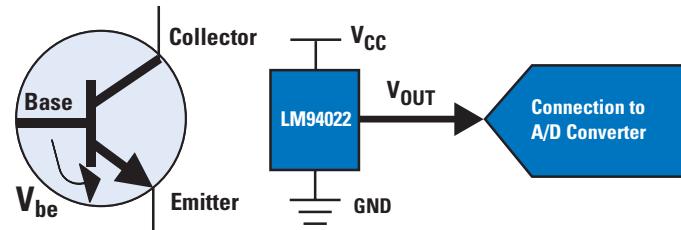
Analog temperature sensors utilize the temperature-dependent V_{be} characteristic of a transistor to convert the temperature being measured into a voltage. The resulting output voltage is directly proportional to the temperature.

Features

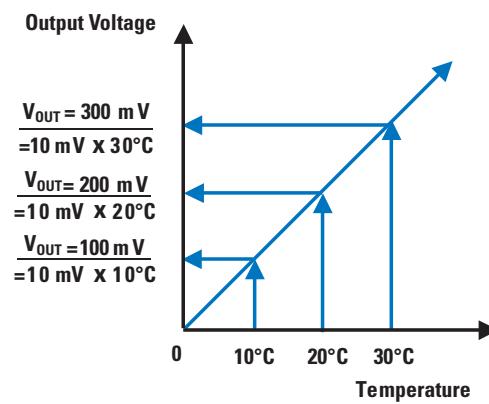
- The excellent linearity compared to thermistors means compensation is not required
- Very simplified and easy-to-use configuration with only three terminals. These are the power supply, ground, and analog output terminals, respectively
- A wide range of packages are available to suit many different applications (SOIC-8, TO-92, SOT23-3, SC-70)
- Power consumption is less than a thermistor, making these sensors ideal for battery-driven applications for example, LM19/20 LM94021/22 : 4 μ A, LM45/50/60/61/62 : 120 μ A

National has a wide range of models available for selection based on the first-order gradient, offset, and operating supply voltage characteristics.

Simple Configuration



Seven Types are Available with Different Gradients and Offsets

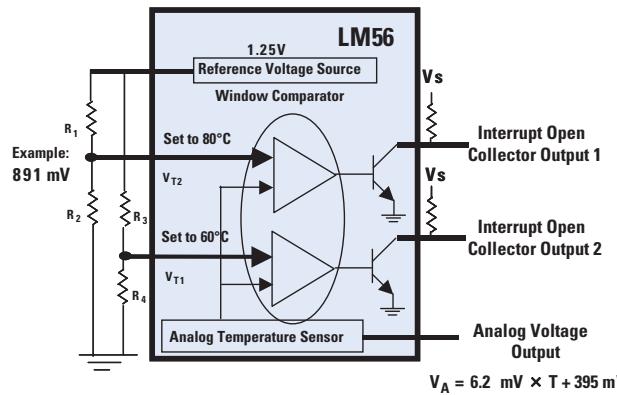


For the LM45, V (Output Voltage) = $+10 \text{ mV}/\text{°C} \times \text{Temperature } (\text{°C})$

Temperature Sensors

Analog Temperature Switch

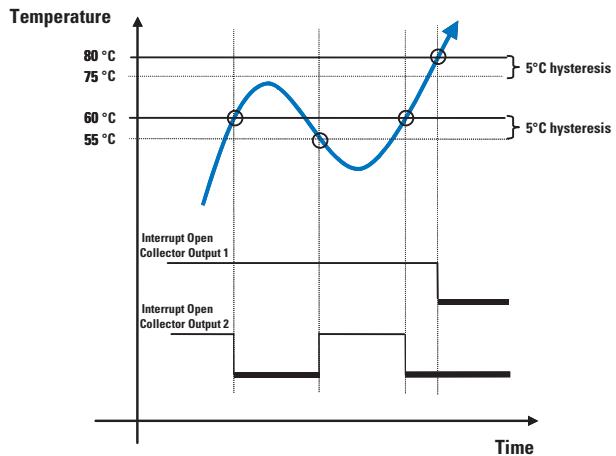
An analog temperature switch integrates an analog temperature sensor with a comparator and reference voltage source that can output an alarm (interrupt signal) at a specific temperature threshold. The setting method is particularly simple and in the case of the LM56 and LM57 temperature sensors, consists of using voltage divider resistors to divide the reference voltage source and obtain the voltage corresponding to the threshold temperature.



Example: Procedure for setting 80°C. When the interrupt temperature is set to 80°C, $V_A = 6.20 \text{ mV} \times 80^\circ\text{C} + 395 \text{ mV} = 891 \text{ mV}$. The reference voltage source needs to be divided by the divider resistors to obtain 891 mV and connected to V_{T1} or V_{T2} on the LM56.

This voltage is applied to one input of the comparator while the other input is driven by the analog temperature sensor. In the case of the LM26 and LM27 sensors in which the threshold temperature is preset in the factory, the devices can be used to implement a temperature monitor function on their own and do not require any software or external resistors to set the threshold.

LM56 Interrupt Output vs Measured Temperature



- * Open collector output 1 is set to 80°C
- * Open collector output 2 is set to 60°C
- * The 5 °C hysteresis is fixed in the LM56

Digital Temperature Sensor

A digital temperature sensor integrates an analog temperature sensor, A/D converter, and digital interface to provide a convenient temperature sensor capable of directly being read by a CPU or microprocessor. National has a wide range of digital temperature sensors that can be selected based on criteria such as (1) accuracy, (2) digital interface, (3) interrupt function, and (4) whether a remote thermal diode sensing function is used.

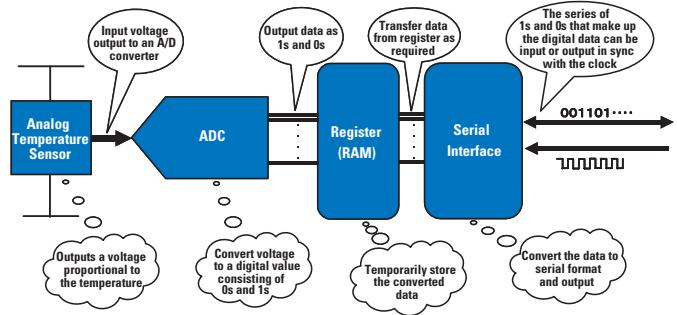
- (1) The range includes a part (the LM92) with an accuracy of $\pm 0.33^\circ\text{C}$, which is superior to any other digital temperature sensor on the market. A sensor can be selected based on the temperature margin in a design.
- (2) Two digital interfaces are available: 2-wire interfaces (I^2C compliant Bus and SMBus) and 3-wire interfaces (SPI and MICROWIRE®). The interface can be selected that suits the given microprocessor.
- (3) A function is available to output an interrupt signal at a specified set temperature. Applicable uses include fan control and shutting down the system at an application-specified temperature.

Hardware Monitors

Hardware monitors are integrated monitoring ICs that, in addition to their temperature measurement function, extend the digital temperature sensor by integrating additional functions including voltage monitoring, fan speed monitoring, power supply control signal monitor parameters, fan speed control, a GPIO port, and an external alert output. The measurement data is automatically saved in an internal RAM and can be read at any time via an interface. Also, the measurement data

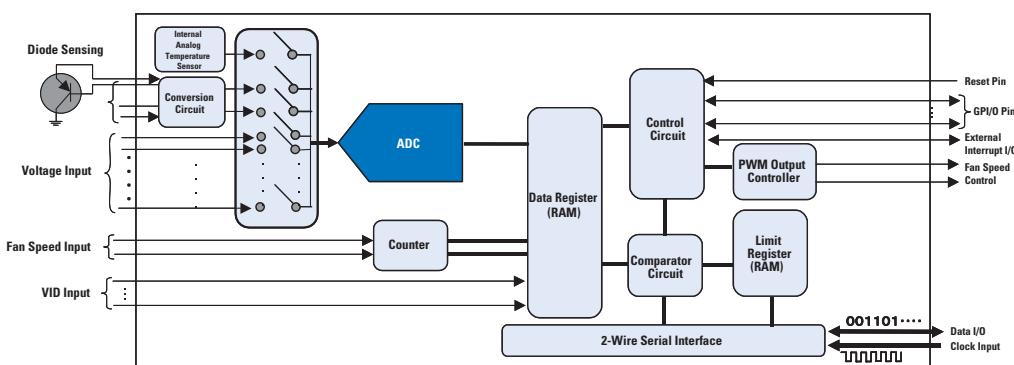
4) A diode-sensing function utilizes the temperature characteristics of a bipolar transistor's base-emitter junction to measure temperature. A bias current from the temperature sensor is applied to a transistor and the differential voltage (representing the change in temperature) is converted to digital temperature data. This method can be used to make direct measurements of the internal temperature of a CPU or GPU that has an integrated thermal diode. Also, because this technique can be used with a general-purpose transistor (2N3904), it simplifies circuit board design since only the transistor needs to be located next to the heat source and the sensor can be mounted elsewhere.

(5) The range includes the parts that use TruTherm® technology to provide high-precision temperature detection for processors produced using 90 nm or finer geometry.



Structure of a Digital Sensor

is automatically compared to user-specified limit values and an alert signal output is provided to signal if an abnormal measurement is detected. In addition to monitoring functions, the ICs can also incorporate a Pulse-Width Modulator (PWM) output function that can be used to control fan speed based on temperature. The LM94/96194 are available with TruTherm technology.

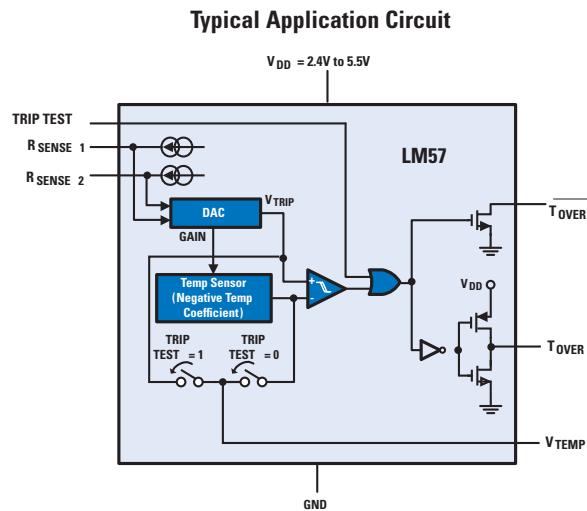


Temperature Sensors

LM26/27 and LM56/57 – PowerWise® Low-Power Temperature Switch with Single or Dual Output

Features

- Combines window comparator output and analog voltage output
- Alarm output temperature is set at the factory (LM26 and LM27)
- 20 μ A to 230 μ A (typ) low supply current
- +2.7V to +5.5V operating supply voltage range
- Detection temperature accuracy:
 - LM26 $\pm 3^{\circ}\text{C}$ (max) (-55°C to 110°C), $\pm 4^{\circ}\text{C}$ (max) (+120°C)
 - LM27 $\pm 3^{\circ}\text{C}$ (max) (-120°C to 150°C)
 - LM56BIM $\pm 2^{\circ}\text{C}$ (max) (-25°C to 85°C)
 - LM57B $\pm 1.5^{\circ}\text{C}$ (max) (-50°C to 150°C)



Analog Temperature Sensors

Product ID	Features	Temp Accuracy ($^{\circ}\text{C}$)	Operating Temp ($^{\circ}\text{C}$)	Operating Supply Voltage Range (V)	Temp Coefficient (mV/C)	Supply Current (μA)	Packaging
LM19/20 E	Low power consumption	$\pm 1.5, \pm 2.5$	-55 to 130	2.4 to 5.5	-11.7	4	SC-70, TO-92, micro SMD-4
LM94021/22/Q E	Low 1.5V operation	± 2.4	-50 to 150	1.5 to 5.5	-5.5/-8.2/10.9/-13.6	5.4	SC70-5
LM94023 E	Low 1.5V operation	± 2.4	-50 to 150	1.5 to 5.5	-5.5/-8.2	5.4	micro SMD-4
LM45	Calibrated in $^{\circ}\text{C}$	$\pm 3, \pm 4.0$	-40 to 125	4.0 to 10	10	120	SOT23/3
LM50	Negative temperature support	$\pm 3, \pm 4.0$	-40 to 150	4.5 to 10	10	130	SOT23-3
LM60	Low voltage support	$\pm 3, \pm 4.0$	-40 to 125	2.7 to 10	6.25	82	SOT23-3, TO-92-3
LM61	Low voltage support	$\pm 3, \pm 4.0$	-30 to 100	2.7 to 10	10	82	SOT23-3, TO-92-3
LM62 E	Low voltage support	$\pm 3, \pm 4.0$	0 to 90	2.7 to 10	15.6	155	SOT23-3

Temperature Switches

Product ID	Accuracy ($^{\circ}\text{C}$)	Trip Point Range ($^{\circ}\text{C}$)	Supply Range (V)	Interrupt Outputs	Interrupt Temp Setting	Analog Temp Sensor	Packaging
LM57 E	$\pm 1.5, 2.3$	-50 to 150	2.4 to 5.5	2	User specified	✓	LLP-8
LM56	$\pm 2, 3, 4$	-40 to 125	2.7 to 10	2	User specified	✓	SOP-8, MSOP-8
LM26LV E	± 2.2	0 to 150	1.6 to 5.5	2	Factory set	✓	LLP-6
LM26 E	± 3	-55 to 125	2.7 to 5.5	1	Factory set	✓	SOT 23-5
LM27	± 3	+120 to 150	2.7 to 5.5	1	Factory set	✓	SOT 23-5

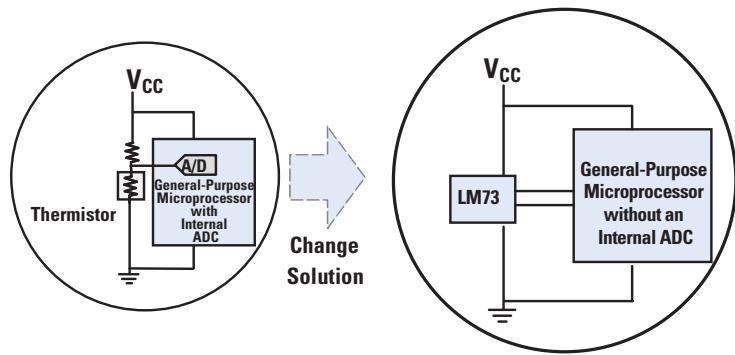
E PowerWise® product

E Evaluation board

LM73 – 13-bit + Sign Digital Temperature Sensor with a 2-Wire Interface

Features

- 2-wire interface (I²C compliant/SMBus 2.0)
- Temperature detection accuracy:
 - ±1.0°C (max) (-10°C to 80°C)
 - ±15°C (max) (-25°C to 115°C)
 - ±2.0°C (max) (-40°C to 150°C)
- 14-bit (13-bit + sign) internal ADC resolution
- ±2.7V to +5.5V supply voltage
- 320 µA (typ) supply current (when interface used),
1.9 µA (typ) (when shut down)



Digital Temperature Sensors

Product ID	Features	Temp Accuracy		Interface	Operating Supply Voltage (V)	Temp Resolutions (°C/LSB)	No. of Interrupts	No. of Available Addresses	Packaging
		Accuracy (°C)	at Range (°C)						
LM71/Q/ LM95071 ^E	High accuracy and resolution	±1.0	0 to 70	MICROWIRE/SPI	2.4 to 5.5	0.03125	—	—	SOT23-5
LM95172Q	175°C operation, high accuracy	±1.2 to 3.5	-40 to 160	SPI	3.0 to 5.5	0.0625	—	—	Die
LM74	Small package	±1.25	-10 to 65	MICROWIRE/SPI	3.0 to 5.5	0.0625	—	—	SOIC-8 Narrow
LM70	Low precision version of LM74	±1.5/2	-10 to 85	MICROWIRE/SPI	2.85 to 5.5	0.125	—	—	MSOP-8, LLP-8
LM95172EWG	High temperature, up to 200°C	±3.0	175 to 200	SPI	3.0 to 5.5	0.0078125	—	—	CERPACK-10
LM92	Highly accurate sensor	±.33 to 1.5	-25 to 150	I ² C compliant bus	2.7 to 5.5	0.0625	2	4	SOIC-8 Narrow
LM76	Precision	±.5, 1.0, 2.5	-10 to 100	I ² C compliant bus	3.0 to 5.5	0.0625	2	4	SOIC-8 Narrow
LM73 ^E	Precision, programmable resolution	±1.0, 1.5	-10 to 110	I ² C compliant/SMBus2.0	2.7 to 5.5	0.03125	1	6	SOT23-6
LM77	Separate open-drain outputs	±1.5, 2	-10 to 100	I ² C compliant bus	3.0 to 5.5	0.25	2	4	SOIC-8 Narrow MSOP-8
LM75A ^E	Industry standard	±2.0	25 to 100	I ² C compliant bus	3.0 to 5.5	0.5	1	8	SOIC-8 Narrow MSOP-8

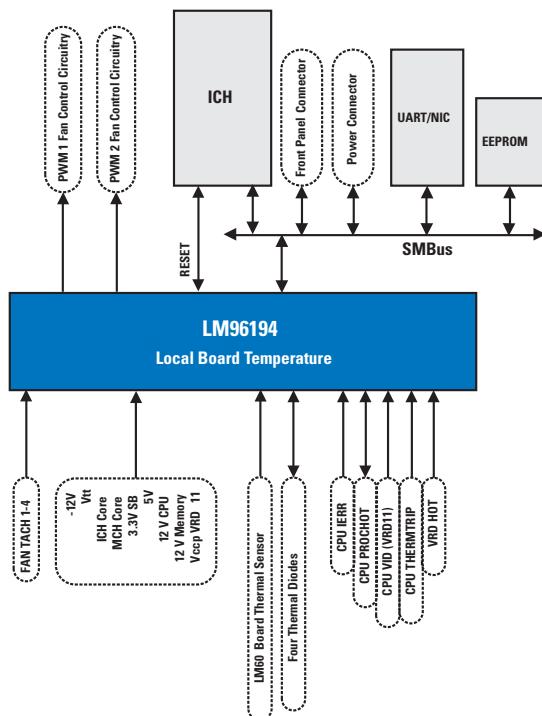
^EEvaluation board

Temperature Sensors

LM96194 – 2-Wire Serial Interface Hardware Monitor IC with Internal TruTherm® Digital Temperature Sensor

Features

- 3.0V to 3.6V supply voltage range
- 2-wire serial bus interface (SMBus)
- Temperature monitoring accuracy
 - Local temperature detection accuracy
±3°C (max) (0°C to 85°C)
 - Remote temperature detection accuracy
±3°C (max) (0°C < T_A < 85°C, 0°C < T_D < 100°C)
±2.5°C (max) (0°C < T_A < 85°C, T_D = 70°C)
- Number of input voltages to be monitored: 9
- Number of fan speeds able to be monitored: 4



Remote Diode Temperature Sensors

Product ID	Remote Temp Accuracy (°C)	Pin-Compatible	Measurement Method	No. of Remote Channels	T _{CRIT}	Comments	Packaging
LM86/89/99 E	±0.75		Traditional	1	1	Factory set addresses	MSOP-8
LM95235/Q E	±0.75		TruTherm®	1	1	Selectable addresses	MSOP-8
LM95245 E	±0.75		TruTherm	1	1	Selectable addresses	MSOP-8
LM95231 E	±1.25		TruTherm	2	—	Factory set addresses	MSOP-8
LM95241	±1.25		TruTherm	2	—	Factory set addresses	MSOP-8
LM95213 E	±1.1		Traditional	0 to 2	3	Selectable addresses	LLP-14
LM95233 E	±0.875		TruTherm	0 to 2	3	Selectable addresses	LLP-14
LM95214 E	±1.1		Traditional	0 to 4	3	Selectable addresses	LLP-14
LM95234 E	±0.875		TruTherm	0 to 4	3	Selectable addresses	LLP-14
LM96194	±2.5		TruTherm	2 to 4	—	Full PI hardware monitor	LLP-48
LM87 E	±3		Traditional	2	1	DAC hardware monitor	TSSOP-24
LM93	±3		Traditional	2	—	Full LUT hardware monitor	TSSOP-56
LM94	±2.5		TruTherm	2 to 4	—	Full PI and LUT hardware monitor	TSSOP-56
LM96163 E	±0.75		TruTherm	1	1	LUT fan control	LLP-10

E PowerWise® product E Evaluation board

LM96080 – System Hardware Monitor with 2-Wire Serial Interface

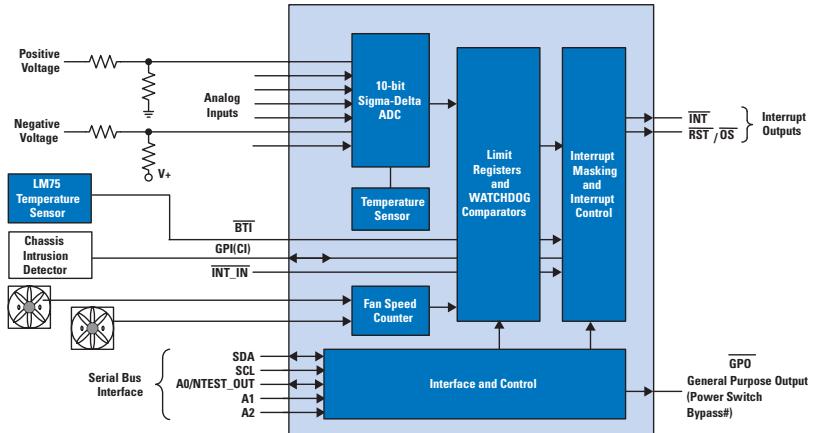
Features

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

Applications

Ideal for use in communications infrastructure, system thermal and hardware monitoring for servers, electronic test equipment and instrumentation, and office electronics

Typical Application Circuit



Hardware Monitors

Product ID	Temp Range (°C)	Temp Accuracy (°C)	Interface	Supply Voltage Range (V)	Temp Resolution (°C)	Remote Diode Thermal Sensor Count	Fan Speed Inputs	Packaging
LM96080 ^E	-40 to 125	±3	I ² C compliant bus	3.0 to 5.5	0.0625	—	2	TSSOP-24
LM81	-25 to 125	±3	SMBus/I ² C compliant bus	2.8 to 3.8	0.0625	—	2	TSSOP-24
LM87 ^E	0 to 100	±2	SMBus/I ² C compliant bus	2.8 to 3.8	0.0625	2	2	TSSOP-24
LM96000 ^E	0 to 125	±2	SMBus	3.0 to 3.6	0.0625	2	4	TSSOP-24
LM93	0 to 100	±2	SMBus	3.0 to 3.6	1	2	4 (max)	TSSOP-56
LM94	0 to 100	±2	SMBus	3.0 to 3.6	0.5	2	4 (max)	TSSOP-56
LM96194	0 to 100	±3	SMBus	3.0 to 3.6	0.5	4	4 (max)	LLP-48

^E Evaluation board

LMK Clock Conditioner Family

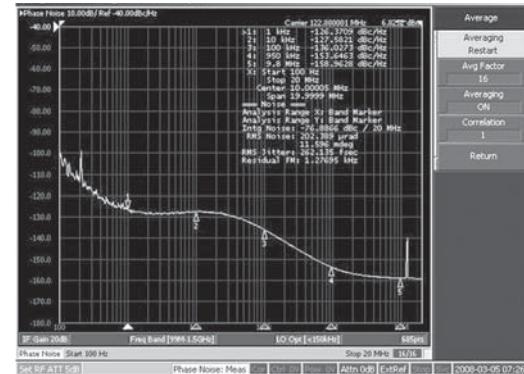
Performance

LMK04000 – Low–Noise Clock Jitter Cleaner with Cascaded PLL

The LMK04000 family of clock jitter cleaners provides ultra-low-noise clocks without external high-performance, voltage-controlled crystal oscillator (VCXO) modules. Using a simple external crystal and cascaded PLLatinum® architecture, the LMK04000 jitter cleaner provides sub-200 fs RMS jitter to improve system performance and accuracy.

Features

- Cascaded architecture (2 PLLs) provides low-noise jitter-cleaner function and clock generation
- Lower BOM cost using internal crystal oscillator circuit
- Ultra-low RMS jitter performance
 - 150 fs RMS jitter (12 kHz to 20 MHz)
 - 200 fs RMS jitter (100 Hz to 20 MHz)
- LVPECL/2VPECL, LVDS, and LVCMS outputs



Applications

Ideal for providing low phase noise reference clocks for local oscillators and sample clocks for ADCs, DACs, and other high-performance components used in wireless infrastructure, test and measurement, medical ultrasound, and imaging equipment

LMK04000 LVPECL Output Phase Noise at 122.88 MHz using a Low-Cost 12.288 MHz Vectron Crystal

- LVPECL noise floor: -160 dBc/Hz
- Output clock frequency: 122.88 MHz
- Jitter performance: 263 fs RMS (100 Hz to 20 MHz)

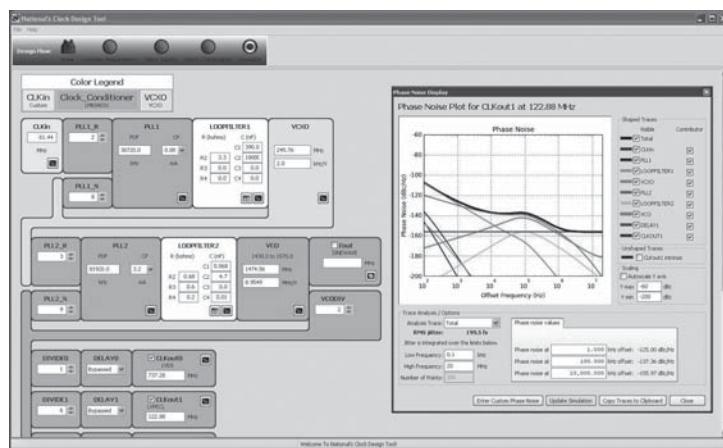
National's Clock Design Tool

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

Features

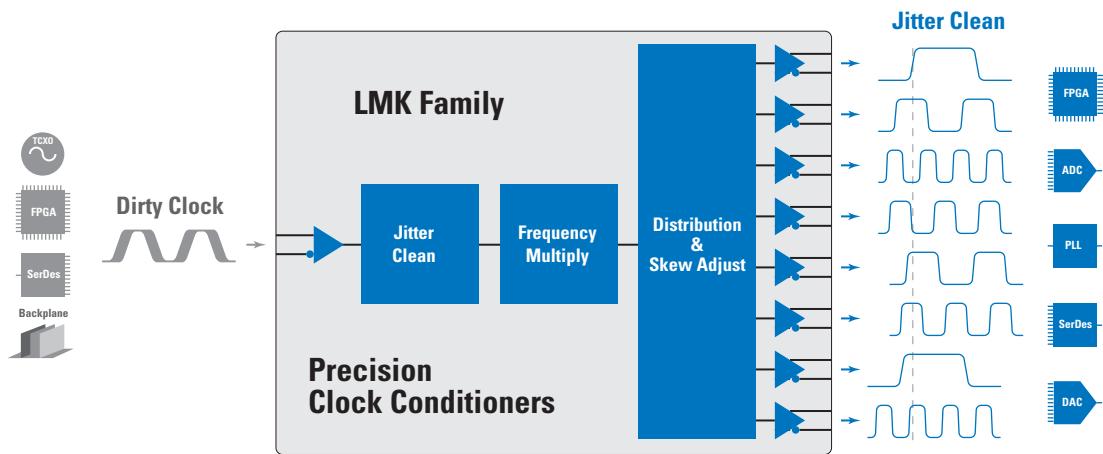
- Easy design parameter entry
- LMK part selection and configuration
- PLL and loop filter customization
- Input clock and VCXO phase noise entry
- Phase noise and jitter simulations and plotting
- Updated to support LMX2531 and LMX2541 part selection and design

To test the Clock Design Tool, visit: national.com/timing



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				
LMK01000 ^E	5	3	0	2:8 Clock Distribution	1 to 1600	NA	0.03 (additive)
LMK01010 ^E	0	8	0		1 to 1600	NA	0.03 (additive)
LMK01020 ^E	8	0	0		1 to 1600	NA	0.03 (additive)
LMK02000 ^E	5	3	0	PLL + Clock Distribution (needs external VCXO)	1 to 860	NA	0.2 (+VCXO)
LMK02002 ^E	4	0	0		1 to 860	NA	0.2 (+VCXO)
LMK03000C ^E	5	3	0	PLL + VCO + Clock Distribution	1 to 648	1185 to 1296	0.4
LMK03000 ^W	5	3	0		1 to 648	1185 to 1296	0.8
LMK03000D	5	3	0		1 to 648	1185 to 1296	1.2
LMK03001C ^E	5	3	0		1 to 785	1470 to 1570	0.4
LMK03001 ^W	5	3	0		1 to 785	1470 to 1570	0.8
LMK03001D	5	3	0		1 to 785	1470 to 1570	1.2
LMK03002C ^E	4	0	0		1 to 860	1566 to 1724	0.4
LMK03002	4	0	0		1 to 860	1566 to 1724	0.8
LMK03033C ^E	4	4	0		1 to 1080	1840 to 2160	0.5
LMK03033	4	4	0		1 to 1080	1840 to 2160	0.8
LMK03200	5	3	0		1 to 800	1185 to 1296	0.8
LMK04000 ^E	3	0	4	Cascaded PLLs + VCO + Clock Distribution (PLL1 requires external Crystal or VCXO)	1 to 648	1185 to 1296	0.15/0.2 (+VCXO/Crystal)
LMK04001 ^E	3	0	4		1 to 785	1430 to 1570	0.15/0.2 (+VCXO/Crystal)
LMK04011 ^E	5	0	0		1 to 785	1430 to 1570	0.15/0.2 (+VCXO/Crystal)
LMK04010	5	0	0		1 to 785	1185 to 1296	0.15/0.2 (+VCXO/Crystal)
LMK04031 ^E	2	2	2		1 to 785	1430 to 1570	0.15/0.2 (+VCXO/Crystal)
LMK04002 ^E	3	0	4		1 to 875	1566 to 1750	0.15/0.2 (+VCXO/Crystal)
LMK04033 ^E	2	2	2		1 to 1080	1840 to 2160	0.15/0.2 (+VCXO/Crystal)

*Integrated from 10 kHz to 20 MHz

^E Evaluation board

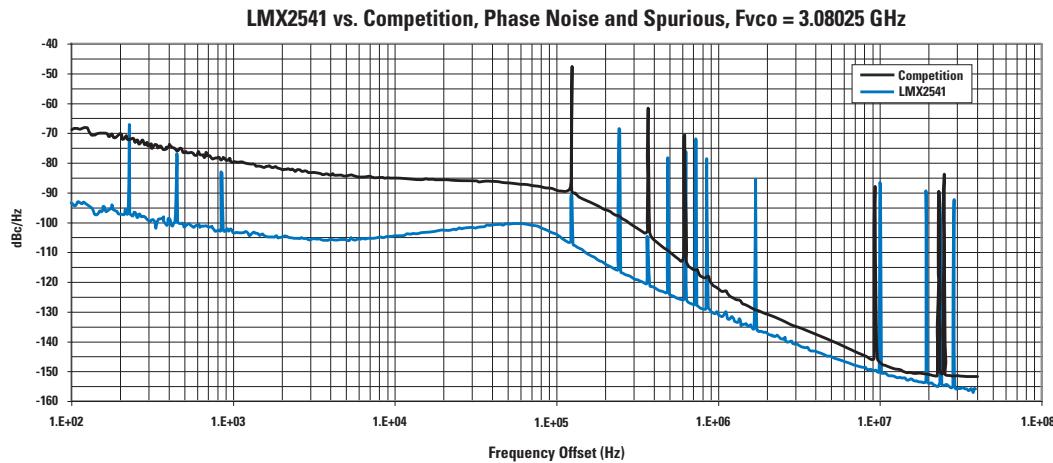
^W WEBENCH enabled

High-Performance Frequency Synthesizers

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 (national.com/timing)
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	Low-Noise Frequency Synthesizers
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: national.com/wireless
Software	PLL Codeloader Evaluation Software
AN-1910	LMK04000 Family Phase Noise Characterization
Web Seminar	Clock Jitter Cleaners

Product ID	VCO Frequency Range (MHz)	Total Device Frequency Range Using Divider Output (MHz)	
LMX2541S02060E	1990 to 2240	31.58	2240
LMX2541S02380E	2200 to 2530	34.92	2530
LMX2541S02690E	2490 to 2865	39.52	2865
LMX2541S03030E	2810 to 3230	44.60	3230
LMX2541S03320E	3130 to 3600	49.68	3600
LMX2541S03740E	3480 to 4000	55.23	4000

High-Performance PLLatinum Family of PLL Products

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

^E Evaluation board^W WEBENCH enabled

LMX2531 PLLatinum Family of High-Performance, Low-Power Synthesizers

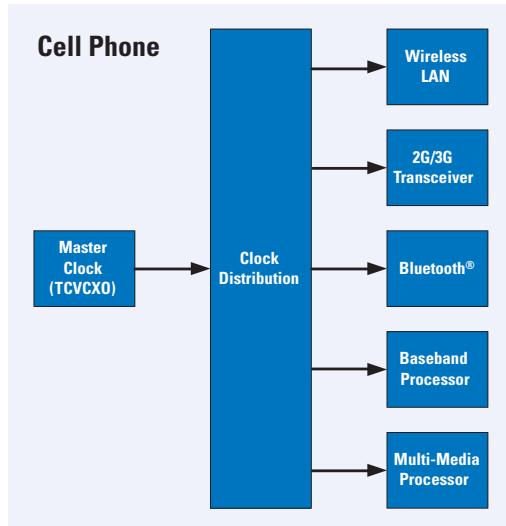
Product ID	Max PLL Freq (MHz)	Min PLL Freq (MHz)	Max Aux PLL Freq (MHz)	Min Aux PLL Freq (MHz)	Normalized PLL Phase Noise (dBc/Hz)	VCO Phase Noise, 100 kHz Offset (dBc/Hz)	Supply Current (mA)
LMX2531LQ1146E	1184	1106	592	553	-212	-121	34
LMX2531LQ1226E	1268	1184	634	592	-212	-121	34
LMX2531LQ1312E	1360	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

Clock Buffers

Master Clock Distribution in Cell Phones; Optimized Clock Distribution Solution

Features

- Proper clock distribution circuitry optimizes bit error rate
- Isolates master clock from switching noise in digital modules
- Isolates sensitive modules from noise in other modules
- Preserves clock amplitude; high drive capability, minimal clock loading
- Prevents frequency pulling; constant clock load impedance under all conditions
- Preserves clock accuracy: low additive phase noise
- Low power consumption
- Tiny footprint

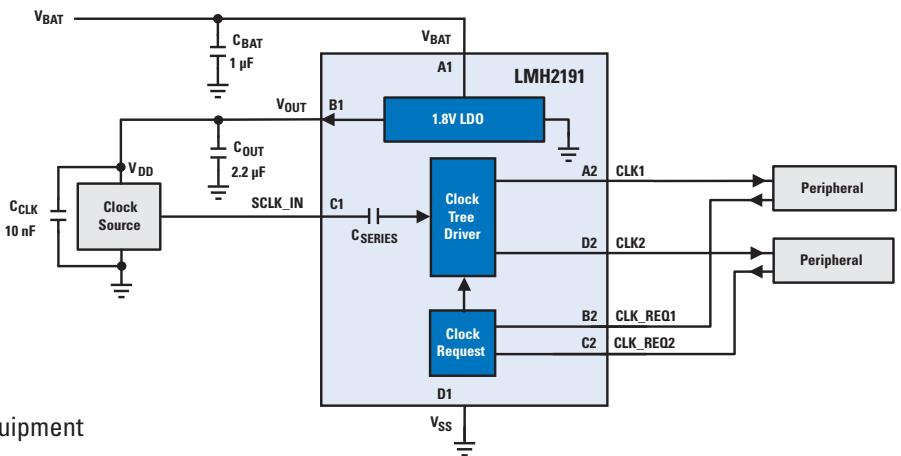


LMH2191 – 2-Channel Clock Buffer with Very Low Phase Noise

Features

- 1 input clock, 2 output clocks
- Very low phase noise: 150 dBc/Hz at 10 kHz (26 MHz)
- Independent clock request pins
- Supports both square or sine wave input
- High isolation of supply noise to clock input
- 50 pF output drive capability
- Integrated LDO
 - 10 mA output current
 - 18 μ Vrms output voltage noise
- Ultra-low standby current

Typical Application Circuit



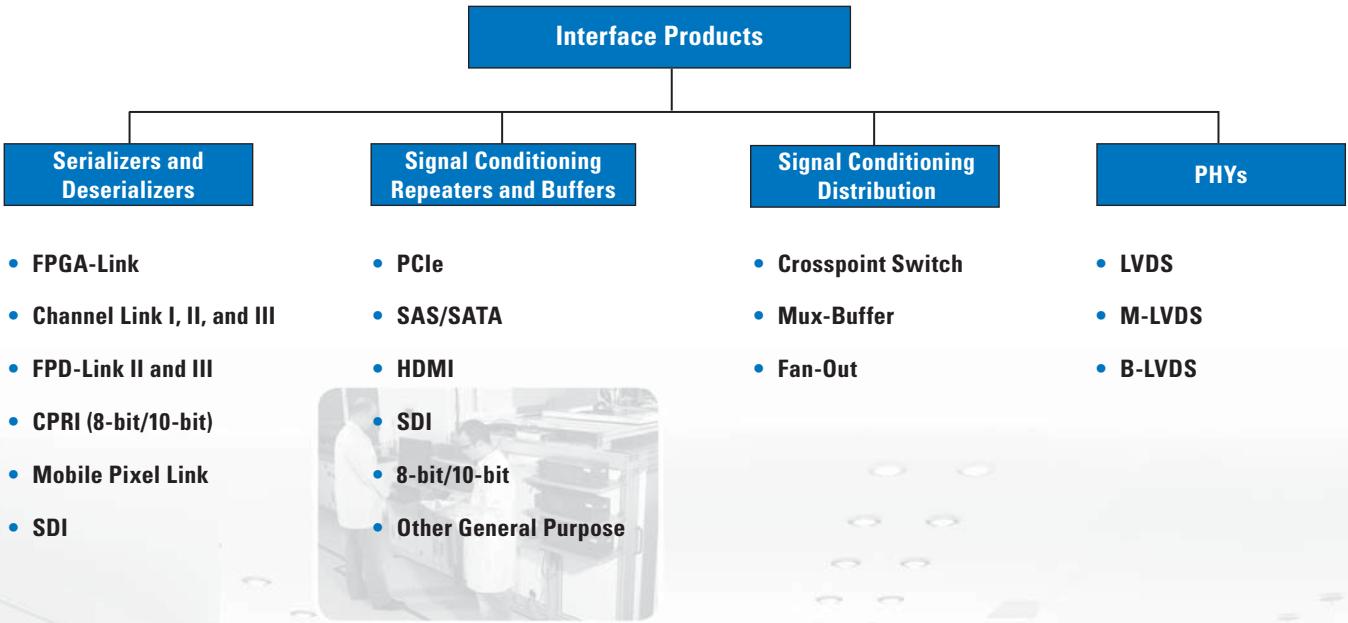
Applications:

Ideal for use in mobile handsets and portable equipment

Product ID	Bandwidth (MHz)	Channels	I _{sup} (mA)	Phase Noise (dBc/Hz)	Slew Rate	Shutdown	Output	Packaging
LMH2191 E	52	2	0.75/ch	-150, 26 MHz, 10 kHz offset	—	✓	Digital	micro SMD-8 (1.015 x 1.615 mm)
LMH2190 E	27	4	0.75/ch	-152, 26 MHz, 10 kHz offset	—	✓	Digital	micro SMD-16 (1.65 x 1.65 mm)
LMH2180 E	75	2	1.15/ch	-132, 26 MHz, 10 kHz offset	106 V/ μ s	✓	Analog	LLP-8, micro SMD-8
LMV112 E	40	2	0.8/ch	-116, 38.4 MHz, 10 kHz offset	110 V/ μ s	✓	Analog	LLP-8
LMV116	45	1	0.6/ch	—	40 V/ μ s	—	Analog	SOT23-5
LMV118	45	1	0.6/ch	—	40 V/ μ s	✓	Analog	SOT23-6

E Evaluation board

Interface Product Portfolio



Ethernet PHYTER® Transceivers

- Precision
- Single
- Mini
- Dual

See national.com/interface for:

- RS-232, 422/23, 485
- UARTs
- USB
- SCAN/JTAG
- FPD-Link/LDI

Also see Clock and Timing on page 60

Serializers and Deserializers

Reduce Parallel Width, EMI – Extend Your Reach

World's Most Robust Serial Interface Solutions for Industrial Imaging, Display, and Control Applications

Features

- Wider operating frequency
- Broad portfolio
- Integrated signal conditioning
- FPGA friendly
- Easy to use
- Low EMI, high ESD protection



Wide Ser/Des Portfolio – Select Applicable Family

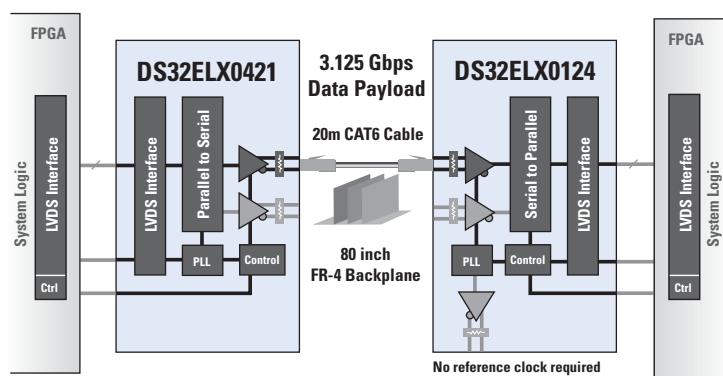
Family	Target Segment	Max Payload (Gbps)	Embedded Clock	Signal Conditioning	Typical Reach at 1.5 Gbps over CAT-5	Fiber Support	Comments
FPGA-Link	Industrial/Embedded	3.125	✓	Advanced EQ, DE	40m	✓	Includes redundant I/O, retimed serial output
Channel Link III	Industrial/Embedded	1.4	✓	Moderate	10m	—	Includes bi-directional control channel
Channel Link II	Industrial/Embedded	2.7	✓	Moderate	10m	✓ (Select products)	Available with LVDS or LVC MOS interface
Channel Link	Industrial/Embedded	6.4 (Multi-lane)	—	Limited	0.5m	—	Standard for machine-vision applications
FPD-Link III	Automotive	2.975	✓	Adaptive EQ	10m	—	AEC-Q100 qualified
FPD-Link II	Automotive	1.5	✓	Moderate	10m	✓	AEC-Q100 qualified
FPD-Link	Industrial/Embedded	9.45 (Multi-lane)	—	Limited	0.5m	—	Wide portfolio for LVDS display interface

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

Features

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

Typical Application Circuit



Serializers and Deserializers

Industrial Video, Imaging, and Display

Family	Embedded Clock	Signal Conditioning	Embedded DC-Balance	Product ID		Parallel Width	Parallel I/O	Min Freq (MHz)	Max Freq (MHz)	Mux Ratio
				Serializer	Deserializer					
FPGA-Link	✓	Advanced Rx EQ, Tx Driver Redundant I/Os Retimed Serial Output	✓	DS32EL0421	DS32EL0124	5	LVDS	125	312.5	ANY:1
			✓	DS32ELX0421	DS32ELX0124	5	LVDS	125	312.5	ANY:1
Channel Link III	✓	Moderate Rx EQ, Tx De-Emphasis	✓	DS92LX1621	DS92LX1622	16	LVC MOS	10	50	16:1
			✓	DS92LX2121	DS92LX2122	21	LVC MOS	10	50	21:1
Channel Link II	✓	Moderate Rx EQ, Tx De-Emphasis	✓	DS92LV2411	DS92LV2412	24	LVC MOS	5	50	24:1
			✓	DS92LV0411	DS92LV0412	4	LVDS	5	50	4:1
			✓	DS99R103	DS99R104	24	LVC MOS	3	40	24:1
			✓	DS92LV3241	DS92LV3242	32	LVC MOS	20	85	32:4
			✓	DS92LV3221	DS92LV3222	32	LVC MOS	20	50	32:2
Channel Link	—	—	—	DS90CR217	DS90CR218A	21	LVC MOS	20/12	85	21:3
			—	DS90CR287	DS90CR288A	28	LVC MOS	20	85	28:4
			✓	DS90CR483A	DS90CR484A	48	LVC MOS	33	112	48:8
			✓	DS90CR485	DS90CR486	48	LVC MOS	66	133	48:8
8-/10-Bit Ser/Des	✓	Moderate Rx EQ, Tx Driver	✓	SCAN25100	SCAN25100	10	LVC MOS	30.72	122.88	10:1
10-/16-/18-Bit Ser/Des	✓	—	—	DS92LV1021A	DS92LV1212A	10	LVC MOS	16	40	10:1
			—	SCAN921025H	SCAN921226H	10	LVC MOS	20	80	10:1
			—	SCAN928028	SCAN926260	nx10	LVC MOS	25/16	66	10:1
			—	DS92LV16	DS92LV16	16	LVC MOS	25	80	16:1
			—	DS92LV18	DS92LV18	18	LVC MOS	15	66	18:1

FPD-Link

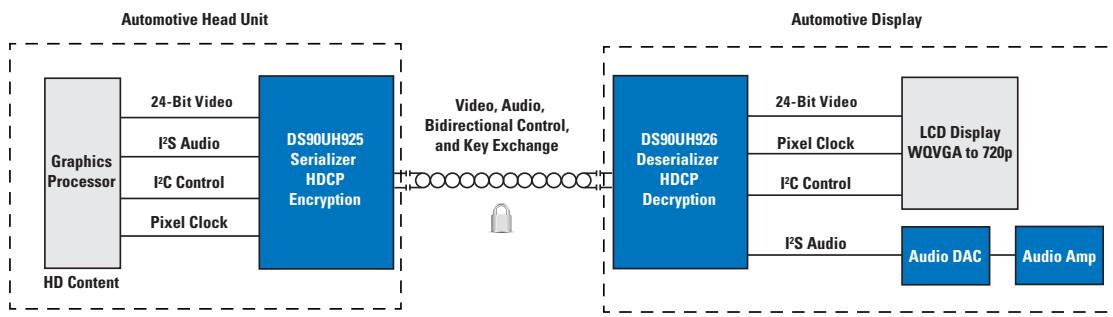
Automotive Infotainment Systems

DS90UH92X – FPD-Link III Bidirectional Control Ser/Des with HDCP

Features

- HDCP cipher integrated in Ser/Des
- FPD-Link III delivers content-protected video on 2 wires
 - Provides bidirectional control channel for HDCP key exchange

- Display enhancements
 - White balancing, dithering, test pattern generator
- I²S digital audio support
 - Integrated jitter cleaning for audio clock
- Single power supply w/ integrated regulator



FPD-Link II and III Ser/Des

Product ID	Description	Pixel Clock Rate (MHz)	Graphics Bits (bpp)	Function	Packaging	Auto Grade
Serializers						
^{NEW} DS90UH925	5 to 85MHz, 24-bit, FPD-Link III LVCMOS with HDCP	5 to 85	24	HDCP cipher and key exchange, real-time bidirectional control	LLP-48	(2)
^{NEW} DS90UB903 E	10 MHz to 43MHz, 18-bit, FPD-Link III LVCMOS	10 to 43	18	Real-time bidirectional control	LLP-40	(2)
^{NEW} DS90UB901 E	10 MHz to 43MHz, 14-bit, FPD-Link III LVCMOS	10 to 43	14	Real-time bidirectional control, CRC checking for video and control data	LLP-32	(2)
^{NEW} DS90UR907 E	5 to 65 MHz, 24-bit color FPD-Link II converter	65	24	Converts, balances, and level shifts 4 LVDS streams	LLP-36	(2)
^{NEW} DS90UR905 E	5 to 65 MHz, 24-bit, FPD-Link II LVCMOS	65	24	Embeds the clock and balances data payload	LLP-48	(2)
DS99R421 E	5 to 43 MHz, 18-bit color FPD-Link II converter	43	18	AC-coupled, DC balance, BIST, enhanced serial link randomization	LLP-36	(2)
DS90UR241 E	5 to 43 MHz, 18-bit color FPD-Link II LVDS	43	18	AC-coupled, DC balance, Built-In Self Test (BIST), scrambling to lower EMI	TQFP-64	(2)
DS90C241 E	5 to 35 MHz, 18-bit color FPD Link II LVDS	35	18	AC-coupled, DC balance	TQFP-48	(2)
Deserializers						
^{NEW} DS90UH926	5 to 85MHz, 24-bit, FPD-Link III LVCMOS with HDCP	5 to 85	24	HDCP cipher and key exchange, real-time bidirectional control	LLP-60	(2)
^{NEW} DS90UB904 E	10 MHz to 43MHz, 18-bit, FPD-Link III LVCMOS	10 to 43	18	Real-time bidirectional control	LLP-48	(2)
^{NEW} DS90UB902 E	10 MHz to 43MHz, 14-bit, FPD-Link III LVCMOS	10 to 43	14	Real-time bidirectional control, CRC checking for video and control data	LLP-40	(2)
^{NEW} DS90UR908 E	5 to 65 MHz, 24-bit color FPD-Link II converter	65	24	Receives data and control signals, extracts clock	LLP-48	(2)
^{NEW} DS90UR906 E	5 to 65 MHz, 24-bit color FPD-Link II	65	24	Receives data and control signals, level shifts signals	LLP-60	(2)
DS99R124 E	5 to 43 MHz, 18-bit color FPD-Link II converter	43	18	AC-coupled, DC balance, BIST, enhanced serial link randomization	LLP-36	(2)
DS90UR124 E	5 to 43 MHz, 18-bit color FPD Link II LVDS	43	18	AC-coupled, DC balance, BIST, frequency spread PTO, slew rate control to lower EMI	TQFP-64	(2)
DS90C124 E	5 to 35 MHz, 18-bit color FPD-Link II LVDS	35	18	AC-coupled, DC balance, adjustable PTO to lower EMI	TQFP-48	(2)

PowerWise® product

^E Evaluation board

Automotive Grade

(2) AECQ Temperature Grade 2

LVDS and CML Repeaters, Equalizers

Signal Conditioning – Extend Your Reach

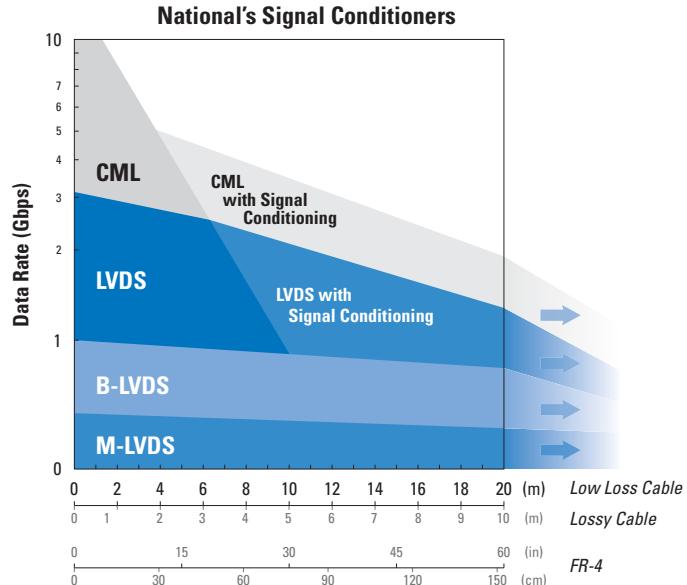
National offers an array of signal conditioning solutions, covering data rates from DC to 10 Gbps and topologies ranging from point-to-point to 32 multidrop loads.

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

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

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

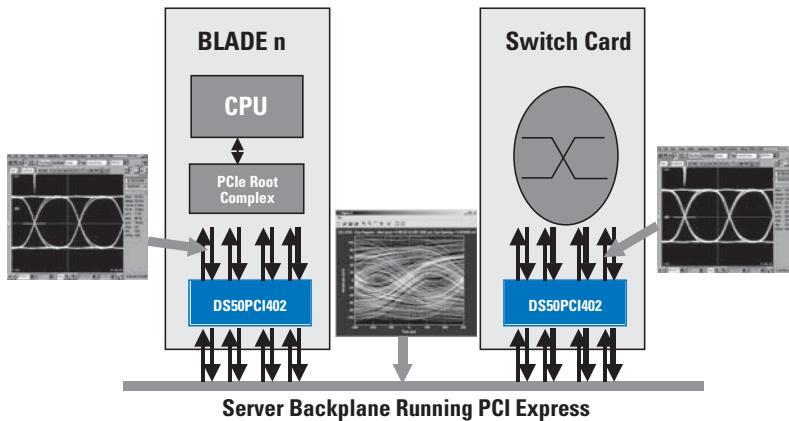
B-LVDS and M-LVDS are lower-speed technologies that use controlled edge rates to improve signal integrity when driving multiple loads in multidrop or multipoint configurations.



DS50PCI402 – PCIe Standards Approved Gen-1/2 Quad Transceiver

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

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



Signal Conditioners

PCIe, SAS, SATA, CPRI, HDMI, Infiniband, and Other High Speed

Protocol Aware Signal Conditioners								
Product ID	Channels	Protocol	Max Speed/Ch (Gbps)	Input SigCon (Max dB)	Output SigCon (Max dB)	Power/Ch (mW)	Packaging	Control Interface
DS50PCI402 E	8	PCIe	5.0	26	-12	95	LLP-54	Pin or SMBus
DS50EV401 E	4	PCIe	8.0	20	—	223	LLP-48	Pin
DS64BR401 E	8	SAS/SATA	6.4	33	-12	95	LLP-54	Pin or SMBus
DS34RT5110 E	3 (TMDS)	HDMI/DVI	3.4	27	-9.0	275	LLP-48	Pin
DS22EV5110 E	3 (TMDS)	HDMI/DVI	2.25	30	-9.0	275	LLP-48	Pin
DS16EV5110A E	3 (TMDS)	HDMI/DVI	2.25	30	—	119	LLP-48	Pin or SMBus
Protocol Agnostic Signal Conditioners								
Product ID	Channels	I/O Compatibility	Max Speed/Ch (Gbps)	Input SigCon (Max dB)	Output SigCon (Max dB)	Power (mW)	Packaging	Configuration
DS80EP100 E	1	LVDS/LVPECL/CML	12.5	7.0	—	0	LLP-6	Fixed
DS64EV400 E	4	LVDS/LVPECL/CML	10	24	—	90	LLP-48	Pin or SMBus
DS64BR401 E	8	LVDS/LVPECL/CML	6.4	33	-12	95	LLP-54	Pin or SMBus
DS50EV401 E	4	LVDS/LVPECL/CML	8.0	20	—	223	LLP-48	Pin
DS38EP100 E	1	LVDS/LVPECL/CML	5.0	7.0	—	0	LLP-6	Fixed
DS42BR400 E	8	CML	4.2	5.0	-9.0	163	LLP-60	Fixed EQ, Pin DE
DS32EV400 E	4	LVDS/LVPECL/CML	3.2	14	—	90	LLP-48	Pin or SMBus
DS25BR440	4	LVDS/LVPECL/CML	3.125	4.0	+6.0	134	LLP-40	Pin
DS25BR400 E	8	CML	2.5	5.0	-9.0	163	LLP-60	Fixed EQ, Pin DE
DS25BR100 E	1	LVDS/LVPECL/CML	3.125	8.0	+6.0	115	LLP-8	Pin
DS15EA101 E	1	0.8V Diff. IN	1.5	35	—	210	LLP-16	Adaptive
DS15BA101 E	1	LVDS/LVPECL/CML	1.5	—	—	150	LLP-8	Fixed
Protocol Agnostic Buffers, Stub-Hiders								
Product ID	Channels	I/O Compatibility	Max Speed/Ch (Gbps)	Input SigCon (Max dB)	Output SigCon (Max dB)	Power (mW)	Packaging	Configuration
DS90LV004	4	LVDS/LVPECL/CML	1.5	—	6.0	96	TQFP-48	Pin PE
SCAN90004 E	4	LVDS/LVPECL/CML	1.5	—	6.0	96	TQFP-48	Pin PE
DS90LV001 E	1	LVDS/LVPECL/CML	0.8	—	—	155	LLP-8, SOIC-8 Narrow	None
DS90LV804	4	LVDS/LVPECL/CML	0.8	—	—	96	LLP-32	None
DS92001	1	LVDS/LVPECL/CML	0.4	—	—	165	LLP-8, SOIC-8 Narrow	None

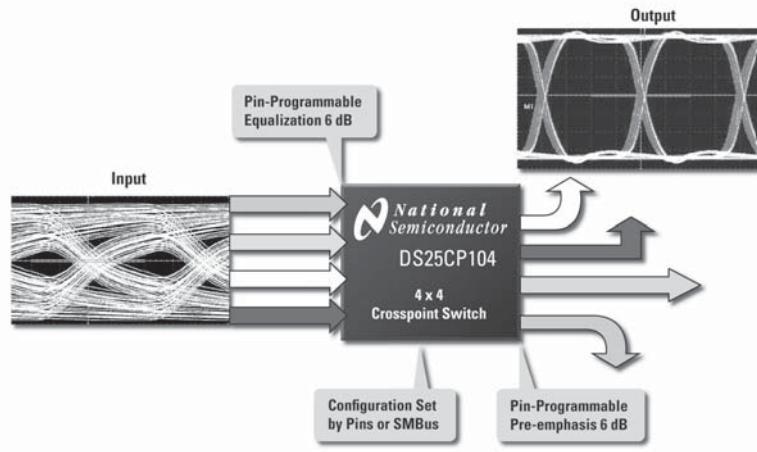
PowerWise® product

E Evaluation board

LVDS and CML Crosspoints, Mux-Buffers, Fan-Outs

Distribute Your Signal, Create Copies

DS25CP104A – PowerWise® LVDS 4 x 4 Crosspoint Switch



Features

- 3.125 Gbps maximum data rate
- 6 dB equalization, 6 dB pre-emphasis compensates for lossy cables, backplanes
- Crosspoint configurable using external pins or SMBus
- 35 ps maximum total jitter
- 518 mW typ power consumption
- Additional configurations available
 - DS25CP102 : 3.125 Gbps 2 x 2
 - DS10CP154A : 1.5 Gbps 2 x 2
 - DS25CP152Q: AEC-Q100 (automotive) grade

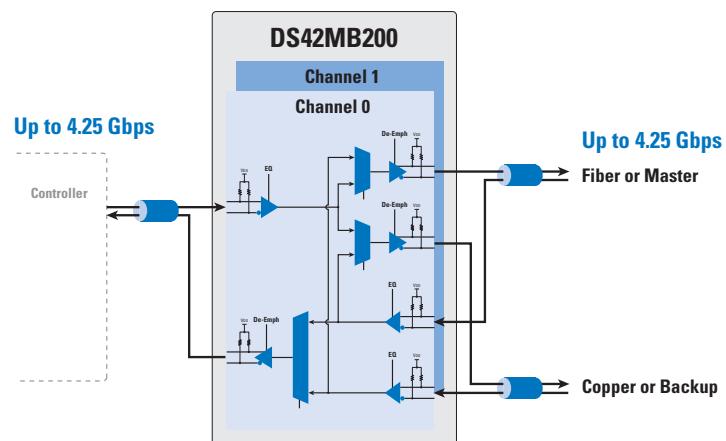
Applications

Ideal for use in routing and switching of video, data, or clock signals, and redundancy

DS42MB200 – Dual-Channel, 4.25 Gbps Redundancy Switch

Features

- 2:1 multiplexer and 1:2 fan-out
- 1 to 4.25 Gbps fully differential data paths
- Fixed input equalization
- Programmable output pre-emphasis
- Independent switch and line side pre-emphasis controls
- Programmable switch-side loopback mode
- On-chip terminations
- For AC-coupled CML interfaces
- Available in 7 x 7 mm flow-through LLP-48 package



Signal Distribution

Crosspoint, Mux-Buffers, Fan-Outs

Crosspoint Switch								
Product ID	Switch Size	Control Interface	Max Speed/Ch (Gbps)	Input SigCon (Max dB)	Output SigCon (Max dB)	Power (mW)	Packaging	Comments
DS25CP104A^E	4 x 4	Pin or SMBus	3.125	EQ	Pre-E	518	LLP-40	
DS25CP102^E	2 x 2	Pin selectable	3.125	EQ	Pre-E	254	LLP-16	Available in AEC-Q
DS25CP152	2 x 2	Pin selectable	3.125	—	—	211	LLP-16	Available in AEC-Q
DS10CP154A^E	4 x 4	Pin or SMBus	1.5	—	—	380	LLP-40	
DS10CP152^E	2 x 2	Pin selectable	1.5	—	—	191	SOIC-16 Narrow	Available in AEC-Q
SCAN90CP02^E	2 x 2	Pin selectable	1.5	—	Pre-E	140	LLP-28, LQFP-32	
DS90CP22^E	2 x 2	Pin selectable	0.8	—	—	330	TSSOP-16, SOIC-16 Narrow	
Mux-Buffer (2:1 Redundancy Switch)								
Product ID	Mux Ratio	Ports	Max Speed/Ch (Gbps)	Input SigCon (Max dB)	Output SigCon (Max dB)	Power (mW)	Packaging	Comments
DS42MB200	2:1 & 1:2	2	4.25	EQ	Pre-E	1000	LLP-48	Loopback
DS42MB100	2:1 & 1:2	1	4.25	EQ	Pre-E	450	LLP-36	Loopback
DS25MB200	2:1 & 1:2	2	2.5	EQ	Pre-E	1000	LLP-48	Loopback
DS25MB100^E	2:1 & 1:2	1	2.5	EQ	Pre-E	450	LLP-36	Loopback
DS15MB200	2:1 & 1:2	2	1.5	—	Pre-E	743	LLP-48	15 kV ESD
SCAN15MB200^E	2:1 & 1:2	2	1.5	—	Pre-E	743	LLP-48	15 kV ESD, JTAG
Fan-Outs (1:n Repeater)								
Product ID	Mux Ratio	Input Channel	Max Speed/Ch (Gbps)	Input SigCon (Max dB)	Output SigCon (Max dB)	Power (mW)	Packaging	Comments
DS25BR204^E	1 to 4	2	3.125	EQ	Pre-E	495	LLP-40	LVDS/LVPECL/CML to LVDS
DS10BR254	1 to 4	2	1.5	—	—	373	LLP-40	LVDS/LVPECL/CML to LVDS
DS90LV110AT	1 to 10	1	0.4	—	—	413	TSSOP-28	LVDS/LVPECL/CML to LVDS
DS91M124^E	1 to 4	1	0.25	—	—	215	SOIC-16	LVC MOS to M-LVDS
DS91M125^E	1 to 4	1	0.25	—	—	221	SOIC-16	LVDS to M-LVDS
DS92CK16	1 to 6	1	0.25	—	—	66	TSSOP-24	Clock distribution

^E Evaluation board

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

Extend Your Reach, Translate Your Signals

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

Two versions of LVDS have been optimized for multipoint: Bus LVDS (B-LVDS) and Multipoint LVDS (M-LVDS). B-LVDS shares many of the characteristics of LVDS but has much higher

current drive (10 mA typ) and controlled (slower) edge rates. B-LVDS is designed specifically for driving multiple loads and in a well-designed backplane can support up to 32 loads. M-LVDS includes all of the desirable attributes for multidrop including increased drive, slow controlled edges, tighter input thresholds, and a wider common mode. M-LVDS is capable of driving 32 loads at speeds up to 250 Mbps.

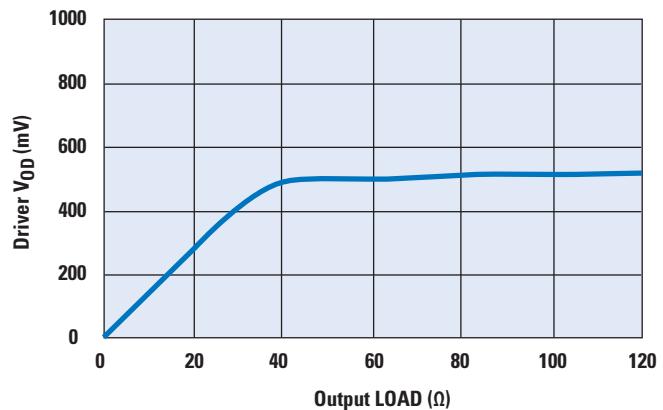
National LVDS/M-LVDS/B-LVDS devices can be used for data and clock distribution.

DS91C176 and DS91D176 M-LVDS Transceivers

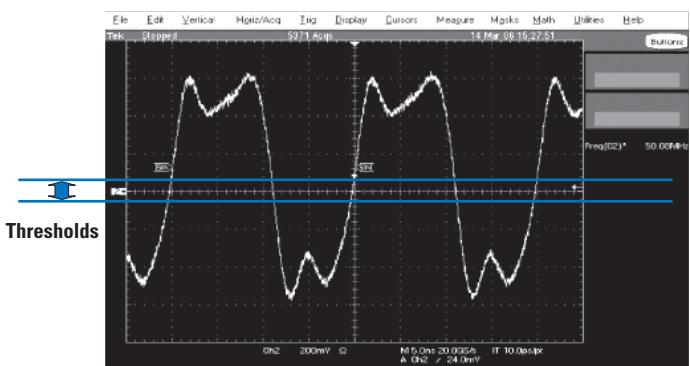
Features

- Meets TIA/EIA-899 M-LVDS standard
- Capable of driving 32 M-LVDS loads
- Controlled 1.8 ns (typ) edge rates tolerant to stubs
- Wide 1.4V to 3.8V input common mode for increased noise immunity
- DS91D176 has type-1 receiver input
- DS91C176 has type-2 100 mV offset fail-safe support
- Up to 200 Mbps operation
- Industrial temperature range
- Single 3.3V supply
- Pin-for-pin compatible replacement for TI SN65MLVDS200, 201, 204, 206
- Available in SOIC-8 packaging

DS91C176 Typical Performance



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



LVDS, M-LVDS, B-LVDS

LVDS Drivers, Receivers, Transceivers

Product ID	Function	Ports	Max Speed/ Ch (Mbps)	IN Signal	OUT Signal	Power (mW)	Packaging	Comments
DS90LV017A	Line driver	1	600	LVTTL	LVDS	17	SOIC-8	>8 kV ESD
DS90LV027A	Line driver	2	600	LVTTL	LVDS	27	SOIC-8	Available in AEC-Q
DS90LT012A	Receiver	1	400	LVDS	LVTTL	18	SOT23-5	Available in AEC-Q
DS90LV011A	Line driver	1	400	LVTTL	LVDS	17	SOT23-5	Available in AEC-Q
DS90LV018A	Receiver	1	400	LVDS	LVTTL	18	SOIC-8	>7 kV ESD
DS90LV028A	Receiver	2	400	LVDS	LVTTL	18	SOIC-8, LLP-8	Available in AEC-Q
DS90LV047A	Line driver	4	400	LVTTL	LVDS	14	SOIC-16, TSSOP-16	Ganged enable
DS90LV048A	Receiver	4	400	LVDS	LVTTL	30	SOIC-16, TSSOP-16	Ganged enable
DS90LV049	Driver+receiver	2+2	400	LVTTL/LVDS	LVTTL/LVDS	70	TSSOP-16	Dual pair, available in AEC-Q
DS90C031B	Line driver	4	155	TTL	LVDS	20	SOIC-16	Robust inputs
DS90C032B	Receiver	4	155	LVDS	TTL	18	SOIC-16	Power off high Z, failsafe
DS36C200	Transceiver	2	100	TTL/LVDS	TTL/LVDS	55	SOIC-14	IEEE1394 compatible
DS90LV019	Driver/receiver pair	1+1	100	TTL/LVTTL/LVDS	TTL/LVTTL/LVDS	45	SOIC-14, TSSOP-14	3.3V or 5V operation

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

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

^E Evaluation board

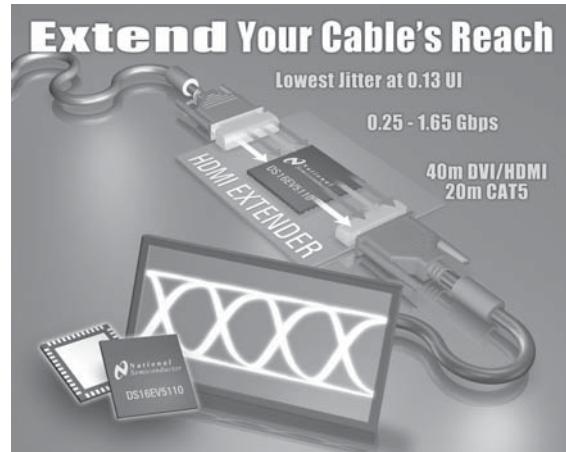
Eye-Opening Cable Equalizers for HDMI/DVI Applications

Features

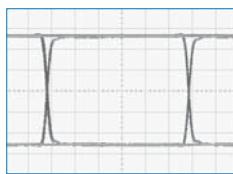
- Significantly extends the reach of DVI, HDMI, and CAT-5 cables
- Pin-selectable boost for equalization optimization
- Pin-selectable de-emphasis for signal conditioning optimization (DS34RT5110)
- Low output jitter
- DS16EV5110A EQ supports 1080p applications – 225 MHz/6.75 Gbps
- DS22EV5110 Super-EQ supports 1080p applications
- DS34RT5110 reclocking EQ supports 1080p/1440p and/or deeper-color/higher-resolution/higher-frame rate applications – 340 MHz/10.2 Gbps
 - Enables multi-hop applications

Applications

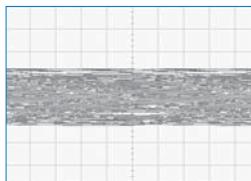
Ideal for use in HDTVs, projectors, extenders, and dongles



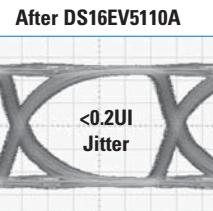
Video Source



Input signal after 25m 28 AWG DVI cable, 1.65 Gbps



DS16EV5110A
EV

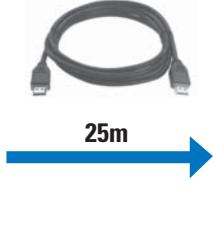


After DS16EV5110A

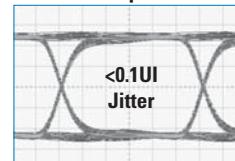
Cable Extending Equalizers

Product ID	Function	Input Equalization	Output	Clock Rate (MHz)	Application	Packaging
DS16EV5110A E	Equalizer	8 levels, pin-selectable	CML	165/225	Sink	LLP-48
DS22EV5110 E	Equalizer	8 levels, pin-selectable	CML w/ De-E	165/225	Source, sink	LLP-48
DS34RT5110 E	Reclocking equalizer	8 levels, pin-selectable	CML w/ De-E	165/225/ 340	Source, multi-hop, repeat, sink	LLP-48

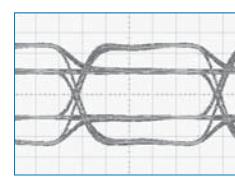
E Evaluation board



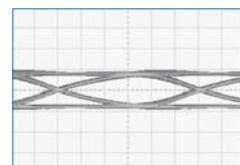
After DS34RT5110/ DS22EV5110 without De-Emphasis



DS34RT5110
RT



At Sink Device After 10m 28 AWG



After DS34RT5110/ DS22EV5110 with De-Emphasis

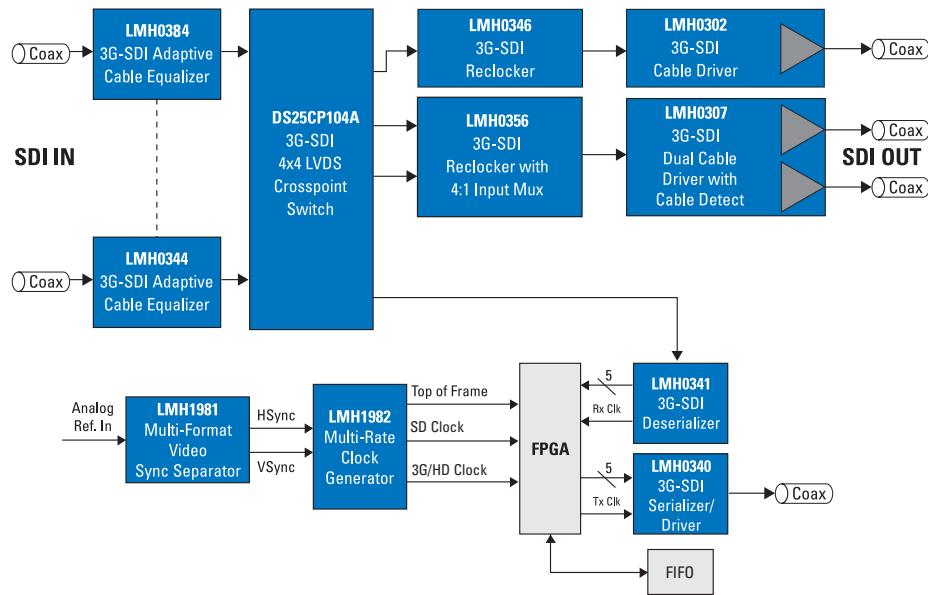
Comprehensive 3 Gbps SDI Solution

3G/HD/SD SDI Equalizer, Deserializer, Serializer, Reclocker, and Cable Driver

National is the first semiconductor supplier to offer a complete end-to-end solution for the rapidly emerging 3 Gbps SDI market. Each of National's 3G-SDI products has a footprint-compatible counterpart for HD/SD and SD-only applications to maximize

designer flexibility in building a system. From HD/SD operation today with an upgrade path to 3 Gbps SDI tomorrow, National's technology offers solutions for any and all SDI needs.

3G/HD/SD SDI Switcher Simplified Block Diagram



Complete SDI Solutions

	Equalizers	Reclockers	Cable Drivers	Serializers	Deserializers	Video Clocking Products
3G	LMH0384 LMH0344	LMH0356 LMH0346	LMH0307 LMH0303 LMH0302	LMH0340	LMH0341	LMH1982 LMH1983 LMH1981
HD	LMH0044 LMH0034	LMH0056 LMH0046	LMH0002 LMH0202	LMH0050 LMH0040 LMH0030	LMH0051 LMH0041 LMH0031	
SD	LMH0024 LMH0074	LMH0036 LMH0026	LMH0001	LMH0070	LMH0071	

Triple-Rate SDI Development Platform for Altera FPGAs

In collaboration with Altera, National Semiconductor has developed a triple-rate SDI and video clocking daughter card for Altera FPGA development kits. National's daughter card is compatible with both the Cyclone-III and the Stratix-III development kits. It plugs directly into the host FPGA development board via Altera's High-Speed Mezzanine Connector (HSMC).

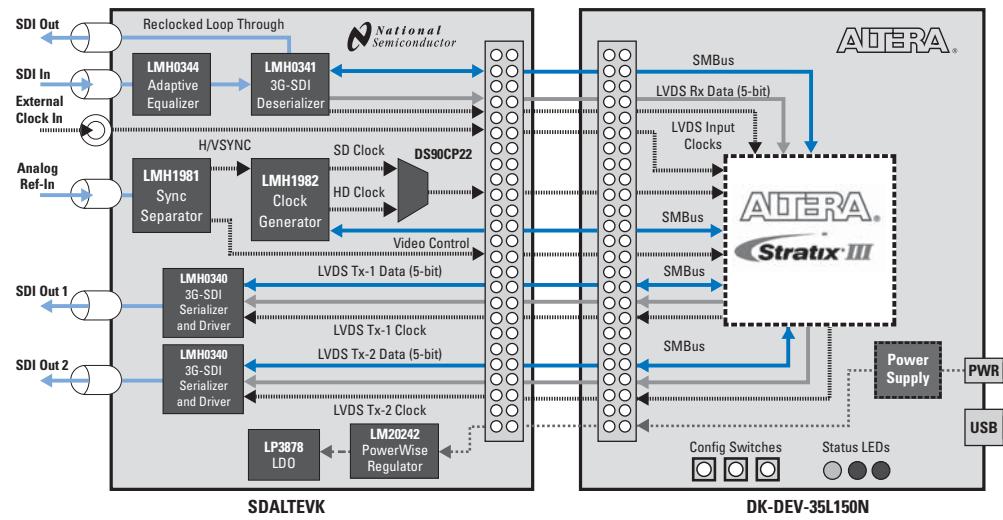
National provides FPGA source code for SMPTE protocol processing (included with the purchase of an evaluation kit or ICs). The FPGA IP along with the daughter card and the FPGA development kit provide broadcast video system designers a comprehensive platform for rapid evaluation and prototyping of new designs, thereby reducing time to market.

Features

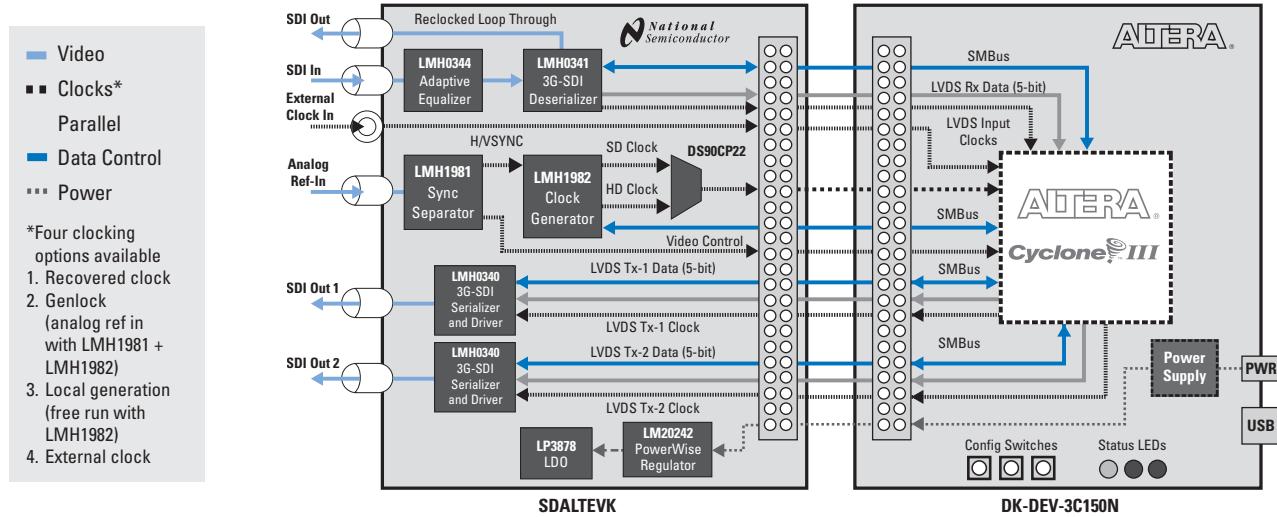
- 3G, HD, and SD compatible
- Comprehensive reference for hardware design and FPGA IP development
- Included HDL (Verilog, VHDL source) supports SDI framing, audio embedding/de-embedding, and test pattern generation
 - IP available for both Cyclone-III and Stratix-III FPGAs
- Support for Genlock

INTERFACE

3G-SDI Development Platform with Altera Stratix-III FPGA



3G-SDI Development Platform with Altera Cyclone-III FPGA



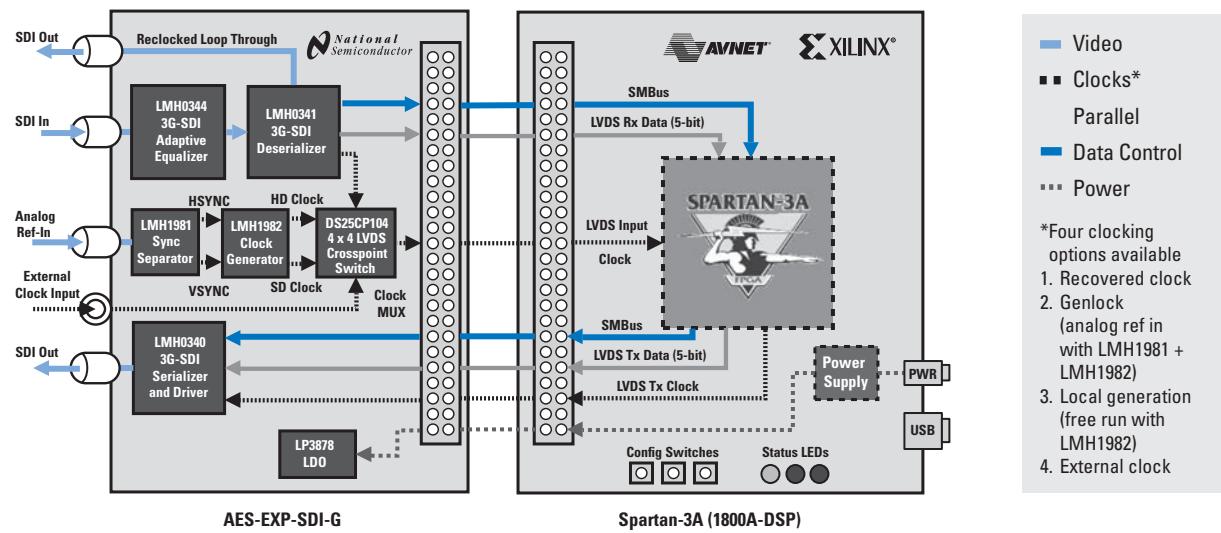
Triple-Rate SDI Development Platform for Xilinx FPGAs

In collaboration with Avnet and Xilinx, National Semiconductor developed a triple-rate SDI and video clocking daughter card for the Xilinx Spartan-3A/3E development kits. The daughter card plugs directly into the Spartan development board through an EXP connector. The combined solution of the daughter card and the development kit provides broadcast video system designers with a comprehensive platform for rapid evaluation and prototyping of new designs, thereby reducing time to market.

Features

- 3G, HD, and SD compatible
- Comprehensive reference for hardware design and FPGA IP development
 - HDL (Verilog, VHDL) available from AVNET
 - Supports SDI framing, audio embedding/de-embedding, and test pattern generation
- Support for Genlock

3G-SDI Development Platform with Xilinx Spartan-3A FPGA



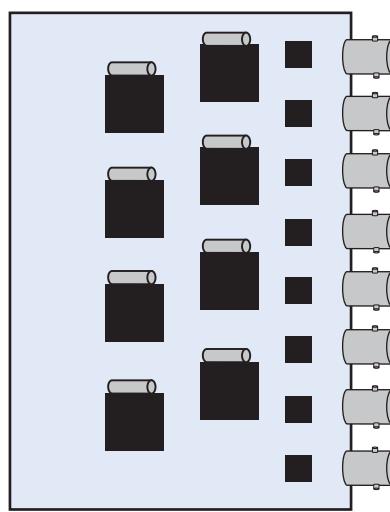
Industry's Smallest Packages

Features

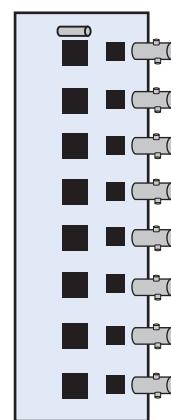
- Enables high-port-density applications
- 3G-SDI cable equalizer: LMH0344GR
 - microArray-25 package (3 x 3 mm)
 - 44% board area savings compared to QFN-16 package
- 3G-SDI cable driver: LMH0307GR
 - microArray-25 package (3 x 3 mm)
 - 44% board area savings compared to QFN-16 package
- 3G-SDI reclocker with 4:1 input mux: LMH0356SQ-40
 - LLP-40 package (5 x 5 mm)
 - 70% board area savings compared to QFN-64 package
- 3G-SDI reclocker: LMH0346SQ
 - LLP-24 package (5 x 4 mm)
 - 75% board area savings compared to QFN-64 package

Cleaner Layout, Reduced Board Area, and Simplified BOM

8-Channel Output Card Using Competition's QFN-64 Reclocker and QFN-16 Driver



8-Channel Output Card Using National's LLP-40 Reclocker and microArray Driver



Advantages:

- Balanced channels
- Improved return loss
- Less board area
- Cleaner layout
- Single shared XTAL
- Lower jitter
- Improved BER
- Higher density

Evolution of Reclockers: Size Comparison*

Then...

Now

Competition	LMH0356SQ	LMH0346MH	LMH0356SQ-40	LMH0346SQ
QFN-64	LLP-48	TSSOP-20	LLP-40	LLP-24
9 x 9 81 mm ²	7 x 7 49 mm ²	6.4 x 6.5 41.6 mm ²	5 x 5 25 mm ²	5 x 4 20 mm ²

*Actual sizes shown

Flexible IP and High-Performance Serializers and Deserializers

National's SDI Ser/Des devices and SMPTE protocol processing FPGA firmware provide a complete system solution. Unlike competing solutions that combine Ser/Des functionality with SMPTE processing in a single chip, National's solution:

- Provides system designers an easy-upgrade firmware path to keep up with evolving SMPTE specifications
- Eliminates expensive and time-consuming silicon re-spins
- Eliminates need for additional board qualifications
- Future-proof system design
- Reduces lifetime cost-of-system maintenance

High-end FPGAs with integrated transceivers use low-geometry CMOS processes and have a high noise floor, causing poor jitter performance. To compensate, designers need additional components such as premium regulators, reference clocks, isolated power and ground planes, and thermal protection that increase design complexity, time, and cost. In contrast, National's Ser/Des solutions work with cost-effective FPGAs that require few additional components.

National delivers the industry's lowest-output-jitter solution (30 ps p-p) in a package that is 60% smaller than competing solutions. The smaller size enables optimal placement of the Ser/Des close to BNC connectors, facilitating return loss network design.

Comparison of System Design Options

	National Ser/Des	High-end FPGA with Integrated Ser/Des	Ser/Des with Integrated SMPTE Processing
System design flexibility to evolve with changing standards	✓	✓	—
Good jitter performance	✓	—	✓
Small board area (device + additional components)	✓	—	—
Upgradable firmware	✓	✓	—
Low Bill of Materials (BOM) cost	✓	—	—
Fast time to market	✓	—	✓
Embedded audio support (up to 16 channels)	✓	—	—
Supports SMPTE level B	✓	✓	—

SDI Serializers and Deserializers

Product ID	Description	Supply Voltage (V)	Typ. Power (mW)	Data Rate (Mbps)	Temp Range ¹	Eval Board Product ID	Packaging
Serializers							
LMH0340	3G/HD/SD serializer with LVDS interface and integrated cable driver	3.3, 2.5	440	270 to 2970	Ind	SDALTEVK (Altera)	LLP-48
LMH0040	HD/SD serializer with LVDS interface and integrated cable driver	3.3, 2.5	440	270 to 1485	Ind	SDXILEVK (Xilinx)	LLP-48
LMH0050	HD/SD serializer with LVDS interface	3.3, 2.5	460	270 to 1485	Ind	SDXILEVK (Xilinx)	LLP-48
LMH0070	SD serializer with LVDS interface and integrated cable driver	3.3, 2.5	400	270	Ind	SDXILEVK (Xilinx)	LLP-48
LMH0030	HD/SD serializer with FIFOs, integrated cable driver, 85 ps typical output jitter, no external VCOs required, BIST, and TPG	3.3, 2.5	430	270 to 1485	Com	—	TQFP-64
Deserializers							
LMH0341	3G/HD/SD reclocking deserializer with LVDS interface and active loopthrough	3.3, 2.5	590	270 to 2970	Ind	SDALTEVK (Altera)	LLP-48
LMH0041	HD/SD reclocking deserializer with LVDS interface and active loopthrough	3.3, 2.5	550	270 to 1485	Ind	SDXILEVK (Xilinx)	LLP-48
LMH0051	HD/SD reclocking deserializer with LVDS interface	3.3, 2.5	555	270 to 1485	Ind	SDXILEVK (Xilinx)	LLP-48
LMH0071	SD reclocking deserializer with LVDS interface and active loopthrough	3.3, 2.5	525	270	Ind	SDXILEVK (Xilinx)	LLP-48
LMH0031	HD/SD deserializer/descrambler with FIFOs, 27 MHz reference, BIST, TPG, and automatic EDH/CRC	3.3, 2.5	850	270 to 1485	Com	SD131EVK	TQFP-64

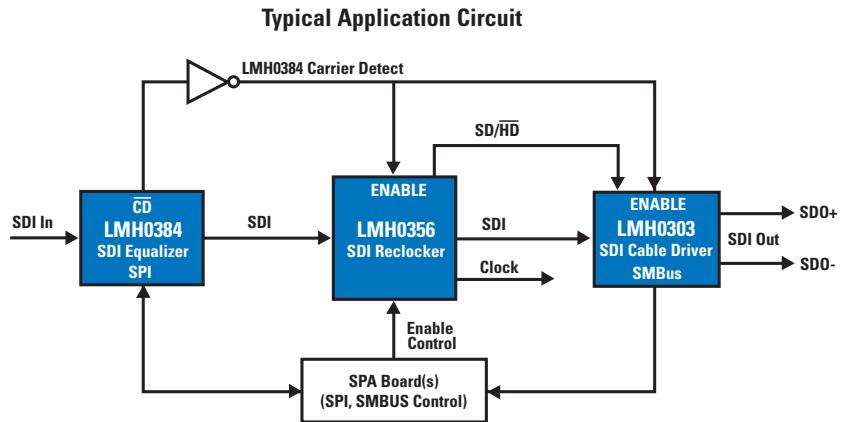
¹Temperature ranges: Com: 0°C to 70°C Ext: 0°C to 85°C Ind: -40°C to 85°C

Intelligent Sensing to Reduce System Power Consumption

PowerWise® Triple-Rate Distribution Amplifier

Features

- Auto signal detection at equalizer input
- Cable detection at driver output
- Significant power savings
 - 95% power savings in power-save mode
- Triple-rate SMPTE support
 - Supports SMPTE 424M (3G), 292M (HD), 259M/C (SD), and DVB-ASI



SDI Equalizers, Reclockers, and Cable Drivers

Product ID	Description	Supply Voltage (V)	Typ Power (mW)	Data Rate (Mbps)	Temp Range ¹	Eval Board Product ID	Packaging
Cable Equalizers							
LMH0384 E	3G/HD/SD extended reach adaptive cable equalizer	3.3	230	143 to 2970	Ind	SD384EVK, SD384SPEVK	LLP-16
LMH0344 E	3G/HD/SD adaptive cable equalizer	3.3	280	143 to 2970	Ind	SD3GDAEVK	microArray-25, LLP-16
LMH0044 E	HD/SD adaptive cable equalizer	3.3	208	143 to 1485	Ext	SD044EVK	LLP-16
LMH0034 E	HD/SD adaptive cable equalizer	3.3	208	143 to 1485	Ext	SD034EVK	SOIC-16
LMH0074 E	SD adaptive cable equalizer with cable detect	3.3	208	143 to 540	Ind	SD074EVK	LLP-16
LMH0024 E	3.3V SD adaptive cable equalizer	3.3	198	143 to 540	Ind	SD024EVK	SOIC-16
Reclockers							
LMH0346 E	3G/HD/SD reclocker with dual differential outputs	3.3	370	270 to 2970	Ind	SD3GDAEVK, SD346EVK	eTSSOP-20, LLP-24
LMH0356 E	3G/HD/SD reclocker with 4:1 input mux and FR4 equalization	3.3	430	270 to 2970	Ind	SD356EVK	LLP-48/LLP-40
LMH0046 E	HD/SD reclocker with dual differential outputs	3.3	330	143 to 1485	Ind	SD046EVK	eTSSOP-20, LLP-24
LMH0056	HD/SD reclocker with 4:1 input mux and FR4 equalization	3.3	360	143 to 1485	Ind	—	LLP-48
LMH0026	SD reclocker with dual differential outputs	3.3	330	270	Ind	—	eTSSOP-20
LMH0036	SD reclocker with 4:1 input mux and FR4 equalization	3.3	360	270	Ind	—	LLP-48
Cable Drivers							
LMH0307 E	3G/HD/SD SDI dual cable driver with cable detect, input LOS, selectable slew rate and 4 mW power-down mode	3.3	275	Up to 2970	Ind	SD307EVK	microArray-25, LLP-16
LMH0302 E	3G/HD/SD cable driver with enable feature	3.3	162	Up to 2970	Ind	SD302EVK	LLP-16
LMH0303 E	3G/HD/SD SDI cable driver with cable detect, input LOS, selectable slew rate and 4 mW power-down mode	3.3	155	Up to 2970	Ind	SD303EVK	LLP-16
LMH0002 E	HD/SD serial digital cable driver with selectable slew rate	3.3	149	Up to 1485	Com/Ind	SD002EVK	SOIC-8
LMH0002 E	HD/SD serial digital cable driver with selectable slew rate	3.3	149	Up to 1485	Ind	SD002SQ-EVK	LLP-16
LMH0202 E	Dual SD/DS serial cable driver with dual differential input and output	3.3	298	Up to 1485	Com	SD202EVK, DVB202-EVK	TSSOP-16
LMH0001 E	SD serial digital cable driver with adjustable output amplitude	3.3	125	Up to 540	Ind	SD001SQ-EVK	LLP-16

PowerWise® Product

E Evaluation board

¹Temperature ranges: Com: 0°C to 70°C

Ext: 0°C to 85°C

Ind: -40°C to 85°C

Mobile Pixel Link

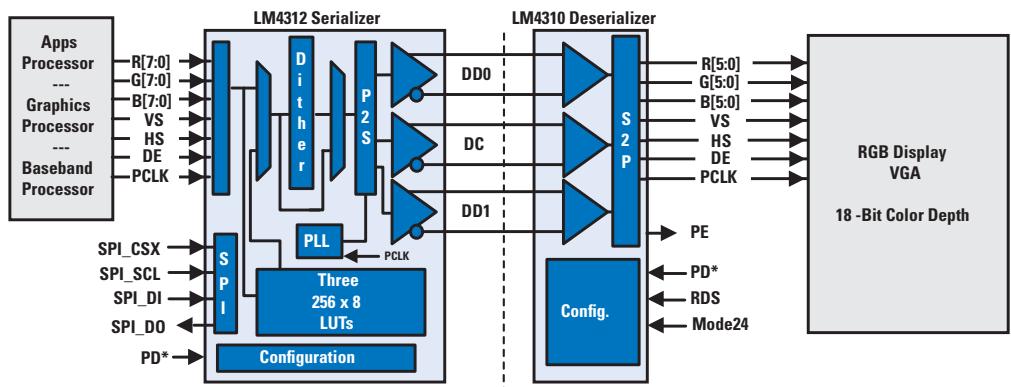
Mobile Pixel Link

Mobile Pixel Link (MPL) is a robust serial interface between video ports on sources and displays that reduces the number of interface wires. MPL features a robust differential transmission interface with a small magnitude signal to offer system-level low-power and low-EMI benefits. Serialized data is sent in mini-

parallel fashion to simplify the data recovery on the receiver and to eliminate the need for a PLL, thus saving power in the receiver. The number of lanes is also scalable, depending upon the bandwidth required by the end application.

MPL-2 Solution

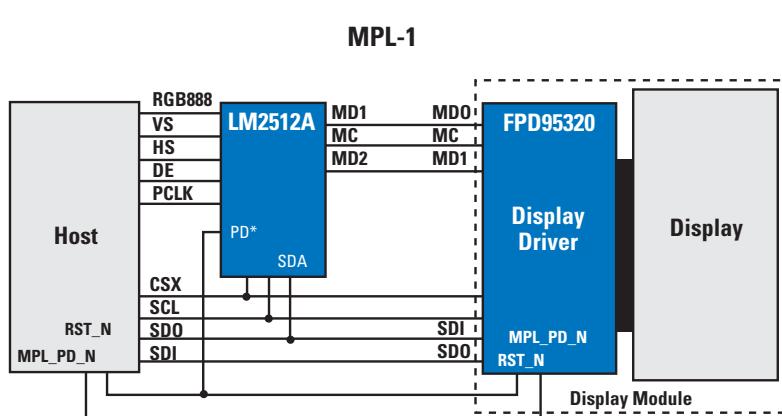
- Most flexible
- Robust differential interface
- Wide clocking range that supports many resolutions
- SLVS physical layer



MPL-2

MPL-1 Solution

- Ideal for H-VGA displays (320 x 480)
- 18-bit to 24-bit color depth
- FPD95320 display driver integrates MPL-1 deserializer



MPL-1

Product ID	Function	Bits	Max PCLK Freq (Hz)	Interface	I/O Levels	Features	Packaging
LM4308	Master/slave	18	30	CPU	MPL-2	Write and read supported	LLP-40/microArray-49
LM4310	Receiver	18 or 24	30	RGB	MPL-2	Sleep mode	LLP-48
LM4312	Transmitter	18 or 24	30	RGB	MPL-2	Sleep mode, optional dithering	LLP-48
LM2512A	Transmitter	24	20	RGB	MPL-1	24 to 18-bit dither	LLP-40/UFBGA-49
FPD95320 *	Receiver	18	—	RGB	MPL-1	Support for partial display modes	Bumped die

*Chip on Glass (COG) display driver

Industrial Ethernet Solutions

For decades, National has delivered robust and reliable Ethernet solutions for the industrial market segment including several breakthroughs such as the industry's first 10/100 transceiver, first Gigabit Ethernet Network Interface Card (NIC), and the industry's first IEEE 1588 precision PHYTER® transceiver.

National's wide offering of single and dual 10/100 PHYs are fully IEEE 802.3 compliant, support UNH interoperability, and deliver ultra-low latency and deterministic delay.

The table compares various temperature ranges, interface types, package types, and feature sets.

Power over Ethernet (PoE) integrates data and power over standard LAN infrastructures. Since PoE devices do not require wall-mounted power supplies, installation and maintenance of such devices is easier with the benefit of lower overall system costs. National's PoE portfolio features 802.3af compliant devices (up to 25W total power) which can be configured in an isolated or non-isolated topology.

Ethernet Solutions

Product ID	Temp Range (°C)	Number of Ports	IEEE 1588	Interface	Typ Power (mW)	Fiber Support	Flexible Port Switching	IEEE 1149.1 (JTAG)	Wake-on-LAN (WOL)	Rx Packet Filtering	Packaging
DP83640 E	-40 to 85	10/100 Single	✓	MII/RMII	280	✓	—	✓	—	—	LQFP-48
DP83848C E	0 to 70	10/100 Single	—	MII/RMII/SNI	265	—	—	✓	—	—	LQFP-48
DP83848I/E E	-40 to 85	10/100 Single	—	MII/RMII/SNI	265	—	—	✓	—	—	LQFP-48
DP83848VYB	-40 to 105	10/100 Single	—	MII/RMII/SNI	265	—	—	✓	—	—	LQFP-48
DP83848YB E	-40 to 125	10/100 Single	—	MII/RMII/SNI	265	—	—	✓	—	—	LQFP-48
DP83848M/T/H E	0 to 70	10/100 Single	—	MII/RMII	265	—	—	—	—	—	LLP-40
	-40 to 85		—			—	—	—	—	—	
	-40 to 125		—			—	—	—	—	—	
DP83848J/K E	0 to 70 -40 to 85	10/100 Single	—	MII/RMII	265	—	—	—	—	—	LLP-40
DP83849C E	0 to 70	10/100 Dual	—	MII/RMII/SNI	300 / Port	—	—	—	—	—	TQFP-80
DP83849I E	-40 to 85	10/100 Dual	—	MII/RMII/SNI	300 / Port	—	✓	✓	—	—	TQFP-80
DP83849ID E	-40 to 85	10/100 Dual	—	MII/RMII/SNI	300 / Port	✓	—	—	—	—	TQFP-80
DP83849IF E	-40 to 85	10/100 Dual	—	MII/RMII/SNI	300 / Port	✓	✓	—	—	—	TQFP-80
DP83816 E	0 to 70	10/100 + MAC Single	—	V2.2 33 MHz PCI bus	116	—	—	—	✓	✓	LQFP-144
DP83865	0 to 70	10/100/1000 Single	—	GMII / RGMII	1100	—	—	✓	✓	—	PQFP-128

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

Product ID	V _{IN} Max (V)	V _{IN} Min (V)	Hot Swap FET RDS _{ON} Typ (Ω)	Integrated DC-DC Controller	Output Power (W)	Auxiliary Support	Reference Accuracy (+/-)	Current Draw with AUX Winding (typ)	Packaging
LM5070 E	75	1.8	1.0	✓	13	48V front only	2.0	0.7	LLP-16, TSSOP-16
LM5071 E	75	1.8	1.0	✓	13	48V front only	2.0	0.7	TSSOP-16
LM5072 E	100	9.0	0.7	✓	25	Fully-configurable front/rear	2.0	0.7	eTSSOP-16
LM5073 E	100	9.0	0.7	—	25	Fully-configurable front/rear	—	—	eTSSOP-14

 PowerWise® product E Evaluation board

Industrial Ethernet Solutions

Synchronize Network Nodes to Sub-10 ns Precision

DP83640 10/100 PHYTER® IEEE 1588 Precision Time Protocol Transceiver

Features

- Supports IEEE 1588 PTP v1 and v2
- 8 ns hardware timestamp
- Internal IEEE 1588 clock
- 12 IEEE 1588 GPIOs
- Packet-based 1588 management
- Copper or fiber support
- ESD 8kV HBM/2kV CDE
- Low power consumption
 - < 23 mW (energy detect mode)
 - < 250 mW (normal operation)

Applications

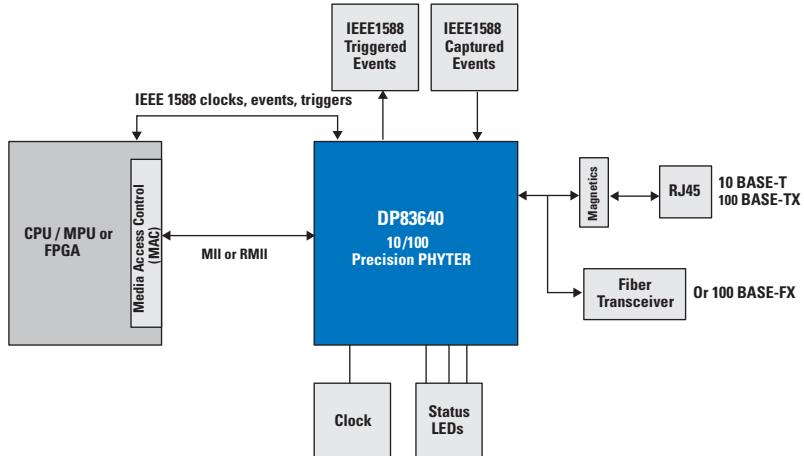
Synchronizes time, frequency, and phase of network components to operate faster with increased precision. Ideal for use in smart grid, telecom, industrial automation, test and measurement, military, and aerospace

For time sync demo video, visit: national.com/ethernet

Precision PHYTER 10/100 IEEE 1588 PHY

Product ID	DP83640T
Parameter	Industrial
Temp Range (°C)	-40 to 85
Number of Ports	Single
Interface	MII/RMII
IEEE 1588 Precision Time Protocol v1 and v2	<10 ns
Cable Health Diagnostics	•
Fiber Support	•
Synchronized GPIOs	12
Synchronized Clock Output	•
IEEE 1149.1 (JTAG)	•
LEDs	3
Packaging	LQFP-48
Package Size (mm)	7 x 7 x 1.4

Typical Application Circuit



Comparing Latency in IEEE 1588 Solution Implementations

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

Industrial Ethernet Solutions

Connect Embedded Devices

DP83848 PHYTER® 10/100 Ethernet PHY Connects Embedded Devices

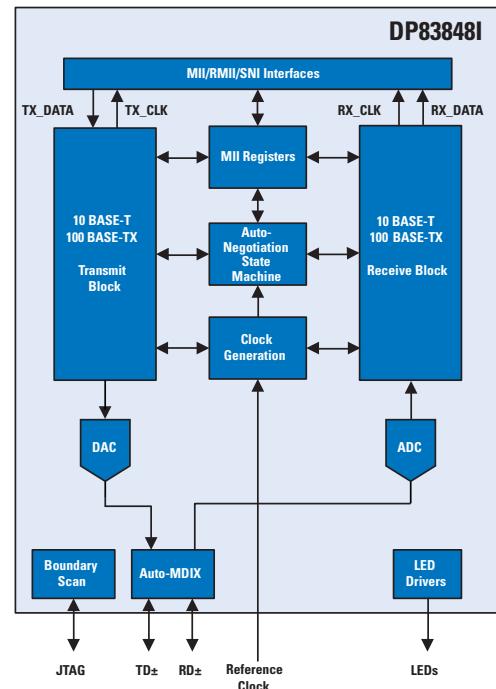
Features

- Industry's lowest deterministic latency reduces control loop jitter by 10x over competition (3 ns vs 32 ns)
- Very low power consumption
 - < 23 mW in energy detect mode, < 250 mW normal operation
- Software utility support
- System diagnostics
- Selectable MII/RMII interface
- Flexible interrupt capability
- Reference clock output (to MAC)
- ESD 4kV HBM/2kV CDE

Applications

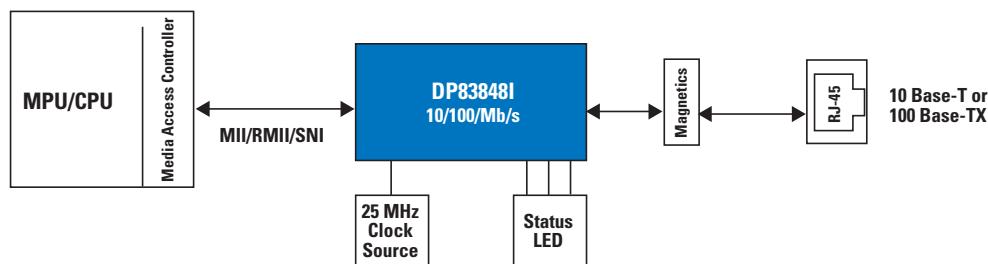
Ideal for use with industrial controls, factory automation, FPGAs, and embedded applications

Simplified Block Diagram



Precision PHYTER 10/100 PHY

Product ID	Application	Temp Range (°C)	Interrupt Pin	IEEE1149.1 (JTAG)	LEDs	Packaging	Size (mm)
Single PHYTER							
DP83848I	Industrial	-40 to 85	✓	✓	3	LQFP-48	7 x 7 x 1.4
DP83848VYB	Extended	-40 to 105	✓	✓	3	LQFP-48	7 x 7 x 1.4
DP83848YB	Extreme	-40 to 125	✓	✓	3	LQFP-48	7 x 7 x 1.4
Mini PHYTER							
DP83848K	Industrial	-40 to 85	—	—	2	LLP-40	6 x 6 x 0.8
DP83848T	Industrial	-40 to 85	—	—	1	LLP-40	6 x 6 x 0.8
DP83848H	Extreme	-40 to 125	—	—	1	LLP-40	6 x 6 x 0.8



Industrial Ethernet Tools

Tools Simplify Ethernet Development

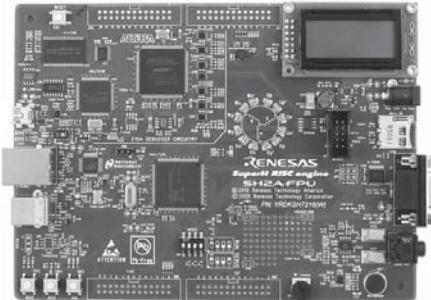


Reneses Reference Design

Demo kit lets users implement IEEE 1588 PTP applications using the Renesas Electronics 32-bit SuperH RISC processor.

Features

- DP83640 Ethernet PHY with IEEE 1588 PTP
- PC connectivity via USB
- Onboard LCD
- Software development tools

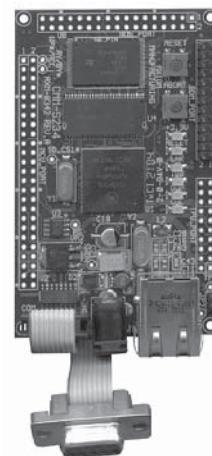


Freescale Reference Design

Comprehensive hardware and software solution to support IEEE 1588 PTP. Enables developers to create Ethernet-based synchronization designs.

Features

- MCF5234 ColdFire processor
- DP83640 Ethernet PHY with IEEE 1588 PTP
- PC connectivity via USB
- IEEE 1588 software stack
- TCP/IP software stack
- Software development tools



For more details on these solutions, see the Ethernet reference design section at national.com/refdesigns

PHYTER® Ethernet Integrity Utility

Extensive Ethernet support and diagnostics tool, allowing complete PHY access for link status, device configuration, and network status monitoring. This software utility provides a unique interface for system development, debug, and diagnostic work as well as automated script generation for system manufacturing and testing.

Features

- Complete link status and easy link setting to speed up analysis in different modes
- Complete register access for development
- Customized scripting environment allows task-oriented script generation to simplify field analysis
- Interactive signal-to-pin descriptions
- Cable and device diagnostics tests

The screenshot shows the "PHYTER® ETHERNET INTEGRITY UTILITY" software interface. The main window displays a graphical representation of a network connection with various ports and status indicators. To the right, there are sections for "Description", "Features", "Benefits", and "PHYTER Device Supported".

Description:
The Analog LaunchPAD Ethernet integrity software, Utilizing the Analog LaunchPAD Ethernet integrity design, allows for accessing complete PHY access for link status, device configuration, and network status monitoring. It also provides a high level advantage of the unique hardware PHY interface and the unique software stack, which is the core of Renesas's Ethernet products. This software utility provides a unique interface for system development, debug, and diagnostic work as well as automated script generation for system manufacturing and testing.

Features:
Custom diagnostic script generation
Complete link status and easy link setting
Complete register access for development
Networking system debug
Manufacturing and diagnostics
Cable length analysis

Benefits:
Complete link status and easy link setting
Complete register access for development
Customized scripting environment
Interactive signal-to-pin descriptions
Cable and device diagnostics tests

PHYTER Device Supported:

- DP83840C (DP83840/DP83840E / PHYTER Dual 10/100 Ethernet Physical Layer with Full Duplex, Auto-Negotiation, and External Temperature, with Removable Passive Heat Sink)
- DP83840C (DP83840/DP83840E / PHYTER Dual 10/100 Ethernet Physical Layer with Full Duplex, Auto-Negotiation, and External Filter (FC) support)
- DP83840C (DP83840/DP83840E / PHYTER Dual 10/100 Ethernet Physical Layer with Full Duplex, Auto-Negotiation, and External Temperature Range)
- DP83840C (DP83840/DP83840E / PHYTER Dual 10/100 Ethernet Physical Layer with Full Duplex, Auto-Negotiation, and External Temperature Range)
- DP83840C (DP83840/DP83840E / ULP-DigPHYTER 10/100/1000 Ethernet Physical Layer)
- DP83840C (DP83840/DP83840E / 10/100/1000 Ethernet Media Access Control and Physical Layer (DigPHYTER))

Applications

Ideal for custom diagnostic script generation, system field support and analysis, networking system debug, manufacturing test diagnostics, and cable length analysis

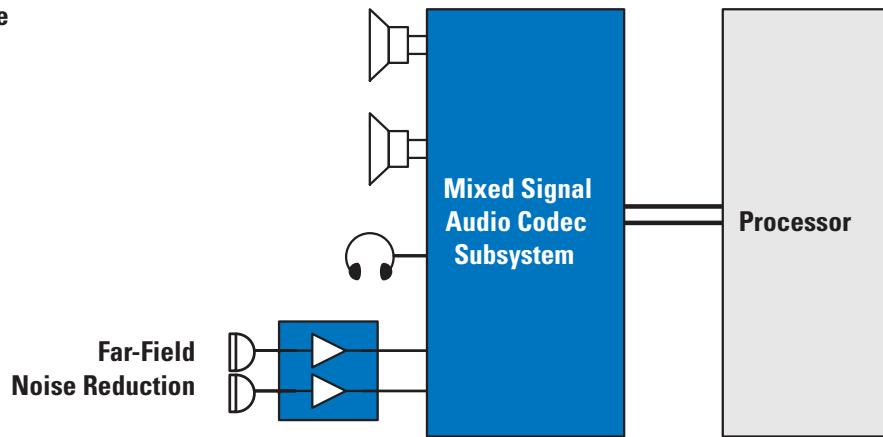
Audio Product Portfolio



Audio System Architectures

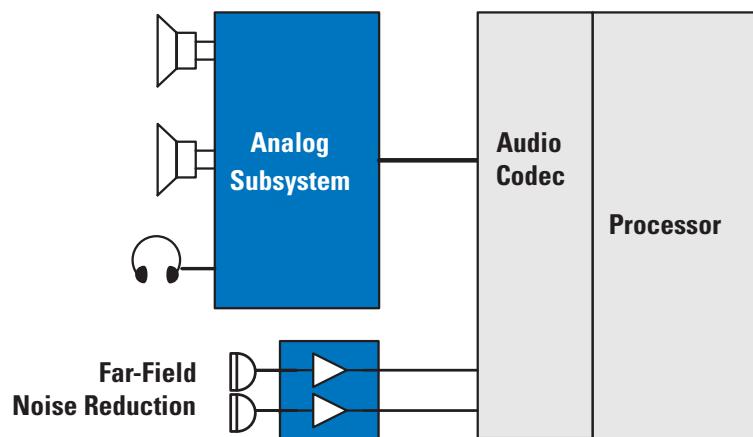
Use this integrated subsystem architecture for processors with digital audio outputs

- Mixed-signal audio codec subsystems
- Far-field noise reduction



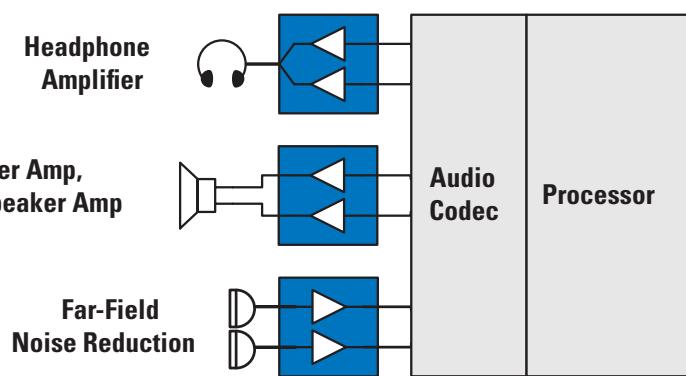
Use this integrated subsystem architecture for processors with analog audio output

- Analog subsystems



Use this discrete audio architecture for processors with analog audio output

- Headphone amplifiers
- Speaker amplifiers
- Ceramic speaker amplifiers



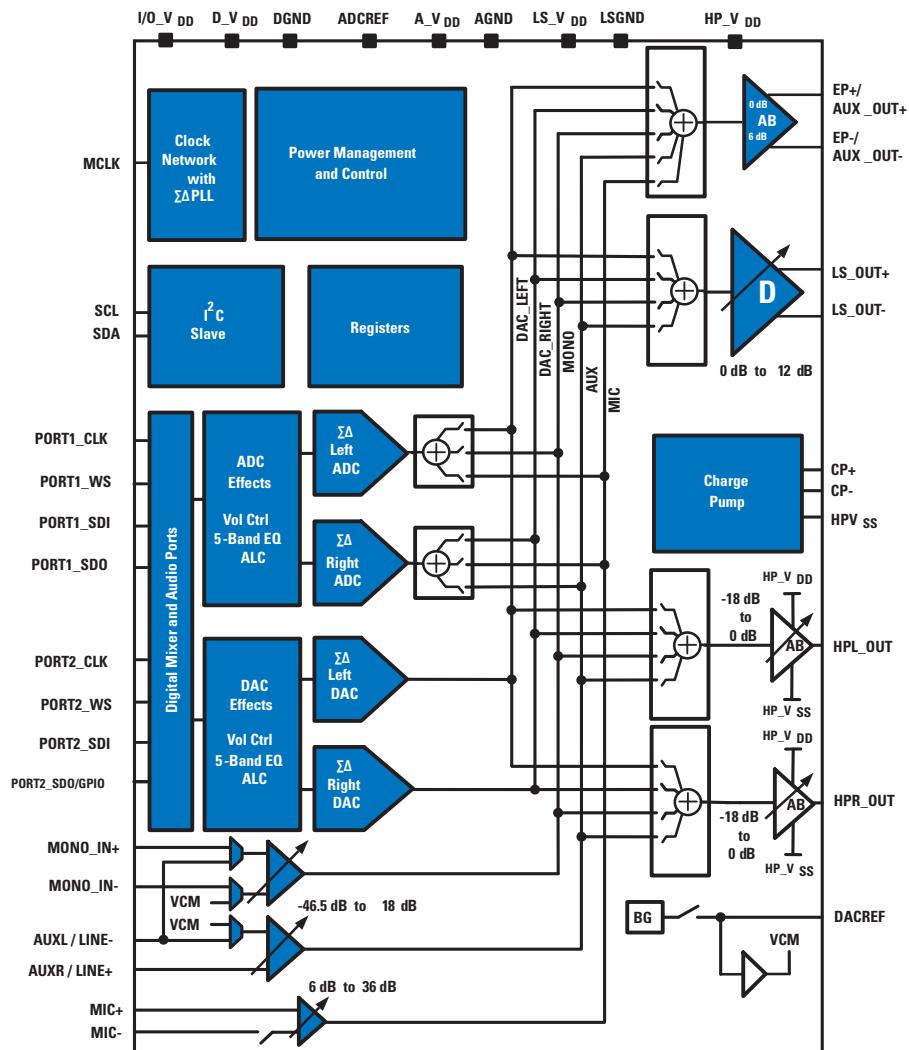
Mixed-Signal Subsystems/Audio Codecs

LM49352 – Mono Class D Audio Codec Subsystem with Ground-Referenced Headphone Amplifiers

Features

- Low-voltage, true-ground headphone amplifier operation
- High-performance 103 dB SNR stereo DAC
- High-performance 97 dB SNR stereo ADC
- Up to 96 kHz stereo audio playback
- Up to 48 kHz stereo recording
- Dual bidirectional I²S- or PCM-compatible audio interface
- Read/write I²C compliant control interface
- Flexible digital mixer with sample rate conversion

Block Diagram



Mixed-Signal Subsystems/Audio Codecs

LM49370 – PowerWise® Audio Codec Subsystem with Ultra-Low EMI, Class D Amplifier, and a PCM Interface for Bluetooth® Transceivers

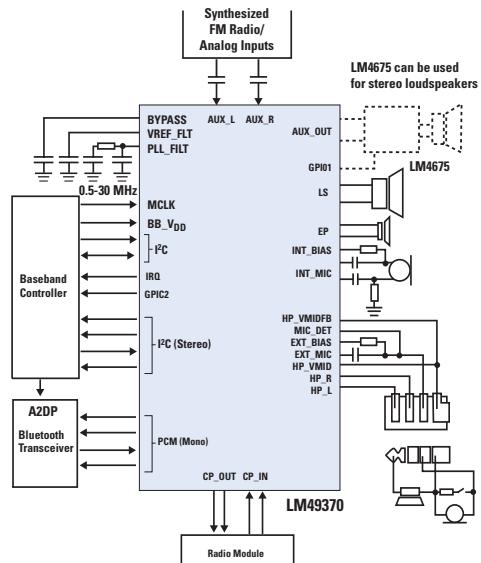
Features

- Spread spectrum Class D architecture reduces electromagnetic interference (EMI)
- Mono Class D 8Ω amplifier, 490 mW at 3.3V
- Output Capacitorless (OCL) or AC-coupled headphone operation
- 33 mW stereo headphone amplifier at 3.3V
- 115 mW earpiece amplifier at 3.3V
- Digital 3D stereo enhancement
- Total harmonic distortion (THD): 0.04%
- Available in micro SMDxt-49 packaging (4 x 4 mm)

Applications

Ideal for use in smartphones, mobile phones, and multimedia terminals, PDAs, Internet appliances, portable gaming, portable DVD/CD/AAC/MP3 players, and digital cameras/camcorders

Typical Application Circuit



LM49450 – 2.2W Stereo Boomer® Class D Audio Subsystem

Features

- 24-bit stereo DAC
- Selectable spread spectrum mode reduces EMI
- Ground-referenced headphone amplifiers with 100 dB SNR
- I²C compliant audio interface; I²C compliant control interface
- Audio sample rates up to 192 kHz
- Advanced click-and-pop suppression
- Micro-power shutdown

Applications

Ideal for use in personal media/MP3 players, portable navigation, digital still/video cameras, mobile phones, and VoIP devices

Product ID	Description	Mono Input Ch.	Stereo Input Ch.	Class D Speaker Driver	Packaging
LM49352 E	1.4W mono Class D speaker, 65 mW ground-referenced headphone with stereo DAC and stereo ADC with I ² S/PCM and auxiliary inputs, I ² C compliant control, 3D, five band EQ, and AGC	2, PCM	1, I ² S	✓	micro SMDxt-36
LM49350 E	1.1W Class D speaker, 69 mW ground-referenced headphone with stereo DAC and stereo ADC with I ² S/PCM and auxiliary inputs, I ² C compliant control, 3D, five-band EQ, and AGC	2, PCM	1, I ² S	✓	micro SMDxt-36
LM49450	Filterless 2.2W stereo Class D audio subsystem with ground-referenced headphone amplifier, 3D enhancement, and headphone sense	—	2, I ² S	✓	LLP-32
LM49370 E	1.2W mono speaker, 31 mW headphone, 115 mW earpiece with I ² C compliant/SPI mode and selectable OCL output	3, PCM	I ² S	✓	micro SMDxt-49
LM49321	520 mW mono speaker, 36 mW headphone, 55 mW earpiece with I ² C compliant/SPI and lower power MP3 playback mode	1	2, I ² S	—	micro SMDxt-36

PowerWise® product Evaluation board

Analog Subsystems

LM49151 – PowerWise® Mono Class D Audio Subsystem with Earpiece Driver and Ground-Referenced Headphone Amplifiers

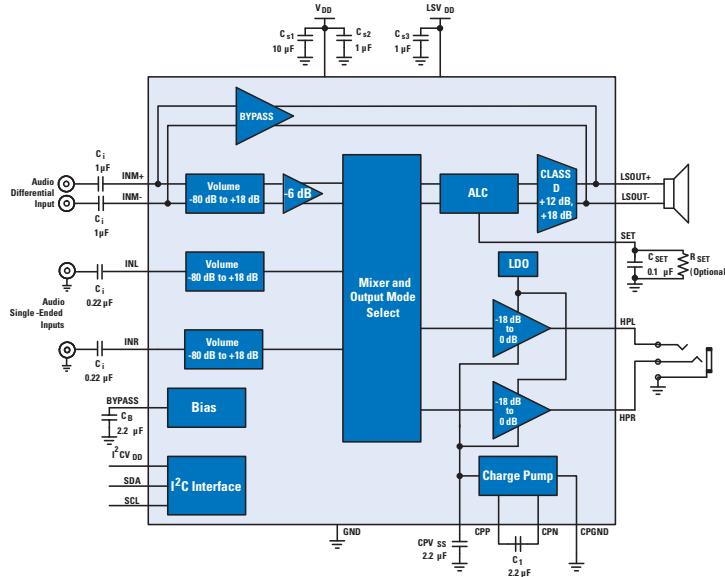
Features

- Class D amplifier with E²S enhanced emission suppression technology for reduced EMI
 - Ground-referenced outputs — eliminates output-coupling capacitors
 - I²C compliant programmable no clip function with clip control
 - Voltage limiter speaker protection
 - I²C compliant volume and mode control
 - Earpiece amplifier
 - Advanced click-and-pop suppression
 - Low supply current

Applications

Ideal for use in mobile phones, personal media devices, MP3 players, portable navigation, laptops, and VoIP devices

Block Diagram



LM49101 – Mono Class AB Audio Subsystem with a True-Ground Headphone Amplifier and Earpiece Switch

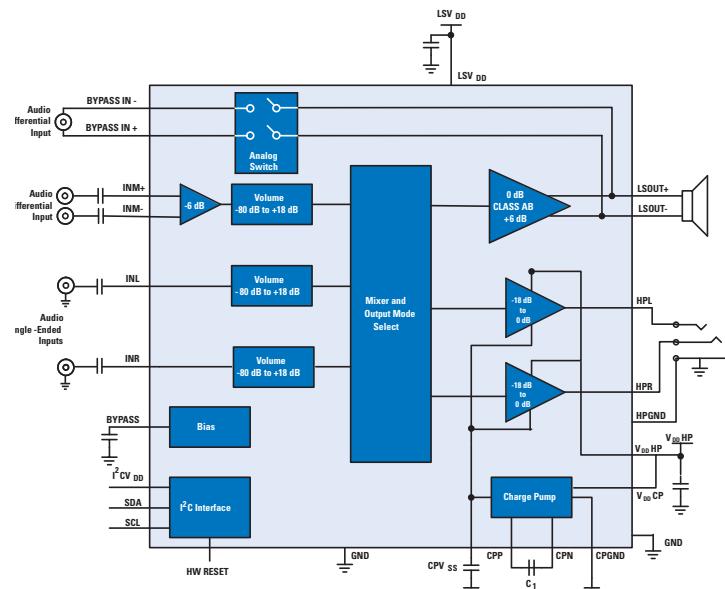
Features

- Differential mono input and stereo single-ended input
 - Separate earpiece (receiver) differential input
 - Analog switch for a separate earpiece path
 - 32-step digital volume control (-80 dB to +18 dB)
 - Three independent volume channels (left, right, mono)
 - Separate headphone volume control
 - Flexible output for speaker and headphone output

Applications

Ideal for use in portable electronic devices, mobile phones, and PDAs

Block Diagram



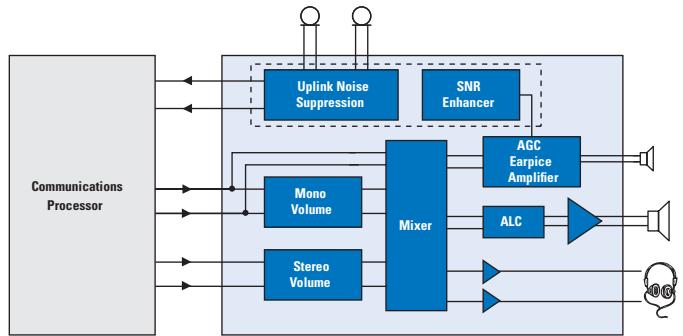
Analog Subsystems

LM49155 – PowerWise® Uplink Noise Suppression and Downlink SNR Enhancement Analog Audio Subsystem

Features

- Noise cancellation for uplink and downlink without DSP type artifacts, distortions, or delays
- Adapting Automatic Gain Control (AGC) on ambient noise level and downlink signal strength for earpiece
- Downlink-adjustable noise-reducing high pass filter
- E²S Class D amplifier with Automatic Level Control (ALC)
- Ground-referenced headphone outputs with advanced click-and-pop suppression
- I²C compliant volume and mode control

Typical Block Diagram



Applications

Designed for use in mobile phones and portable electronic devices

Analog Subsystems

Product ID	Description	Mono Input Ch.	Stereo Input Ch.	THD (%)	Class D Speaker Driver	Packaging
LM49155 E	Uplink noise suppression and downlink SNR enhancement analog audio subsystem	3	1	0.01	✓	micro SMD-36
LM49200 E	Stereo Class AB audio subsystem with true ground headphone amplifier	1	1	0.05	—	micro SMD-20
LM49151 E	1.25W mono Class D audio subsystem with automatic level control, earphone path and ground-referenced headphone amplifier	1	1	0.02	✓	micro SMD-20
LM49150 E	1.25W mono Class D audio subsystem with earphone path and ground-referenced headphone amplifier	1	1	0.04	✓	micro SMD-20
LM49250 E	Stereo Class D audio subsystem with ground-referenced headphone amplifier and mono earpiece	1	2	0.14	✓	micro SMDxt-36
LM49101 E	1.3W mono Class AB audio subsystem with ground-referenced headphone amplifier and mono earpiece	2	1	0.065	—	micro SMD-25
LM49100 E	1.275W mono speaker (BTL), 50 mW headphone with I ² C compliant, mode and volume control, and ground-referenced headphone drivers	1	2	0.035	—	microArray-25
LM49120 E	1.3W mono speaker, 85 mW headphone with I ² C compliant/SPI mode and volume control, and selectable OCL output	1	2	0.05	—	micro SMD-16
LM4946 E	1.3W mono speaker, 85 mW headphone with I ² C compliant/SPI mode and volume control, National 3D and selectable OCL output	1	2	0.05	—	LLP-24, micro SMD-25
LM49270 E	2.2W stereo speaker, 155 mW headphone with volume control, National 3D and selectable OCL output	1	2	0.02	✓	LLP-28
LM4949 E	1.19W stereo speaker, 89 mW headphone with I ² C compliant mode and volume control and selectable OCL output	1	1 or 2	0.02	✓	micro SMD-25
LM4947 E	1.19W mono speaker, 87 mW headphone with I ² C compliant mode and volume control, National 3D and selectable OCL output	1	1 or 2	0.03	✓	micro SMD-25

PowerWise® product Evaluation board

Noise Reduction

LMV1051 – Adaptive Noise Canceling Microphone Processors with Microphone Beamforming Technology

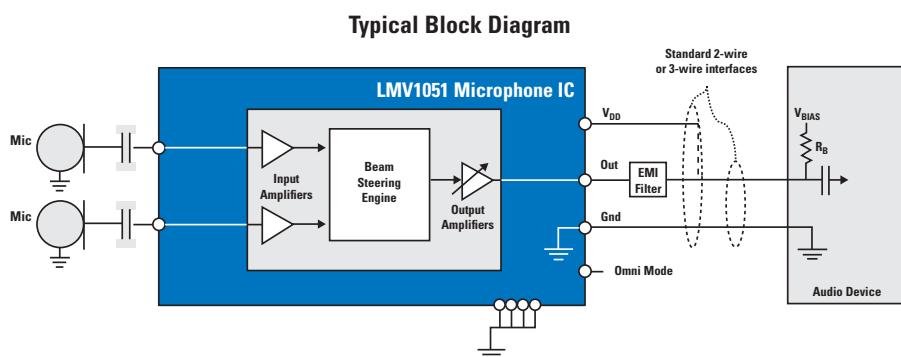
Features

- Up to 30 dB peak noise rejection of stationary and non-stationary noise sources with active directional pattern
- Wind noise protection automatically reduces wind noise by 20 dB
- Natural voice quality through analog signal processing without the voice distortion, artifacts, or latency introduced by DSP solutions
- Dual microphone technology improves voice clarity in all environments
- Flat frequency response from active microphone array

- Extremely low power (200 μ A)
- Comparable DSP-based ICs consume tens of millamps of current

Applications

Microphone beamforming technology maintains voice clarity and intelligibility, while canceling interference noise by dynamically adapting the system microphone pattern for wired headset accessories such as headphones and lanyards, mobile handsets, and smartphones



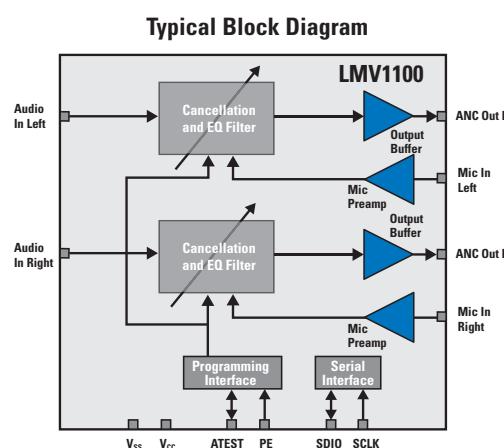
LMV1100 – Active Noise Canceling Processors with Integrated Custom-Tuned Filters

Features

- Up to 25 dB noise canceling at 200 Hz
- Wide noise cancel frequency range from 40 Hz to 800 Hz
- Full range through audio frequency response from 20 Hz to 20 kHz
- Programmable, on-chip filters optimize noise cancellation profile
- Highly-integrated single IC reduces BOM cost by up to 66% and footprint from 50% to 80% over discrete solutions

Applications

Active noise canceling technology reduces ambient noise by up to 25 dB over a wide frequency range for over-the-ear headphone designs and wired and Bluetooth® stereo headphones



Product ID	Output	Far-field Noise Suppression (dB) at 300 Hz	SNRI (dB) at 300 Hz	Shutdown	Supply Current (mA)	Supply Voltage Range (V)	Packaging
LMV1051	Single-ended	30	20	—	0.21	1.5 to 4	LLP-10
LMV1090 ^E	Differential	42	33	✓	0.6	2.7 to 5.5	micro SMD-16
LMV1091 ^E	Differential	42	33	✓	0.6	2.7 to 5.5	micro SMD-16
LMV1100	Single-ended	Feedback ANC-25 dB	—	—	3.4	3 to 3.6	LLP-32

PowerWise® product

^E Evaluation board

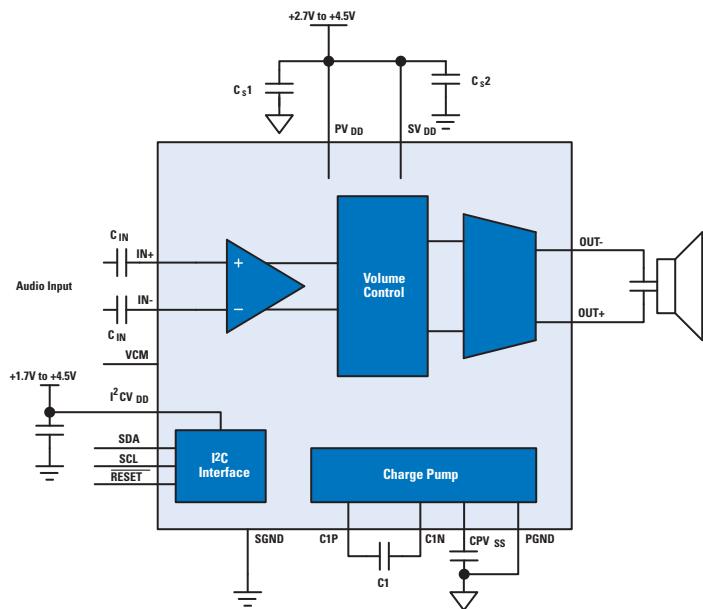
Ceramic Speaker Drivers

LM48557 – Mono, Bridge-Tied Load, Ceramic Speaker Driver with I²C Compliant Volume Control and Reset

Features

- Integrated charge pump
- Bridge-tied load output
- Differential input
- High PSRR
- I²C compliant volume and mode control
- Reset input
- Advanced click-and-pop suppression
- Low supply current
- Minimum external components
- Micro-power shutdown
- Available in space-saving micro SMD-16 packaging

Typical Application Circuit



Applications

Ideal for use in mobile phones, PDAs, notebook electronic devices, and MP3 players

Boosted Boomer® Piezo Ceramic Speaker Drivers

Product ID	Description	THD+N (%)	Output Voltage (V _{P-P})	Output Voltage Condition	Packaging
LM4802B	12 V _{P-P} boosted ceramic speaker driver	0.05	12	V _{DD} =4.2V, RL=2 μF + 30Ω, THD ≤ 1%	LLP-28
LM4953 E	12.6 V _{P-P} ceramic speaker driver with ground reference, ultra-low noise, fixed gain	0.02	12.6	V _{DD} =3.6V, RL=2 μF + 30Ω, THD ≤ 1%	LLP-14
LM4960	24 V _{P-P} Piezoelectric speaker driver	0.04	24	V _{DD} =3.0V, RL=800 nF + 20Ω, THD ≤ 1%	LLP-28
LM4961 E	15 V _{P-P} ceramic speaker driver	0.05	15	V _{DD} = 5.0V, 2 RL=μF + 30Ω, THD ≤ 1%	LLP-28
LM4962 E	15 V _{P-P} ceramic speaker driver with band switch function, can drive LM4951 for stereo solution	0.04	15	V _{DD} =5.0V, RL=2 μF + 9.4Ω, THD ≤ 1%	micro SMD-20
LM48555 E	15.5 V _{P-P} ceramic speaker driver	0.05	15	V _{DD} =5.0V, RL=2 μF + 9.4Ω, THD ≤ 1%	micro SMD-12
LM48556 E	17.5 V _{P-P} fully differential ceramic speaker driver	0.03	17.5	V _{DD} =4.5V, THD ≤ 1%	micro SMD-12
LM48557 E	5.8V _{RMS} ceramic speaker driver with I ² C compliant volume control and 48 db gain	0.05	16.4	V _{DD} =4.2V, RL=1 μF+22Ω, THD ≤ 1%	micro SMD-16
LM48823 E	5.4V _{RMS} ceramic speaker driver with I ² C compliant volume control and reset	0.015	15.3	V _{DD} =4.2V, RL=2.2 μF+15Ω, THD ≤ 1%	micro SMD-16
LM48580 E	25 V _{P-P} ceramic speaker driver	1.0	25	V _{DD} =3.6V, RL=6 μF + 10Ω, THD ≤ 1%	micro SMD-12

PowerWise® product

^E Evaluation board



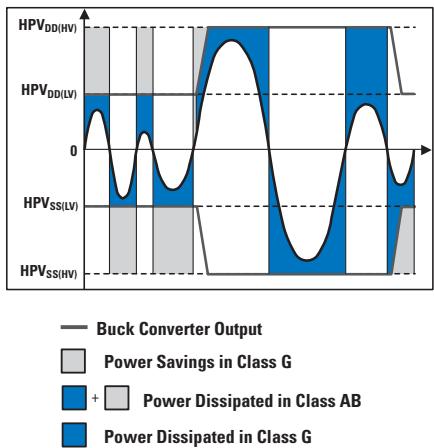
Audio eBook resources available online
www.national.com/analog/audio/ebooks

Ground-Referenced Headphone Boomer® Amplifiers

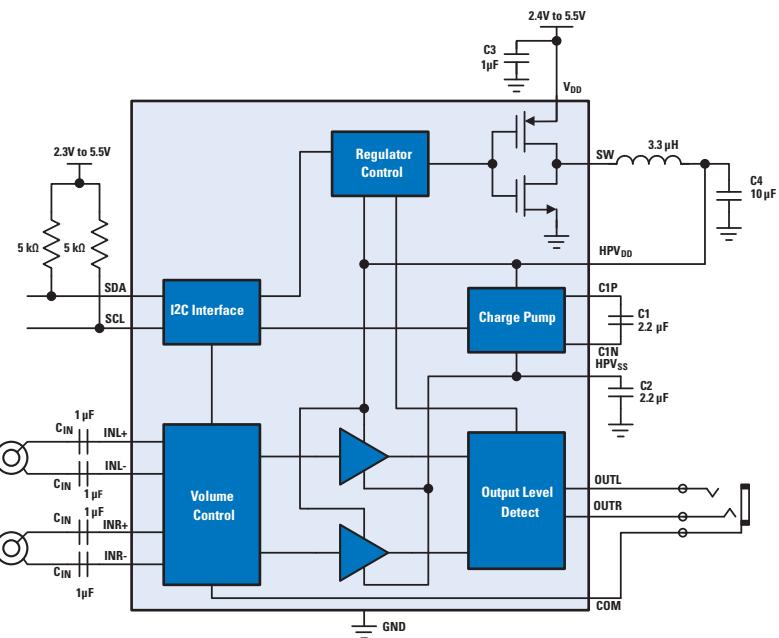
LM48824 – Class G Headphone Amplifier with I²C Compliant Volume Control

Features

- Class G power savings
- Ground-referenced headphone outputs – eliminates output-coupling capacitors
- Common-mode sense
- I²C compliant volume and mode control
- High-output impedance in shutdown
- Differential inputs
- Advanced click-and-pop suppression
- Low supply current
- Low Total Harmonic Distortion (THD) mode option



Typical Application Circuit

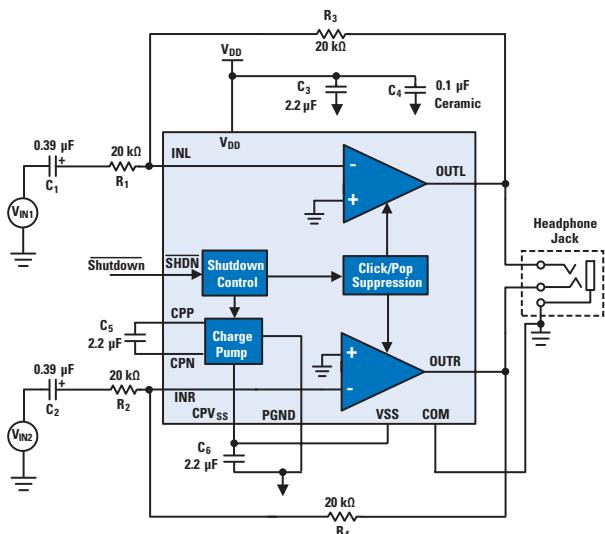


LM48861 – PowerWise® Ground-Referenced, Ultra-Low Noise, Stereo Headphone Amplifier

Features

- Ground-referenced outputs – eliminates output-coupling capacitors
- Common-mode sensing
- Advanced click-and-pop suppression
- Low supply current
- Low-power shutdown mode
- Minimum external components
- Micro-power shutdown
- ESD protection of 8 kV HBM contact

Typical Application Circuit



Headphone Boomer® Amplifiers

Ground-Referenced Headphone Boomer® Amplifiers

Product ID	Description	I_{DDQ} (mA)	THD (%)	Output Power THD ≤ 1%, $V_{CC} = 3V$		PSRR (dB)	Supply Voltage Range (V)	Packaging
				16Ω (mW)	32Ω (mW)			
LM4920	50 mW headphone, fixed logic levels, fixed 1.5 V/Vgain	7.0	0.03	43	50	70	1.6 to 4.2	micro SMD-14
LM4982	50 mW headphone, ultra-low noise, IntelliSense, 32-step I ² C compliant volume control	8.1	0.05	47	51	66	1.6 to 4.0	micro SMD-16
LM48820	95 mW headphone, ultra-low noise, fixed 1.5 V/Vgain	4.7	0.01	95	80	80	1.6 to 4.5	micro SMD-14
LM48821	52 mW headphone, ultra-low noise, direct coupled, I ² C compliant volume control	3.0	0.015	52	53	82	2.0 to 4.0	micro SMD-16
LM48860	30 mW headphone, ultra-low noise, fixed 1.5V/V gain	4.0	0.014	40	50	80	2.5 to 5.5	micro SMD-12
LM48822	35 mW headphone, ultra-low noise, common mode sense and I ² C compliant volume control	3.5	0.04	35	40	110	2.4 to 5.5	micro SMD-16
LM48861 	22 mW headphone amplifier, ultra-low noise, and common mode sense	2.0	0.04	22	24	83	1.2 to 2.8	micro SMD-12
LM48824 	37 mW Class G headphone, ultra-low noise, I ² C compliant volume control	0.9	0.02	37	29	100	2.4 to 5.5	micro SMD-16

Output Capacitor-less/Capacitor-Coupled Headphone Boomer Amplifiers

Product ID	Description	I_{DDQ} (mA)	THD (%)	Output Power THD ≤ 1%, $V_{CC} = 3V$		PSRR (dB)	Supply Voltage Range (V)	Packaging
				16Ω (mW)	32Ω (mW)			
LM4809	105 mW headphone with shutdown low, can drive 8Ω	1.4	0.03	38	25	70	2.0 to 5.5	LLP-8, SOIC-8 Narrow, mini SOIC-8
LM4811	105 mW headphone with up/down volume control, can drive 8Ω	1.3	0.03	38	25	60	2.0 to 5.5	LLP-10, mini SOIC-10
LM4908 ¹	120 mW headphone, 0.1% THD+N	1.6	0.05	35	25	84	2.0 to 5.5	LLP-8, SOIC-8 Narrow, mini SOIC-8
LM4910	35 mW headphone, bypass capacitor-less, OCL output	3.5	0.03	46	28	65	2.0 to 5.5	LLP-8, SOIC-8 Narrow, mini SOIC-8
LM4911	40 mW headphone, low noise, selectable cap-coupled/OCL output	2.0	—	40	25	65	2.0 to 5.5	LLP-10, mini SOIC-10
LM4916	1.5V, mono 85 mW BTL output, 14 mW stereo headphone	1.0	0.2	0.055W	—	66	0.9 to 2.5	LLP-10, mini SOIC-10
LM4921	Low-voltage I ² S 16-bit stereo DAC with stereo headphone power amplifier and volume control	6.0	0.03	50	—	62	2.6 to 5.5	micro SMD-20
LM4925	2-cell, single-ended output, 40 mW stereo headphone audio amplifier	1.0	0.05	40	—	70	1.5 to 3.6	LLP-10, mini SOIC-10
LM4924	40 mW 2-cell headphone with OCL output	1.5	0.01	40	24	66	1.4 to 3.6	LLP-10, mini SOIC-10
LM4929	40 mW headphone with low noise and OCL output	1.5	—	40	25	65	2.0 to 5.5	mini SOIC-10
LM4980 	42 mW stereo headphone with 2-cell battery operation and advanced click-and-pop suppression	1.0	0.02	42	28	90	1.5 to 3.3	LLP-10
LM4985	135 mW headphone with OCL or cap-coupled output, 32-step I ² C compliant volume control	3.0	0.08	45	23	77	2.0 to 5.5	micro SMD-12

¹10 kV ESD Rated

 PowerWise® product

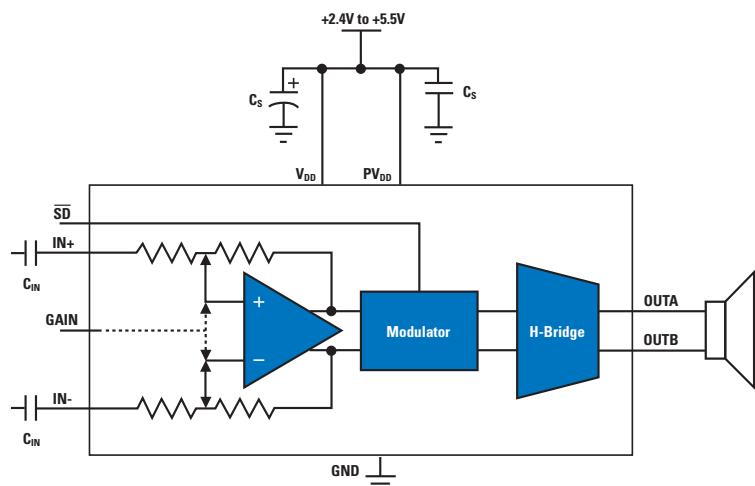
High-Efficiency Boomer® Class D Amplifiers

LM48312 – 2.6W, Ultra-Low-EMI, Filterless, Mono Class D Audio Power Amplifier

Features

- Passes FCC Class B radiated emissions with 20 inches of cable
- E²S system reduces EMI while preserving audio quality and efficiency
- Output short-circuit protection with auto-recovery
- No output filter required
- Improved audio quality
- Minimum external components
- Five logic selectable gain settings (0, 3, 6, 9, 12 dB)
- Low-power shutdown mode
- Click-and-pop suppression

Typical Application Circuit



Applications

Ideal for use in mobile phones, handhelds, and laptop speakers

High-Efficiency Boomer Class D Amplifiers

Product ID	Description	THD (%)	Output Power THD ≤ 1%		Packaging
			4Ω (W)	8Ω (W)	
LM4673 E	Mono filterless	0.02	2.15	1.24	micro SMD-9, LLP-8
LM4674 E	Stereo filterless	0.05	1.9	1.25	micro SMD-16, LLP-16
LM4674A E	Filterless 2.5W stereo Class D	0.05	1.9	1.25	micro SMD-16
LM4675 E	Mono, ultra-low EMI	0.02	2.2	1.3	micro SMD-9, LLP-8
LM48310 E	Mono filterless, E ² S	0.03	2.1	1.3	LLP-10
LM48311 E	Mono filterless, E ² S	0.03	2.1	1.3	micro SMD-9
LM48410 E	Stereo, ultra-low EMI, filterless, 3D	0.025	1.9	1.2	LLP-24
LM48411 E	Stereo filterless, E ² S	0.03	2.0	1.25	micro SMD-16
LM48413 E	Stereo, E ² S, 3D	0.03	—	1.2	micro SMD-18

E PowerWise® product

E Evaluation board

Boosted Boomer® Moving Coil

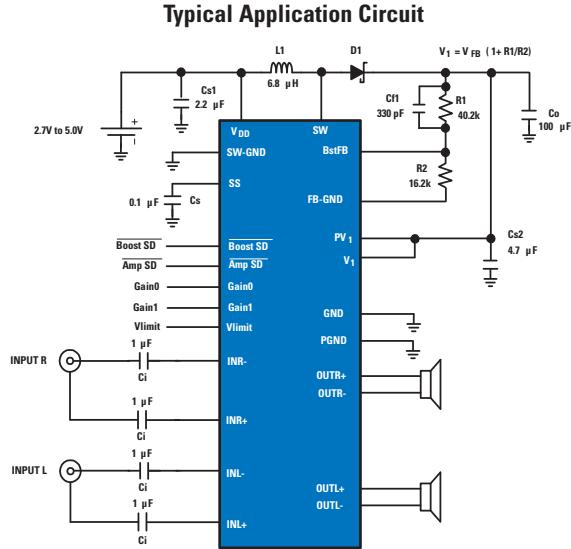
LM48520 – Boosted Stereo Class D Audio Power Amplifier with Output Speaker Protection and Spread Spectrum

Features

- Advanced click-and-pop suppression
- Low 0.04 μA shutdown current
- 78% efficiency
- Filterless Class D
- 2.7V to 5.0V operation
- 4 adjustable gain settings
- Adjustable output swing limiter with soft clipping
- Speaker protection
- Short-circuit protection on audio amplifiers
- Independent boost and amplifier shutdown pins

Applications

Ideal for use in mobile phones, PDAs, portable media devices, cameras, and handheld games



LM48512 – Boosted, Ultra-Low-EMI, Mono Class D Audio Power Amplifier

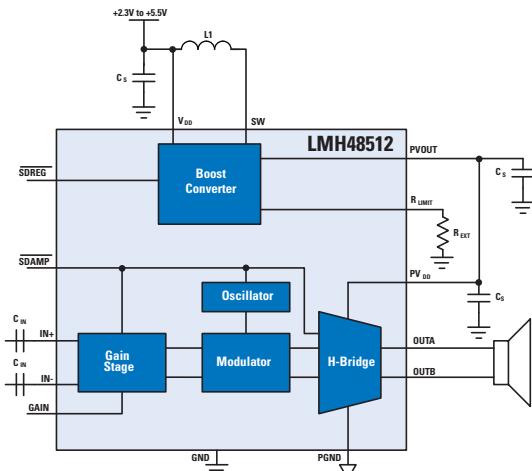
Features

- E²S system reduces EMI while preserving audio quality and efficiency
- Integrated boost converter
- Supply voltage level detection on boost converter
- Low-power shutdown mode

Applications

Ideal for use in smartphones and mobile phones

Typical Application Diagram



Boosted Boomer Moving Coils

Product ID	Description	THD (%)	Output Power at THD $\leq 1\%$		Packaging
			4Ω (W)	8Ω (W)	
LM4804	1.8W low voltage, high power	0.15	—	1.9 at 4.2V, 2%	LLP-28
LM4805	1W low voltage, high power (supplies 1W down to 3V)	0.25	—	1.2 at 4.2V	LLP-28
LM48510	1.2W boosted Class D	0.07	1.7 at 3.3V	1.2 at 3.3V	LLP-16
LM48511	3W boosted Class D with ultra-low EMI and spread spectrum	0.03	5.4 at 5V	3.0 at 5V	LLP-24
LM48512	1.8W boosted Class D with E ² S	0.03	1.8	2.7	micro SMD-16
LM48520	1.1W boosted Class D with speaker protection and spread spectrum	0.04	—	1.1 at 3.3V	micro SMD-25

PowerWise® product

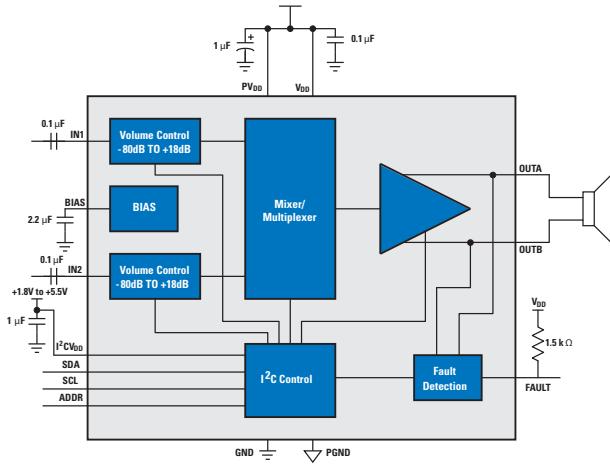
Mono and Stereo Boomer® Audio Amplifiers

LM48100Q – PowerWise® Mono, 1.3W Audio Power Amplifier with Output Fault Detection and Volume

Features

- Output fault detection
- I²C compliant volume and mode control
- Input mixer/multiplexer
- High PSRR
- Individual 32-step volume control
- Short circuit and thermal protection
- Advanced click-and-pop suppression
- Low-power shutdown mode
- AEC-Q100 (automotive) grade
- Available in eTSSOP-14 packaging

Typical Application Circuit



Fully Differential Mono Boomer Amplifiers

Product ID	Description	THD (%)	Output Power at 1% THD+N V _{CC} = 5V		Packaging
			4Ω (W)	8Ω (W)	
LM4923 E	LM4898 with improved output power	0.02	—	1.1	LLP-8
LM4927	1.3W high PSRR	0.03	2.1	1.3	LLP-8
LM4941 E	1.25W RF suppression, high PSRR and CMRR	0.04	—	1.25	micro SMD-9, LLP-8

Mono Boomer Audio Amplifiers

Product ID	Description	THD (%)	Output Power V _{CC} = 5V		Packaging
			4Ω (W)	8Ω (W)	
LM4819 E	350 mW audio power amplifier with shutdown mode	1.0	—	0.25	LLP-8, SOIC-8
LM4951	1.8W (at 7.5V) wide voltage range	0.07	—	0.9	micro SMD-9, LLP-10
LM4954	3W (into 3Ω) wide voltage range	0.01	1.6	1.2	micro SMD-9
LM4991 E	3W (into 3Ω)	0.02	2.13	1.1	LLP-8, SOIC-8
LM4995 E	1.3W	0.01	—	1.3	micro SMD-9, LLP-8
LM4951A	1.8W (at 7.5V) wide voltage range with short circuit protection	0.07	—	1.8	LLP-10
LM48100Q	Mono, 1.25W audio power amplifier with output fault detection and volume control	0.02	—	1.25	eTSSOP-14

Stereo Boomer Amplifiers

Product ID	Description	THD (%)	Output Power THD ≤ 1%, V _{CC} = 5V		Packaging
			4Ω (W)	8Ω (W)	
LM4928 E	1.2W stereo fully differential with RF suppression	0.04	1.8	1.2	micro SMD-16, LLP-14
LM4992 E	1.07W stereo with independent channel shutdown	0.15	—	1.07	LLP-14

PowerWise® product

E Evaluation board

Specialty Audio

Specialty Audio Synch LED Drivers

Product ID	Description	Audio Channels	Control	Number of Outputs	Supply Voltage (V)	LED Drive Current (1x)	Supply Voltage Range (V)	Packaging
LM4970	Audio synchronized color LED driver	3	I ² C compliant	3	3	18 mA	2.7 to 5.5	LLP-14

12V Boomer® Audio Amps

Product ID	Description	Supply Voltage Range (V)	THD (%)	Output Power at THD ≤ 1% V _{cc} = 12V		Packaging
				4Ω (W)	8Ω (W)	
LM4950	7.5W mono or 3.1W stereo	9.6 to 16	0.14	3.1	6.2	T0220-9, T0263-9

Specialty Audio Motor Drivers

Product ID	Description	Supply Voltage Range (V)	Quiescent Current V _{DD} = 3V (mA)	Wake up Time (ms)	Output Current V _{DD} = 3V (mA)	Output Voltage (V _{OUT})	Shutdown Current (µA)	Packaging
LM48580 ^E	High-voltage haptic driver	2.5 to 5.5	3.5	1.4	—	25 V _{P-P} (V _{DD} =3.6V, THD+N≤1%, RL=6 µF + 10Ω)	0.1	micro SMD-12
LM4570 ^E	Haptic motor driver	2.4 to 5.5	1.9	2.4	192	—	0.1	LLP-8

^E PowerWise® product

^E Evaluation board

LM48580 – Boomer® High-Efficiency, High-Voltage Haptic Piezo Actuator and Ceramic Speaker Driver

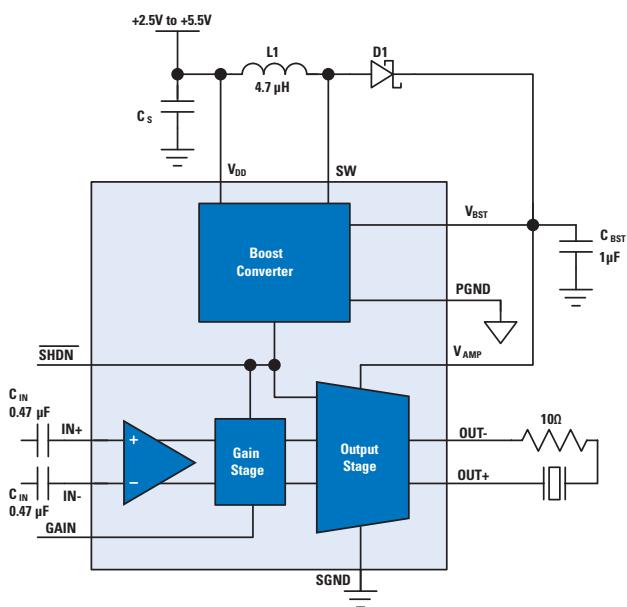
Features

- 25 V_{P-P} (typ) output voltage
- Quiescent power supply current at 3.6V
- Integrated boost converter
- Bridge-Tied Load (BTL) output
- Differential input
- Three pin-programmable gains
- Low supply current
- Minimum external components
- Micro-power shutdown
- Available in space-saving micro SMD-12 packaging

Applications

Ideal for use in touchscreen smartphones, tablet PCs, portable electronic devices, and MP3 players

Typical Application Circuit



Choosing an Audio Power Amplifier

Selecting an appropriate audio power IC for a particular application is dependent upon the desired output power, its corresponding THD specification, a specified load impedance, and available voltage supply rails.

With the varying output power specifications stated by IC manufacturers, and the variables mentioned above, choosing the correct IC is sometimes difficult. The following paragraphs are intended to simplify the decision making process by explaining the general issues with specifying output power with respect to THD and some of the other variables mentioned above.

Power may be represented in many forms, but for general purposes, power is based on the current through a resistance multiplied by the voltage drop across that resistance, as shown in *Equation 1*.

$$(1) P = VI$$

Two other equivalent forms of the same equation based on either the voltage or current are shown in *Equations 2* and *3*, respectively.

$$(2) P = V^2/R$$

$$(3) P = I^2R$$

The output power of an audio IC can be represented by any of the preceding equations, and depending upon the measurement device, the output voltage or current can be represented as peak or root-mean-square (rms) amplitude. It is an industry standard to evaluate linear systems with a sinewave whose rms voltage can be obtained through *Equation 4*.

$$(4) V_{rms} = \sqrt{\frac{1}{T} \int v(t) dt} \text{ from } t=0 \rightarrow t=T$$

Deriving the above equation for one period of a sinewave [$v(t) = V_{pk} \sin(\omega t)$] results in *Equation 5*.

$$(5) V_{rms} = V_{pk}/\sqrt{2}$$

The industry standard continuous average output is found by using the output rms voltage, as shown in *Equation 6*.

$$(6) P_{rms} = V_{rms}^2/RL$$

If the same output power is to be obtained using the peak output voltage as seen on an oscilloscope, then

Equation 5 should be substituted into *Equation 6*, resulting in *Equation 7*.

$$(7) P_{rms} = V_{pk}^2/2RL$$

Equation 6 or *7* are the most general equations stating the output power of a power IC based on a sinewave output into pure resistance. All of the above equations would change if the signal form changed or the load included some form of reactance. It should also be noted that if the peak output voltage were used directly into *Equation 2*, then a peak output power rating would result. This nonstandard technique misleads customers into thinking that a part is capable of much more than what is really true. System design engineers therefore may have a difficult time distinguishing between the different power ratings stated by semiconductor manufacturers.

Every output power rating of an audio IC has a corresponding Total Harmonic Distortion (THD) specification that states the quality of music reproduction by the device. The more linear an amplifier is, the lower the THD rating will be, therefore providing clearer music amplification.

In some instances, IC manufacturers state output power levels with THD values equal to 10%; a condition well into clipping. When observed on an oscilloscope, a sinewave appears to have its peaks cut off. This condition of clipping can occur from two factors; the maximum output voltage swing is reached or the maximum output current drive capability is reached. Both of these limiting factors can control the maximum output power capability, as indicated through *Equations 1-3*.

As shown in *Figures 1-3*, the amount of clipping increases the number and level of harmonics produced by the amplifier as its output limitations are reached and exceeded. Although output power is increased as the amplifier is driven farther into clipping, the quality of sound is adversely affected by the increasingly distorted waveform.

Choosing an Audio Power Amplifier

The output power obtained from one IC with a 10% THD specification will not be competitive with another amplifier whose power is the same, but whose THD is lower. For a given supply voltage load, two audio amplifiers can only be compared on equal footings if their THD specifications are equivalent. The amplifier whose power is the same, but has a lower THD, will generally be more expensive. This is partly because the output stage needs to be larger to support more current drive capability. This makes the device more expensive to produce and thus translates into a higher end cost for the customer.

In summary, it should be remembered when selecting an audio IC that any power rating has a corresponding THD specification which is based on a given voltage supply and load. Most consumer applications require clean crisp music as opposed to the harsh sound of clipping, so beware of those 10% distortion ratings and make sure that your comparisons are apples to apples.

In support of the above information, this audio selection guide is set up to allow easy selection of parts based on supply voltage range, load impedance, and most importantly, power with respect to THD level.

Figure 1: Amplifier output: $P_o = 80W$, $THD+N = 0.00056\%$, $R_L = 8\Omega$

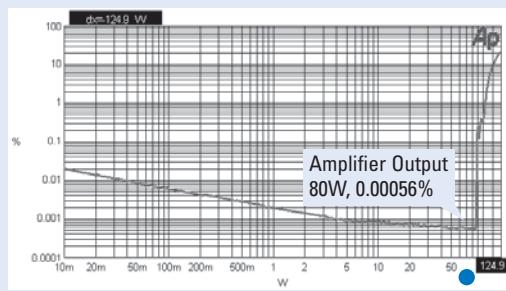
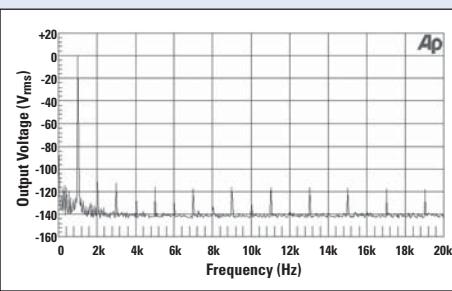
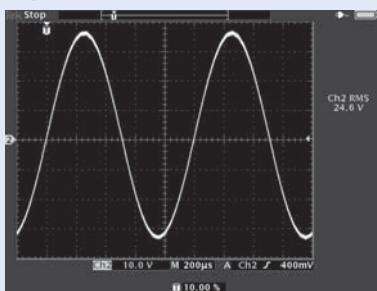


Figure 2: Amplifier output: $P_o = 106W$, $THD+N = 1\%$, $R_L = 8\Omega$

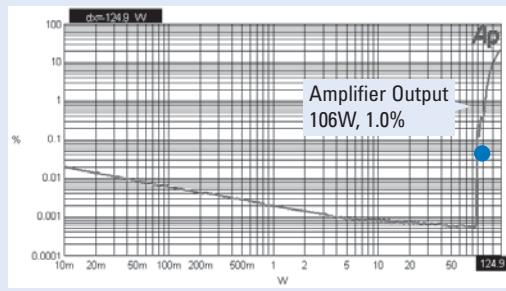
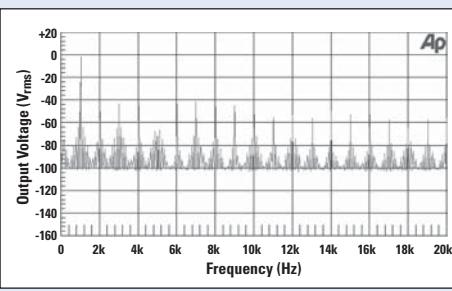
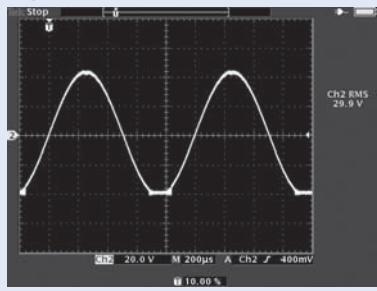


Figure 3: Amplifier output: $P_o = 125W$, $THD+N = 10\%$, $R_L = 8\Omega$

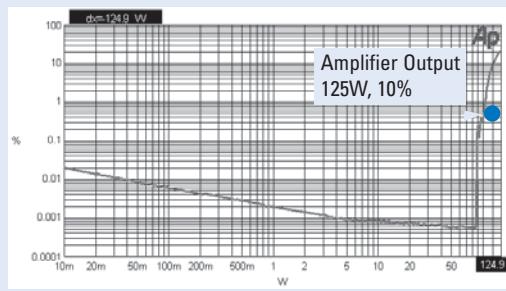
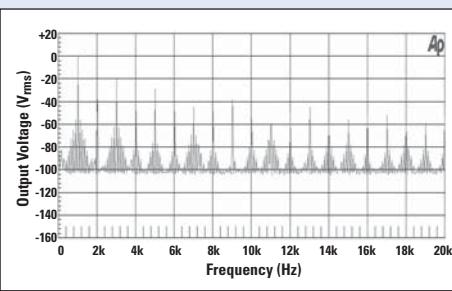
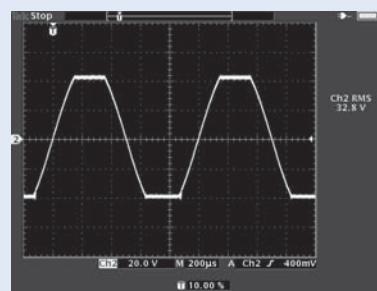


Figure 1 - 3 are collected using National's LM4702

High-Performance Audio Op Amps and Buffers

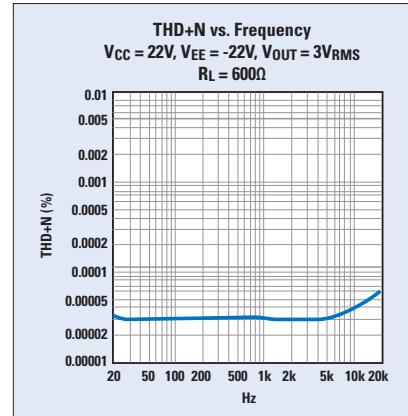
LME49860 – 44V Dual, High-Performance, High-Fidelity Operational Amplifier

Features

- Easily drives 600 Ω loads
- Optimized for superior audio signal fidelity
- Output short circuit protection
- PSRR and CMRR exceed 120 dB (typ)
- Available in SOIC-8 and DIP-8 packaging

Applications

Ideal for use in high-quality audio amplification, phono pre-amps, high-performance professional audio, high fidelity active filters, equalization and crossover networks, high-performance line drivers and receivers, and high-voltage industrial applications including test, measurement, and ultrasound



Audio Operational Amplifiers

Product ID	Description	Input Voltage Noise Density (nV/ $\sqrt{\text{Hz}}$)	THD (%)	Slew Rate (V/ μs)	GBWP (MHz)	PSRR (dB)	Supply Voltage (V)	Packaging
LME49710 E	High-performance, high-fidelity audio op amp	2.7	0.00003	20	56	125	± 2.5 to ± 17	DIP-8, MSOP-8, T099-8
LME49870 E	High-performance, high-fidelity audio op amp	2.7	0.00003	20	55	125	± 2.5 to ± 22	SOIC-8
LM4562 E	Dual high-performance, high-fidelity audio op amp	2.7	0.00003	20	56	110	± 2.5 to ± 17	DIP-8, MSOP-8, T099-8
LME49720 E	Dual high-performance, high-fidelity op amp	2.7	0.00003	20	56	110	± 2.5 to ± 17	DIP-8, MSOP-8, T099-8
LME49860 E	44V dual high-performance, high-fidelity audio op amp	2.7	0.00003	20	55	120	± 2.5 to ± 22	SOIC-8
LME49740 E	Quad high-performance, high-fidelity audio op amp	2.7	0.00003	20	56	125	± 2.5 to ± 17	DIP-14, SOIC-14
LME49713 E	High-performance, high-fidelity current feedback audio op amp	1.9	0.00008	1900	30	102	± 5 to ± 18	SOIC-8
LME49721 E	High-performance, high-fidelity, rail-to-rail input/output audio op amp	4.0	0.0002	8.5	20	103	2.2 to 5.5	MSOP-8
LME49723 E	Dual, high-fidelity audio op amp	3.6	0.0002	8	17	100	± 2.5 to ± 17	MSOP-8
LME49722 E	Dual high-performance, high-fidelity audio op amp	1.9	0.00002	22	55	120	± 2.5 to ± 18	MSOP-8
LME49725 E	Dual high-performance, high-fidelity audio op amp	3.3	0.0004	15	40	120	± 4.5 to ± 18	MSOP-8
LME49743 E	Quad high-performance, high-fidelity audio op amp	3.5	0.0001	12	30	98	± 4 to ± 17	TSSOP-14
LME49726 E	High-current, low-distortion, rail-to-rail output audio op amp	6.9	0.00002	3.7	6.25	104	2.5 to 5.5	MSOP-8
LME49724 E	High-performance, high-fidelity, fully-differential audio op amp	2.1	0.00003	18	50	125	± 2.5 to ± 18	PSOP-8
LME49871 E	High-performance, high-fidelity, current-feedback audio op amp	1.9	0.00012	1900	213	102	± 5.0 to ± 22	SOIC-8
LME49880 E	High-performance, high-fidelity, JFET input audio op amp	7.0	0.00003	17	25	110	± 5.0 to ± 17	PSOP-8 Narrow
LME49990 E	Ultra-low-distortion, ultra-low-noise-audio op amp	0.9	0.00001	22	110	144	± 5.0 to ± 18	SOIC-8 Narrow

Headphone Buffers

Product ID	Description	THD (%)	Output Current (mA)	Slew Rate (V/ μs)	GBWP (MHz)	Supply Voltage (V)	Supply Voltage (V)	Packaging
LME49600 E	High-performance, high-fidelity, high-current audio buffer	0.00015	250	2000	110/180	± 18 V	± 5 to ± 18	T0263-5
LME49610 E	High-performance, high-fidelity, high-current audio buffer	0.00003	250	2000	120/200	± 22 V	± 2.5 to ± 22	T0263-5

E Evaluation board

High-Performance Audio Power Amplifier Driver

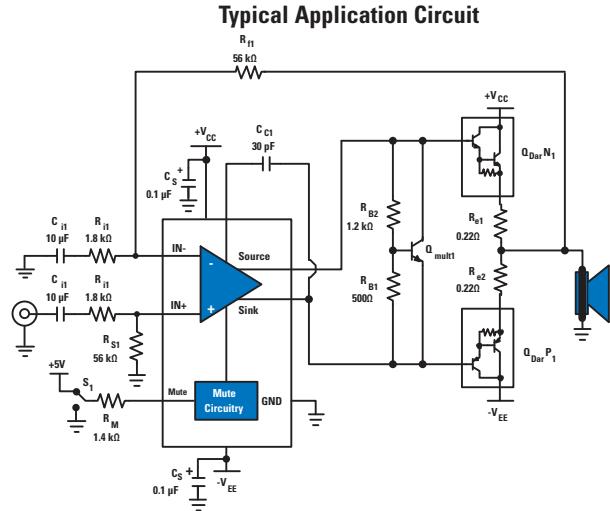
LME49811 – Mono High-Fidelity 200V Driver with Mute

Features

- Very high-voltage operation
- Scalable output power
- Minimum external components
- External compensation
- Thermal shutdown and mute

Applications

Ideal for use in AV receivers, audiophile power amps, pro audio, and high-voltage industrial applications

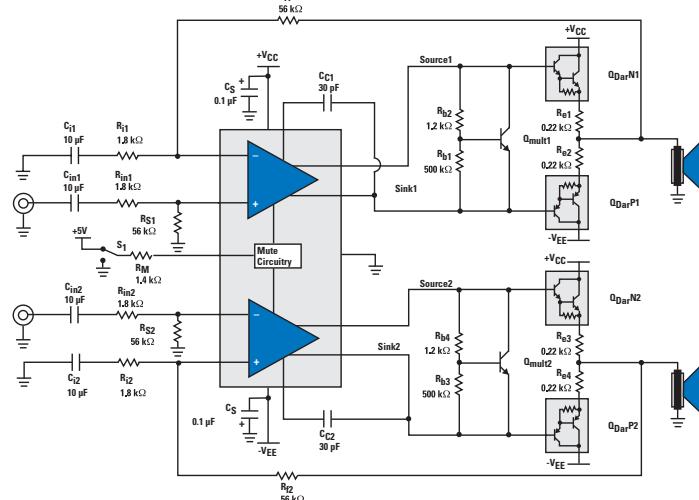


Audio Power Amplifier Drivers

Product ID	Description	Supply Voltage (V)	Typical THD Ratings (%)	THD Measurement Conditions	PSRR (dB)	Supply Voltage Range (V)	Mute/Shutdown	Packaging
LM4702B	Stereo high-fidelity audio power amplifier driver	±100	0.003	A _V = 30 dB, V _{OUT} = 20 V _{RMS} at 1 kHz	110	±20 to ±100	Mute	TO220-15
LM4702C	Stereo high-fidelity audio power amplifier driver	±75	0.005	A _V = 30 dB, V _{OUT} = 14 V _{RMS} at 1 kHz	110	±20 to ±75	Mute	TO220-15
LME49810	Mono high-fidelity audio power amplifier driver with Baker clamp	±100	0.0007	No load, BW = 30 kHz, V _{OUT} = 20 V _{RMS} at 1 kHz	110	±20 to ±100	Mute	TO247-15
LME49811	Mono high-fidelity audio power amplifier driver with mute	100	0.005	No load, A _V = 30 dB V _{OUT} = 10 V _{RMS} at 1 kHz	110	±20 to ± 100	Mute	TO220-15
LME49830	Mono high-fidelity audio power amplifier input state with mute	±100	0.0006	No load, A _V = 30 dB, V _{OUT} = 30 V _{RMS} at 30 kHz	105	±20 to ± 100	Mute	TO247-15

LM4702 – Stereo High-Fidelity 200V Driver with Mute

Typical Application Circuit



Features

- Very high voltage operation
- Scalable output power
- Minimum external components
- External compensation
- Thermal shutdown and mute

Applications

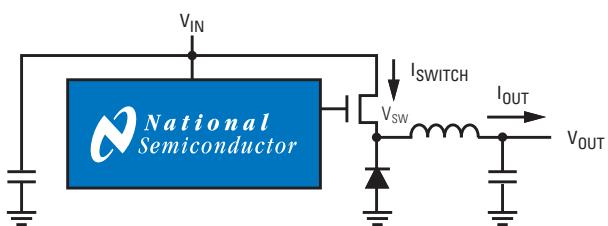
Ideal for use in AV receivers, audiophile power amps, pro audio, and high-voltage industrial applications

Power Management Product Portfolio



Switching Power Supply Topologies

Buck



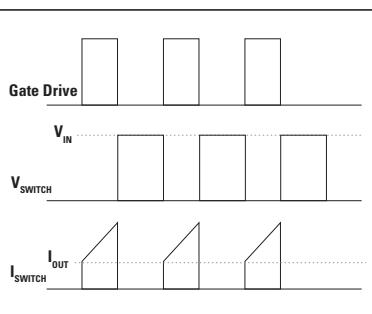
Function: Step-down ($V_{OUT} < V_{IN}$)

When to use: Typically when V_{IN} is 3x to 5x V_{OUT} and I_{OUT} is $> 0.5A$ and $< 5A$

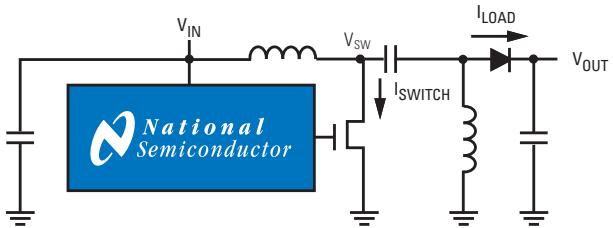
Characteristics: Easy to design and good efficiency for the above mentioned typical $V_{IN}/V_{OUT}/I_{OUT}$ conditions

Devices to use: All buck integrated regulators and controllers

Comments: Can do multi-output or isolation through coupling a second inductor to the one shown in the basic circuit



SEPIC



SEPIC = Single-Ended Primary Inductor Converter

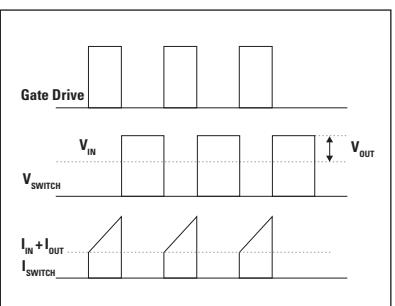
Function: Buck-boost (V_{IN} max. $> V_{OUT}$ min.)

When to use: Excellent option when buck-boost operation is needed and no transformer is desired

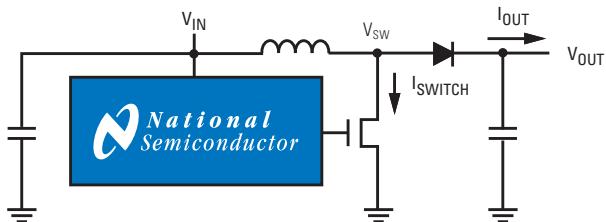
Characteristics: Lower input ripple than flyback, no snubber circuitry required

Devices to use: Any boost/flyback regulator or controller

Comments: Also useful for replacing boost circuits when true shutdown is required



Boost



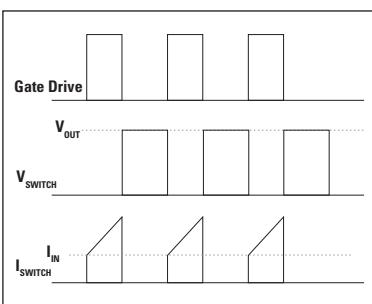
Function: Step-up ($V_{OUT} > V_{IN}$)

When to use: Typically used when transformerless, regulated output voltages larger than input voltages at output currents beyond 100 mA - 200 mA are required

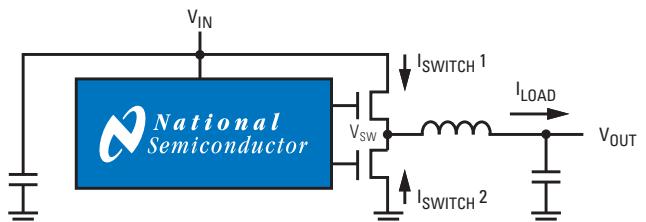
Characteristics: Best for low-power conversion (up to 10W or 20W) and output voltages less than or equal to 7x the input voltage

Devices to use: All boost/flyback regulators and controllers

Comments: Output current $V_{IN}/V_{OUT} \times 0.7 \times$ switch current



Synchronous Buck

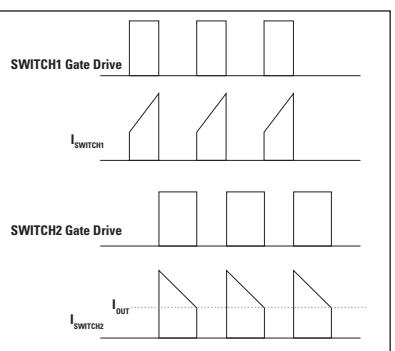


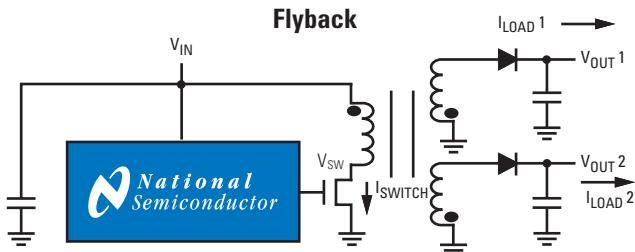
Function: Step-down ($V_{OUT} < V_{IN}$)

When to use: When high efficiency is required with high-output current ($> 5A$) or low duty cycles ($V_{IN} > 5 \times V_{OUT}$ and/or $I_{OUT} < 0.5A$)

Characteristics: A second switch replaces the diode in the basic buck topology, reducing losses in the conditions mentioned above

Devices to use: Any "synchronous rectification" buck integrated regulator or controller



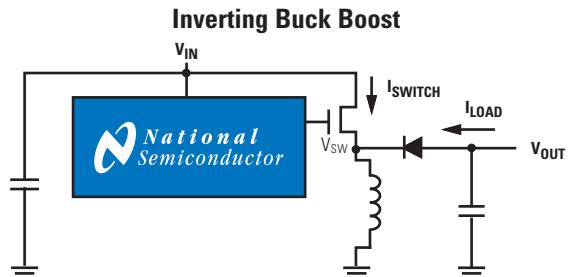
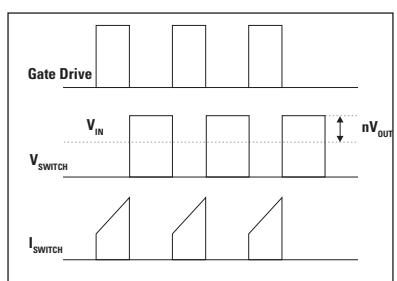


Function: Step-up, step-down, invert or buck-boost

When to use: Typically when multi-output or isolation is required, when step-up beyond $8 \times V_{IN}$ is required or when the max. voltage or current of the switch needs to be extended in order to take advantage of the turns-ratio conversion from the transformer

Characteristics: Ideal for medium-power conversion (5W to 100W)

Devices to use: All boost/flyback regulators and controllers



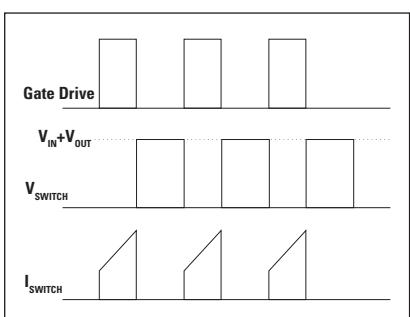
Function: Inverting (negative output from positive input, $-V_{OUT}$ can be greater than or less than V_{IN})

When to use: When an inverted, regulated output is needed. This topology is commonly used for output currents from approximately 300 mA to 5A

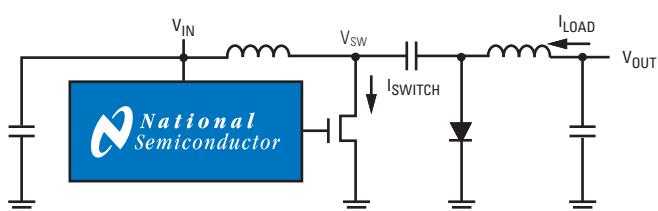
Characteristics: Easy to implement, single output

Devices to use: Any buck integrated regulator or controller (see National's App Note AN-1157 for implementing with a SIMPLE SWITCHER® buck regulator)

Comments: Alternatives for voltage inversion include cuk topologies (low noise) or switched capacitor converters where I_{OUT} is less than 200 mA (no inductor needed)



Cuk



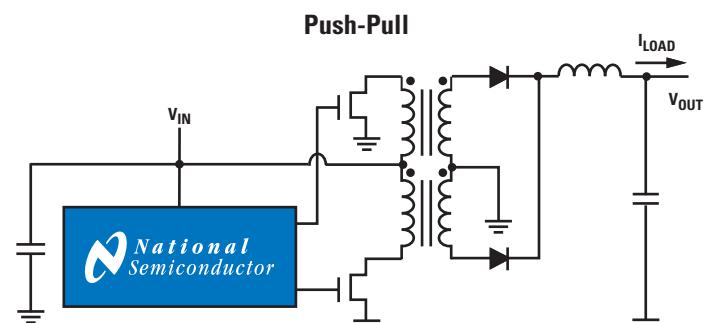
Function: Inverting (V_{OUT} is negative; V_{IN} is positive)

When to use: When a regulated, negative, low-ripple voltage is needed from a positive supply

Characteristics: Continuous current at input and output translates into a very low-ripple/very low-noise design

Devices to use: Any boost/flyback regulator – this is easiest with parts that have a negative FB input pin

Comments: OK for isolation when a 1:1 transformer is added

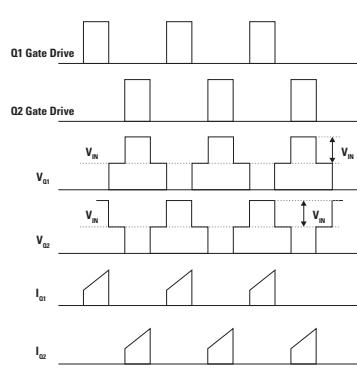


Function: Isolated step-down, step-up or buck-boost and multiple outputs

When to use: When isolated, medium-to-high power conversion is needed (25 W to 1000 W). This topology can also be used when the input voltage range is very wide or when the V_{IN}/V_{OUT} ratio in step-down applications requires a very small duty cycle (and thus might yield poor regulation) if a standard buck topology is used.

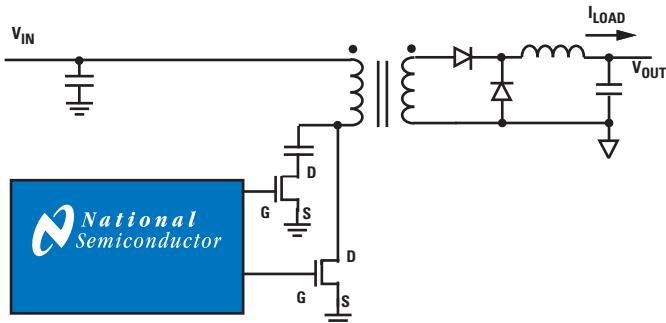
Devices to use: LM5030, LM5037, and LM25037 current-mode push-pull controller

Comments: The peak current and voltage stress in the switches are given by: $V_{PK} = 2.6 V_{IN}$ max., $I_{PK} = 1.56 \times P_{OUT}/V_{IN}$ min.



Switching Power Supply Topologies

Active Clamp Forward



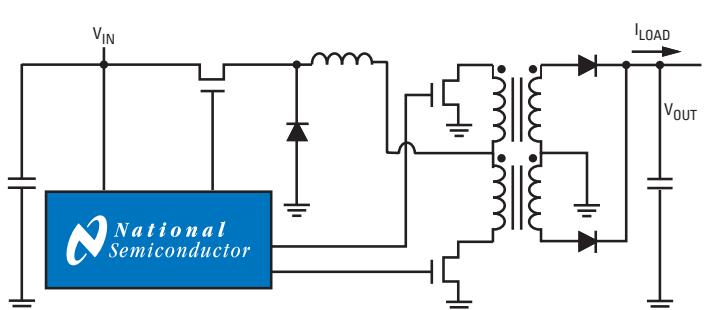
Function: Isolated, step-down or step-up

When to use: High step down ratios and/or isolated output and 100-300W power

Devices to use: LM5025, LM5026, LM5032, LM5034

Comments: Forward topology requires lower peak current than flyback. At the start of a switch conduction, the net magnetization of the transformer core must be zero. Active clamp recycles the reset energy, improving efficiency.

Current-Fed Push-Pull (Cascaded)

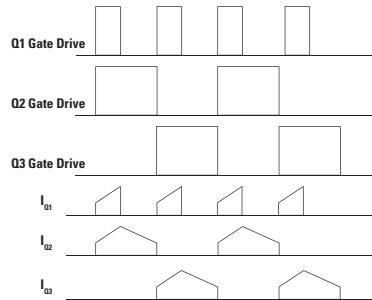


Function: Isolated step-down, step-up, or buck-boost topologies. Can do tightly regulated multiple outputs.

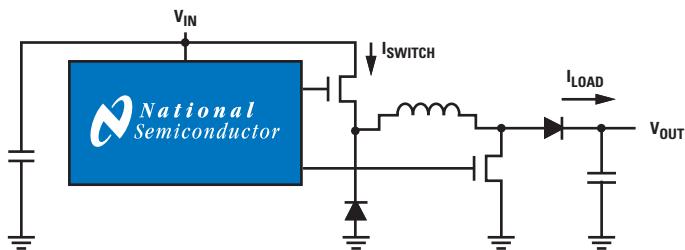
When to use: When isolated medium-to-high-power conversion is needed, but reduced losses, high efficiency, and no output inductor are also desired.

Characteristics: The current-fed cascaded topology consists of a buck regulation stage followed by a push-pull isolation stage.

Because the buck stage feeds continuous current to the push-pull stage, no output inductor is required.



Single Inductor Buck and Boost



Function: Step-up and step-down

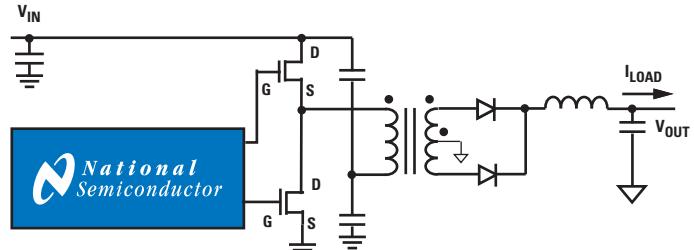
When to use: This topology is an alternative to SEPIC and flyback topologies when automatic step-up/step-down functionality is needed, but no transformer or second inductor is required

Characteristics: A second switch and output diode are added, resulting in an effective overlapped boost topology on top of a basic buck topology. If desired, synchronous rectification can be implemented to increased efficiency (both diodes may be replaced by FETs).

Devices to use: LM5118

Comments: Be sure to watch the voltage applied to the gate in the second FET which will be V_IN. If V_IN is too high for the selected FET specifications, use voltage limiting circuitry.

Half Bridge



Function: Isolated, step-down or step-up

When to use: High step-down ratios and/or isolated output and 200 to 1000W power

Devices to use: LM5033, LM5035, LM5037, and LM25037

Comments: The half bridge converter is similar to the push-pull converter, but FETs are subject to lower voltages stresses and a center-tapped primary is not required. The reversal of the magnetic field is achieved by reversing the direction of the primary winding current flow. For higher output power capability, a full bridge may be used instead.

Save Development Time and Costs

WEBENCH® Designer 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

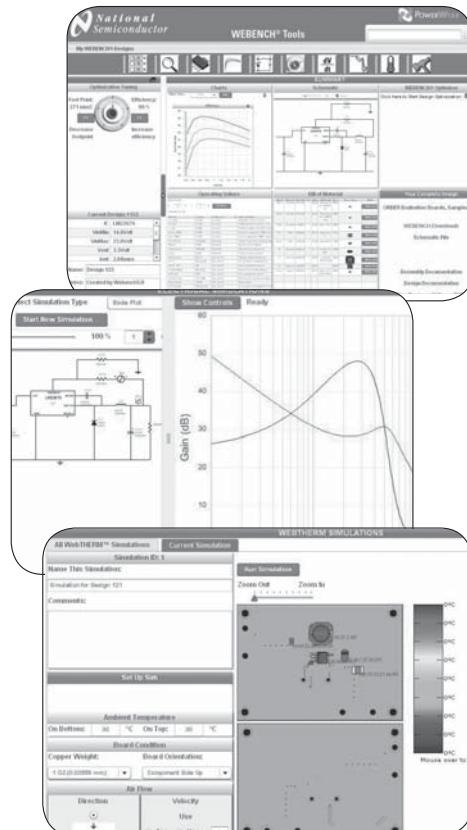
- Input your design requirements
- Choose a recommended part from a customized list

Choose from only those parts that meet your specifications

Design It

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

Create your custom BOM using readily available parts



Analyze It

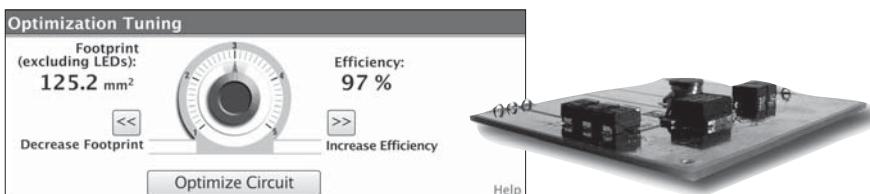
- Simulate your circuit and evaluate performance using electrical and thermal simulations
- Simulate electrical characteristics, choose probe points, and examine waveforms to determine performance
- Simulate thermal behavior and your circuit on a PCB in your defined environment and view color heat maps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

Solve your design problems before you prototype

Build It

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

Save weeks getting your final design into production



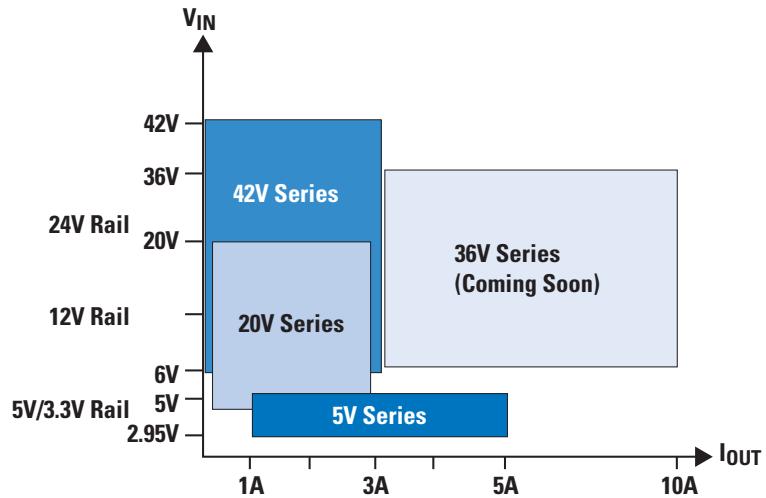
24 HOUR SHIPPING!

SIMPLE SWITCHER® Power Modules

SIMPLE SWITCHER® Power Modules

Easy-to-use SIMPLE SWITCHER power modules feature an innovative package with best-in-class EMI and thermal performance. The modules provide high efficiency over a wide input voltage and output current range. Each module series is pin-to-pin compatible for faster time to market.

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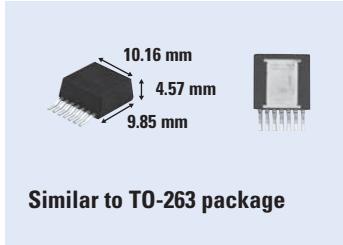


Highly Integrated Solution in Easy-to-Use Package

The power module integrates control circuitry, synchronous MOSFETs, a shielded inductor, and small passives in an easy-to-use package. This removes many design and layout challenges such as choosing the right inductor, selecting the switching frequency, and optimizing the switch node for thermal and EMI performance.

Benefits of this innovative package include:

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



Similar to TO-263 package

Low EMI

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

Best-in-Class Thermal Performance

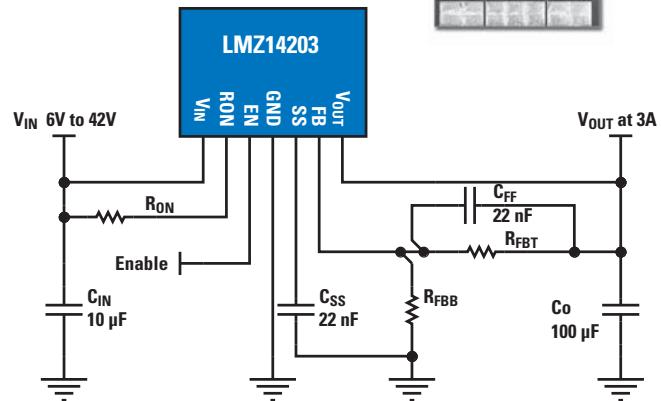
The new SIMPLE SWITCHER power modules offer outstanding thermal performance with very low system heat generation. The modules are versatile in a wide range of temperature environments, even successfully operating at very high ambient temperatures. No airflow or external heat sinks are required, reducing cost and complexity.

Features

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

Applications

Ideal for use in point-of-load conversion from the 3.3V, 5V, 12V, 24V, and 36V input rail; powering digital ICs such as FPGAs, ASICs, and DSPs; loosely regulated distribution bus systems; and industrial controls, telecommunications, and networking equipment



NEW! SIMPLE SWITCHER Power Modules

Product ID	Output Current	V _{IN} Min (V)	V _{IN} Max (V)	V _{OUT} Min (V)	V _{OUT} Max (V)	T _j Range (°C)	Packaging
LMZ10503 E, W	3.0	2.95	5.5	0.8	5.0	-40 to 125	TO-PMOD-7
LMZ10503EXT E, W	3.0	2.95	5.5	0.8	5.0	-55 to 125	TO-PMOD-7
LMZ10504 E, W	4.0	2.95	5.5	0.8	5.0	-40 to 125	TO-PMOD-7
LMZ10504EXT E, W	4.0	2.95	5.5	0.8	5.0	-55 to 125	TO-PMOD-7
LMZ10505 E, W	5.0	2.95	5.5	0.8	5.0	-40 to 125	TO-PMOD-7
LMZ10505EXT E, W	5.0	2.95	5.5	0.8	5.0	-55 to 125	TO-PMOD-7
LMZ12001 E, W	1.0	4.5	20	0.8	6.0	-40 to 125	TO-PMOD-7
LMZ12001EXT E, W	1.0	4.5	20	0.8	6.0	-55 to 125	TO-PMOD-7
LMZ12002 E, W	2.0	4.5	20	0.8	6.0	-40 to 125	TO-PMOD-7
LMZ12002EXT E, W	2.0	4.5	20	0.8	6.0	-55 to 125	TO-PMOD-7
LMZ12003 E, W	3.0	4.5	20	0.8	6.0	-40 to 125	TO-PMOD-7
LMZ12003EXT E, W	3.0	4.5	20	0.8	6.0	-55 to 125	TO-PMOD-7
LMZ14201 E, W	1.0	6	42	0.8	6.0	-40 to 125	TO-PMOD-7
LMZ14201EXT E, W	1.0	6	42	0.8	6.0	-55 to 125	TO-PMOD-7
LMZ14202 E, W	2.0	6	42	0.8	6.0	-40 to 125	TO-PMOD-7
LMZ14202EXT E, W	2.0	6	42	0.8	6.0	-55 to 125	TO-PMOD-7
LMZ14203 E, W	3.0	6	42	0.8	6.0	-40 to 125	TO-PMOD-7
LMZ14203EXT E, W	3.0	6	42	0.8	6.0	-55 to 125	TO-PMOD-7

E Evaluation board

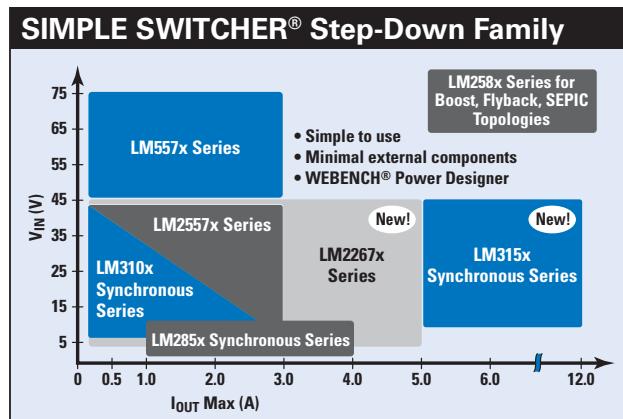
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SIMPLE SWITCHER® Solutions

SIMPLE SWITCHER Products

National's award-winning SIMPLE SWITCHER® products allow you to design and optimize robust power supplies with a minimum set of external components. Supporting input voltage ranges of 3V to 75V, each SIMPLE SWITCHER series provides you with multiple products with pin-to-pin compatibility for added design flexibility. Plus, all SIMPLE SWITCHER products utilize National's WEBENCH® Power Designer end-to-end design and prototyping tools.

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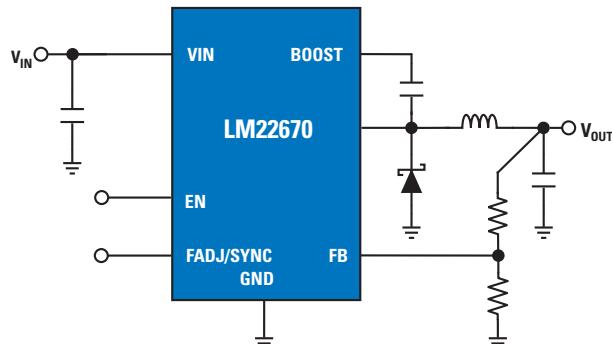
LM2267x AND LM22680 SIMPLE SWITCHER Regulators

The LM2267x and LM22680 SIMPLE SWITCHER regulators provide intuitive, easy-to-use design capabilities while delivering high performance and flexibility.

Features

- Wide input voltage range from 4.5V to 42V
- Load currents from 0.5A to 5A
- Adjustable and fixed output voltages down to 1.285V
- Adjustable and fixed switching frequencies allows for optimization between size and efficiency (up to 1 MHz)
- Frequency sync up to 1 MHz allows for easy management of EMI and/or input capacitance optimization
- Precision enable – precise turn-on and turn-off for power sequencing needs assists with proper system startup
- External soft-start – flexibility to control output voltage ramp up, ensuring proper end-system startup to avoid latch up conditions
- Available in PSOP-8 and TO263-7 THIN packaging – exposed DAPs provide enhanced thermal dissipation, halogen-free and lead-free
- Fully enabled for WEBENCH Power Designer

Typical Application Circuit



LM2267x and LM22680 SIMPLE SWITCHER Non-Synchronous Regulators

Product ID	Output Current (mA)	V _{IN} Max (V)	V _{IN} Min (V)	V _{OUT} Min (V)	Frequency Range (kHz)	f _{sync}	PWM Mode	Packaging
LM22671/74 E,W	500	42	4.5	1.285	200 to 1000 Adj	✓/-	Voltage	PSOP-8
LM22672/75 E,W	1000	42	4.5	1.285	200 to 1000 Adj	✓/-	Voltage	PSOP-8
LM22680 E,W	2000	42	4.5	1.285	200 to 1000 Adj	✓	Voltage	PSOP-8
LM22670/73/76 E,W	3000	42	4.5	1.285	200 to 1000 Adj	✓/-/-	Voltage	TO263-7 Thin, PSOP-8
LM22677/78/79 E,W	5000	42	4.5	1.285	200 to 1000 Adj	✓/-/-	Voltage	TO263-7 Thin

E Evaluation board W WEBENCH enabled

SIMPLE SWITCHER® Regulators

SIMPLE SWITCHER Buck Family

Maximum Load Current												
		Frequency	Input Voltage (V)	0.5A	0.75A	1A	1.5A	2A	2.5A	3A	4A	5A
Asynchronous	VM	Adj. up to 1 MHz	4.5 to 42	LM22671		LM22672		LM22680		LM22670		LM22677
		Fixed 500 kHz	4.5 to 42	LM22674		LM22675				LM22673		LM22678
	CM	Adj. up to 1 MHz	6 to 42	LM25574			LM25575			LM25576		
		Adj. up to 500 kHz	6 to 75	LM5574			LM5575			LM5576		
Synchronous	COT	Adj. up to 1 MHz	4.5 to 42		LM3103		LM3100		LM3102			
	VM	500/1500 kHz	2.85 to 5.5					LM2852				
		550 kHz								LM2853		
		500/1000 kHz									LM2854	
	COT	Adj. up to 1 MHz	6 to 42	LM3150 SIMPLE SWITCHER controller up to 12A with adjustable V _{OUT}								
		250/500/750 kHz		LM315x SIMPLE SWITCHER controller up to 12A with fixed V _{OUT}								

Asynchronous Rectification, Synchronous Rectification, CM = Current Mode Control Loop, VM = Voltage Mode Control Loop, COT = Constant On-Time Control

LM2557x/LM557x – PowerWise® SIMPLE SWITCHER Regulators Deliver Customized Performance and Flexibility to Fit Your Design

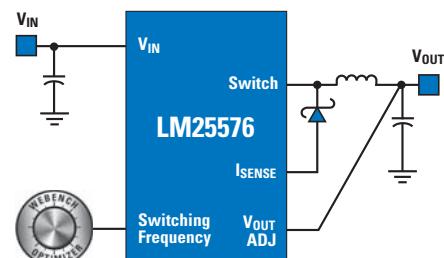
New Emulated Current-Mode (ECM) SIMPLE SWITCHER Family Features

- High V_{IN} to low V_{OUT} step-down ratios
- Superior transient response
- Fast design, guaranteed performance and flexibility
- Fully enabled WEBENCH Power Designer

LM2557x and LM557x SIMPLE SWITCHER Non-Synchronous Regulators

Product ID	Output Current (mA)	V _{IN} Max (V)	V _{IN} Min (V)	V _{OUT} Min (V)	V _{OUT} Max (V)	Frequency Range (kHz)	f _{sync}	On/Off Pin	PWM Mode	Packaging
LM25574 E,W	500	42	6	1.23	40	50 to 1000	✓	✓	Current	TSSOP-16
LM5574 E,W	500	75	6	1.23	70	50	✓	✓	Current	TSSOP-16
LM25575 E,W	1500	42	6	1.23	40	50 to 1000	✓	✓	Current	eTSSOP-16
LM5575 E,W	1500	75	6	1.23	70	50	✓	✓	Current	eTSSOP-16
LM25576 E,W	3000	42	6	1.23	40	50 to 1000	✓	✓	Current	eTSSOP-20
LM5576 E,W	3000	75	6	1.23	70	50	✓	✓	Current	eTSSOP-20

Typical Application Circuit



SIMPLE SWITCHER Boost/Flyback/SEPIC

Product ID	I _{OUT}	V _{IN} Max (V)	V _{IN} Min (V)	V _{OUT} Min (V)	Frequency Range (kHz)	Packaging
LM2585 W	3	40	4	1.23	100	TO-220, TO-263
LM2586 W	3	40	4	1.23	100 to 200	TO-220, TO-263
LM2587 E,W	5	40	4	1.23	100	TO-220, TO-263
LM2588 W	5	40	4	1.23	100 to 200	TO-220, TO-263

PowerWise product Evaluation board WEBENCH enabled

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SIMPLE SWITCHER® Synchronous Regulators

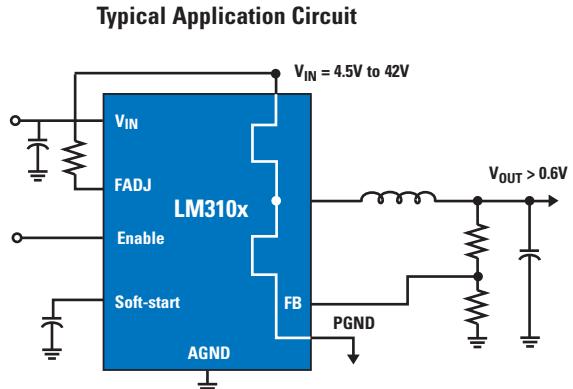
LM310x – PowerWise® Synchronous SIMPLE SWITCHER® Step-Down Regulators

Features

- COT control provides lightning-fast transient response
- Stable with ceramic capacitors
- Near-constant frequency operation from unregulated supplies
- No loop compensation reduces external component count
- Pre-bias startup
- DCM operation for a light load
- Over voltage protection
- Available in thermally-enhanced eTSSOP-20 packaging

Applications

Ideal for use in embedded systems, industrial controls, automotive telematics and body electronics, and Point-of-Load (POL)



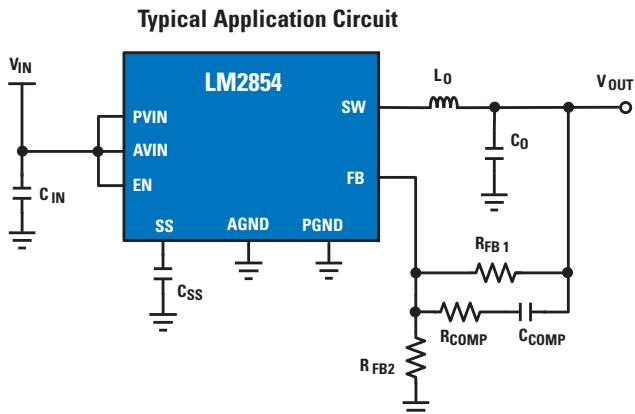
LM285x – PowerWise 500 kHz/1 MHz Synchronous SIMPLE SWITCHER Step-Down Regulator

Features

- Input voltage range of 2.95V to 5.5V
- Maximum load current of 4A
- Fixed switching frequency of 500 kHz or 1 MHz
- Adjustable output down to 0.8V
- Wide bandwidth voltage mode control loop, partial internal compensation
- Pre-biased load startup capability
- 100% duty cycle capability
- Available in eTSSOP-16 packaging

Applications

Ideal for use in low-voltage point-of-load regulation, local solution for FPGA/DSP/ASCI/microprocessor core, or I/O power, broadband, and communications infrastructure



SIMPLE SWITCHER Synchronous Regulators

Product ID	Output Current (mA)	V _{IN} Max (V)	V _{IN} Min (V)	V _{OUT} Min (V)	V _{OUT} Max (V)	Frequency Range (kHz)	PWM Mode	Packaging
LM3103 E,W	750	42	4.5	0.6	38	1000	COT	eTSSOP-16
LM3100 E,W	1500	36	4.5	0.8	7	1000	COT	eTSSOP-20
LM2852 E,W	2000	5.5	2.85	0.8	3.3	500, 1500	Voltage	eTSSOP-14
LM3102 E,W	2500	42	4.5	0.8	7	1000	COT	eTSSOP-20
LM2853 E,W	3000	5.5	3	0.8	3.3	550	Voltage	eTSSOP-14
LM2854 E,W	4000	5.5	2.95	0.8	5	500, 1000	Voltage	eTSSOP-16

LM315x – SIMPLE SWITCHER® Synchronous 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 Controller

- Input voltage ranging from 6V to 42V
- Output current up to 12A
- COT 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
- Available in eTSSOP-14 packaging for enhanced thermal performance

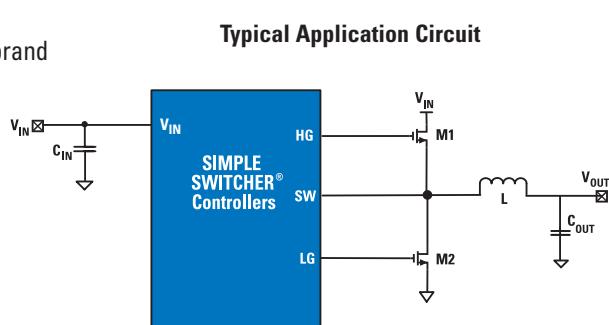
LM3150 Controller

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

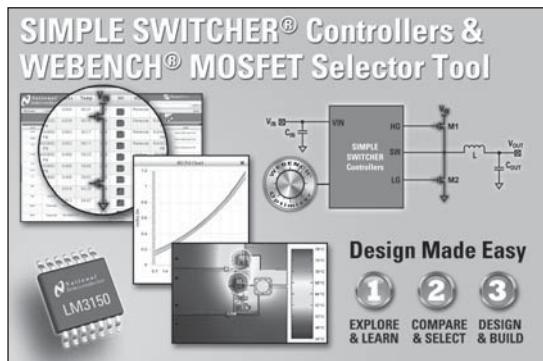
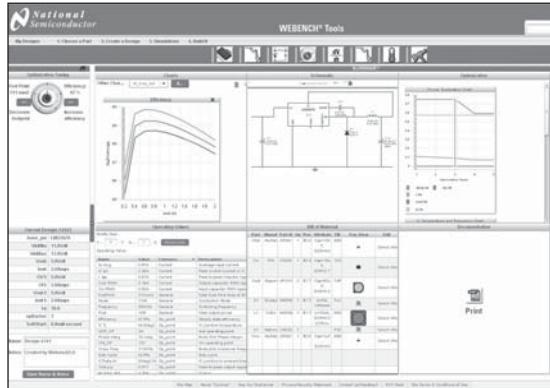
LM3151/52/53 Controller

- 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, and board evaluation



Typical Application Circuit



SIMPLE SWITCHER Synchronous Controllers

Product ID	V _{IN} Max (V)	V _{IN} Min (V)	V _{OUT} Min (V)	V _{OUT} Max (V)	Feedback Tolerance %	Frequency Range (kHz)	Packaging
LM3150 E ^W	42	6	0.6	Adj	1.50	Adj to 1 MHz	eTSSOP-14
LM3151 W ^W	42	6	3.3	3.3	1.50	250 kHz	eTSSOP-14
LM3152 W ^W	33	6	3.3	3.3	1.50	500 kHz	eTSSOP-14
LM3153 W ^W	18	6	3.3	3.3	1.50	750 kHz	eTSSOP-14

PowerWise® product ^E Evaluation board ^W WEBENCH enabled

Non-Synchronous Step-Down (Buck) Switching Regulators

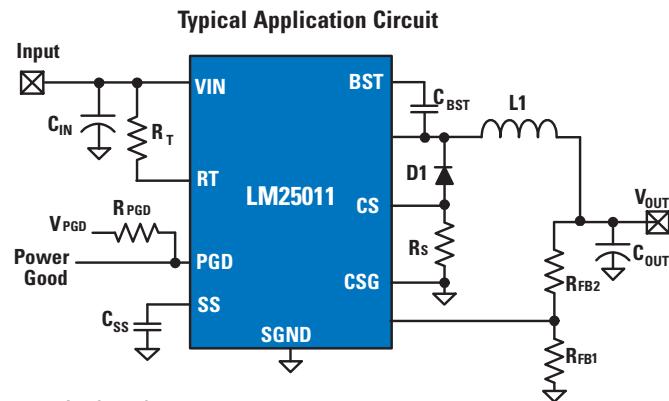
LM25011 – 42V COT Buck Regulator with Current Limit Adjustable to 2A

Features

- AEC-Q100 Grade 1 qualified
(-40°C to +125°C operating junction temperature)
- 6V to 42V input operating voltage range
- Integrated 2A N-channel buck switch
- Adjustable current limit allows for smaller inductor
- Adjustable output voltage from 2.51V
- Power GOOD output
- Switching frequency adjustable to 2 MHz

Applications

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



Non-Synchronous Step-Down (Buck) Switching Regulators

Product ID	Output Current (mA)	V _{IN} Max (V)	V _{IN} Min (V)	V _{OUT} Min (V)	V _{OUT} Max (V)	Frequency Range (kHz)	f _{sync}	PWM Mode	Packaging
LM5009/9A E, W	150	95	9.5/6.0	2.5	85	50 to 600	—	COT	LLP-8, MSOP-8
LM2841 E	300	42	4.5	0.765	34	550 to 1250	—	Voltage	TSOT-6
LM5008/8A E, W	350	95	9.5/6.0	2.5	75	50 to 600	—	COT	LLP-8, MSOP-8
LM(2)5007 E, W	500	42/75	9.0	2.5	37	50 to 800	—	COT	MSOP-8, LLP-8
LM2842 E	600	42	4.5	0.765	34	550 to 1250	—	Voltage	TSOT-6
LM2694 E	600	30	8.0	2.5	24	50 to 1000	—	Hysteretic	LLP-10, TSSOP-14
LM34919/B E, W	600	40	8.0/6.0	2.5	35	Up to 2600	—	COT	micro SMD-10
LM2736 E, W	750	18	3.0	1.25	16	550, 1600	—	Current	SOT23-6
LM2830 W	1000	5.5	3.0	0.6	4.5	1600, 3000	—	Current	SOT23-5
LM2734/Z E, W	1000	20	3.0	0.8	18	550, 1600	—	Current	SOT23-6
LM34930 E	1000	33	8.0	2.5	30	Up to 2000	—	COT	micro SMD-12
LM(2)5010/A E, W	1000	42/75	8.0/6.0	2.5	37/70	50 to 1000	—	COT	LLP-10, eTSSOP-14
LM2695 E	1250	30	8.0	2.5	24	50 to 800	—	Hysteretic	LLP-10, eTSSOP-14
LM34917/A E	1250	33	8.0	2.5	30	2000	—	COT	micro SMD-12
LM34910/C E, W	1250	36/50	8.0	2.5	33/45	1000	—	COT	LLP-10
LM34914 E	1250	40	8.0	2.5	37	1300	—	COT	LLP-10
LM2831 E, W	1500	5.5	3.0	0.6	4.5	550, 1600, 3000	—	Current	SOT23-5
LM2738 E	1500	20	3.0	0.8	18	500, 1600	—	Current	LLP-8, eMSOP-8
LM26001 E	1500	38	3.0	1.25	35	150 to 500	✓	Current	TSSOP-16EP
LM27341/2	1500/2000	20	3.0	1.0	18	1000 to 2350	✓	Current	LLP-10, eMSOP-10
LM2832 E, W	2000	5.5	3.0	0.6	4.5	550, 1600, 3000	—	Current	LLP-6, eMSOP-8
LM25011 E, W	Up to 2000	42	6.0	2.5	37	Up to 2000	—	COT	eMSOP-10
LM(2)5005 E, W	2500	42/75	7.0	1.23	37/70	50 to 500	✓	Current	eTSSOP-20
LM2833 E	3000	5.5	3.0	0.6	4.5	3000	—	Current	LLP-10, eMSOP-10
LM2696 E, W	3000	24	4.5	1.25	20	100 to 500	—	COT	eTSSOP-16
LM26003 E	3000	38	3.0	1.25	35	150 to 500	✓	Current	eTSSOP-20

PowerWise® product

E Evaluation board

W WEBENCH enabled

COT=Constant On-Time Control

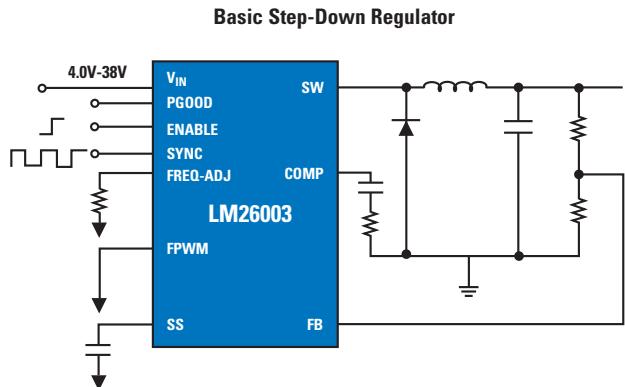
LM2600x – 1.5/3A Buck Regulators with High-Efficiency Sleep Mode

Features

- 10 μ A in shutdown mode, 40 μ A in sleep mode
- 3V cold-crank compatibility
- 4V to 38V continuous input range
- 1.5% reference accuracy
- Frequency synchronization
- Low input version LM26001B (3V to 18V)

Applications

Ideal for use in automotive telematics, navigation systems, and in-dash instrumentation



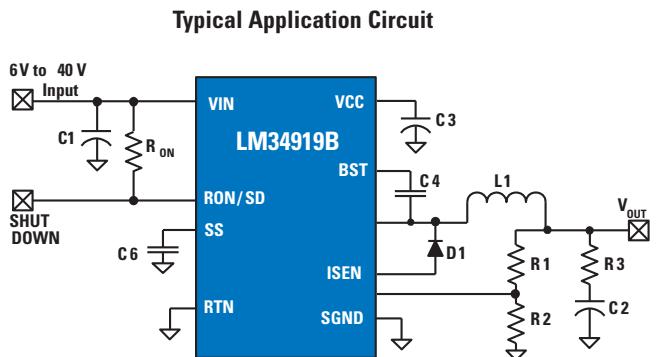
LM34919B – PowerWise® Ultra-Small 40V, 600 mA Constant On-Time Buck Switching Regulator

Features

- 8V to 40V input voltage range
- No loop compensation required
- Ultra-fast transient response
- Operating frequency remains constant with load current and input voltage
- 2.6 MHz maximum switching frequency
- AEC-Q100 Grade 1 qualified
- Integrated N-Channel buck switch
- Adjustable output voltage
- Integrated start-up regulator
- Valley current limit at 0.64A
- Precision internal reference
- Low bias current
- Available in micro SMD-10 packaging

Applications

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



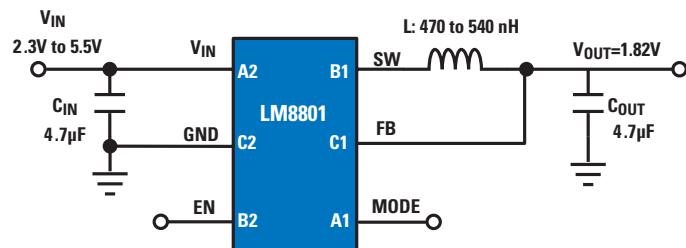
Synchronous Step-Down (Buck) Switching Regulators

LM8801 – High-Precision, 6 MHz, Step-Down DC-DC Converter for Mobile Applications

Features

- 6 MHz switching frequency
- High efficiency and low quiescent current
- $\pm 1.5\%$ output voltage accuracy and tight load transients
- Forced PWM and auto PFM/PWM modes
- Under-voltage protection
- Current overload protection
- Thermal shutdown protection
- Soft-start
- Output current up to 600 mA
- Fixed output voltages from 0.7V to 2V
- Input voltage range from 2.3V to 5.5V

Typical Application Circuit



Applications

Ideal for use in space-constrained applications

Product ID	Output Current (mA)	V_{IN} Max (V)	V_{IN} Min (V)	V_{OUT} Min (V)	V_{OUT} Max (V)	Frequency Range (kHz)	f_{sync}	On/Off Pin	PWM Mode	Packaging
LM3670 E, W	350	5.5	2.5	0.7	3.3	1000	—	✓	Voltage with input feed forward	SOT23-5
LM3673 E, W	350	5.5	2.7	1.1	3.3	2000	—	✓	Voltage with input feed forward	micro SMD-5
LM3679 E	350	5.5	2.5	1.2	1.8	3000	—	✓	Auto	micro SMD-5
LM2619	500	5.5	2.8	1.5	3.6	500 to 1000	✓	✓	Current	micro SMD-10
LM3671 E, W	600	5.5	2.7	1.1	3.3	2000	—	✓	Voltage with input feed forward micro SMD	SOT23-5, LLP-6
LM3674 E, W	600	5.5	2.7	1	3.3	2000	—	✓	Voltage with input feed forward	SOT23-5
LM3676	600	5.5	2.9	1.1	3.3	2000	—	✓	Voltage with input feed forward	LLP-8
LM3677 E	600	5.5	2.7	1.2	3.3	3000	—	✓	Voltage with input feed forward	micro SMD-5, LLP-6
LM8801	600	5.5	2.3	1.7	2.0	6000	—	✓	Voltage with input feed forward	micro SMD-6
LM3691 E	1000	5.5	2.3	0.75	1.8	4000	—	✓	Voltage with input feed forward	micro SMD-6
LM2651 E	1500	14	14	1.24	13	3000	—	✓	Current	TSSOP-16
LM2653 E	1500	14	4	1.5	5.0	300	—	✓	Current	TSSOP-16
LM3678 E	1500	5.5	2.5	0.8	3.3	3300	—	✓	PWM only	LLP-10
LM2655 E	2500	14	4	1.24/3.3	13/3.3	300	—	✓	Current	TSSOP-16
LM2650 E	3000	18	4.5	1.5	16	90 to 300	—	✓	Current	SOIC-24 Wide

PowerWise® product

E Evaluation board

W WEBENCH enabled

LM21305 – PowerWise® 5A, Adjustable-Frequency Synchronous Buck Regulator

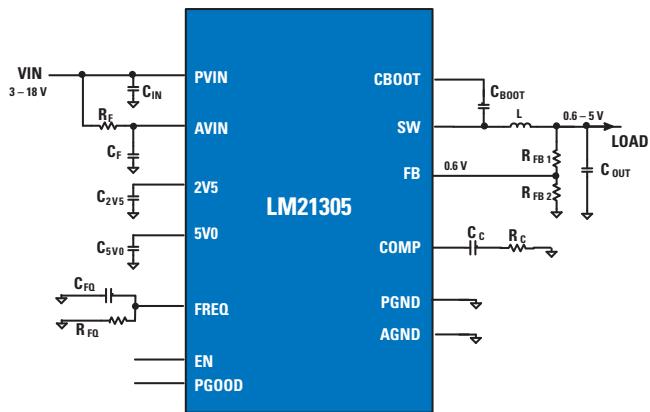
Features

- Single-rail input voltage from 3V to 18V
- 1% typical output voltage accuracy
- High-efficiency switcher core
- 300 kHz to 1.5 MHz switching frequency range
- Resistor-programmable switching frequency
- Precision enable and internal soft-start
- Power GOOD function, UVLO, and OVP

Applications

Ideal for use in point-of-load regulation from 3.3V, 5V, and 12V rails; power supplies for DSPs, FPGAs, ASICs, and processors; and broadband, networking, and optical communications infrastructure applications

Sequencing and Tracking for Multiple Rails Typical Application



Product ID	Output Current (A)	V _{IN} Max (V)	V _{IN} Min (V)	V _{OUT} Min (V)	V _{OUT} Max (V)	Frequency Range (kHz)	f _{sync}	On/Off Pin	PWM Mode	Packaging
LM20242 E	2.0	36	4.5	0.8	32	1000	—	✓	Current	eTSSOP-20
LM20123 E, W	3.0	5.5	2.95	0.8	5.0	1500	—	✓	Current	eTSSOP-16
LM20133 E, W	3.0	5.5	2.95	0.8	5.0	460 to 1.5 MHz	✓ (in)	✓	Current	eTSSOP-16
LM20143 E, W	3.0	5.5	2.95	0.8	5.0	500 to 1500	—	✓	Current	eTSSOP-16
LM20323 E, W	3.0	36	4.5	0.8	32	500	—	✓	Current	eTSSOP-20
LM20333 E, W	3.0	36	4.5	0.8	32	250 to 1.5 MHz	✓ (in)	✓	Current	eTSSOP-20
LM20343 E, W	3.0	36	4.5	0.8	32	250 to 1 MHz	—	✓	Current	eTSSOP-20
LM20124 E, W	4.0	5.5	2.95	0.8	5.0	1000	—	✓	Current	eTSSOP-16
LM20134 E, W	4.0	5.5	2.95	0.8	5.0	460 to 1.5 MHz	✓ (in)	✓	Current	eTSSOP-16
LM20144 E, W	4.0	5.5	2.95	0.8	5.0	500 to 1000	—	✓	Current	eTSSOP-16
LM20154 E, W	4.0	5.5	2.95	0.8	5.0	1000	✓ (out)	✓	Current	eTSSOP-16
LM20125 E, W	5.0	5.5	2.95	0.8	5.0	500	—	✓	Current	eTSSOP-16
LM20145 E, W	5.0	5.5	2.95	0.8	5.0	250 to 750	—	✓	Current	eTSSOP-16
LM21305 E, W	5.0	18	3.0	0.6	5.0	300 to 1500	✓ (in)	✓	Current	LLP-28
LM20136 E, W	6.0	5.5	2.95	0.8	5.0	460 to 1500	✓ (in)	✓	Current	eTSSOP-16
LM20146 E, W	6.0	5.5	2.95	0.8	5.0	250 to 750, Adj	—	✓	Current	eTSSOP-16

PowerWise® product

E Evaluation board

W WEBENCH enabled

Switched-Capacitor Converters and Regulators

LM2772 – Switched-Capacitor Buck Regulator in Tiny Package

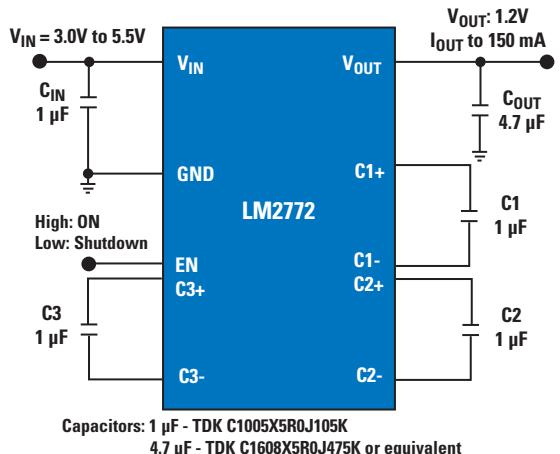
Features

- Output current up to 150 mA
- 1.2V output voltage
- Inductor-less charge pump solution minimizes PCB board space
- PFM mode during light load operation maximizes standby times in battery-powered applications
- 1.1 MHz fixed-frequency switching minimizes output voltage ripple and optimizes output voltage precision
- Multiple gain architecture provides high efficiency over entire input voltage range
- Built-in thermal protection to protect from damage due to overheating
- Available in LLP-10 packaging for optimizing solution size

Applications

Ideal for use in DSP, memory, and microprocessor power for cellular handsets and battery-powered devices

Typical Application Circuit



Switched-Capacitor Converters and Regulators

Buck Regulators									
Product ID	Output Current (mA)	V _{IN} Max (V)	V _{IN} Min (V)	V _{OUT} Min (V)	V _{OUT} Max (V)	Frequency Range (kHz)	On/Off Pin	Quiescent Current (mA)	Packaging
LM2772 ^E	150	5.5	2.7	1.2	1.2	1100	✓	0.05	LLP-10
LM2771 ^E	250	5.5	2.7	1.5	1.5	1100	✓	0.045	LLP-10
LM2773 ^E	300	5.5	2.5	1.6	1.8	1150	✓	0.048	micro SMD-9
Boost Converters									
Product ID	Switch Current (mA)	V _{IN} Max (V)	V _{IN} Min (V)	V _{OUT} Min (V)	V _{OUT} Max (V)	Frequency Range (kHz)	On/Off Pin	Quiescent Current (mA)	Packaging
LM2750 ^E	0.12	5.6	2.7	5.0	5.2	1700	✓	5	LLP-10
LM2751	0.15	5.5	2.8	4.5	5.0	9.5 to 725	✓	0.425	LLP-10
LM2757 ^E	0.18	5.5	2.7	4.1	5.0	1242	✓	1.3	micro SMD-12
LM2753	0.4	5.5	3.0	5.0	5.0	725	✓	0.06	LLP-10

PowerWise® product

^E Evaluation board

^W WEBENCH enabled

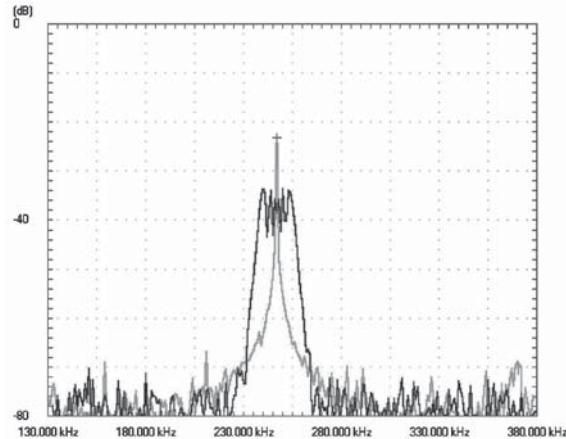
Step-Down (Buck) Switching Controllers

LM(2)5088 – Wide-Input-Range, Emulated Current-Mode NFET Buck Controller

Features

- 4.5V to 75V input range (LM5088)/4.5V to 42V input range (LM25088)
- Optional $\pm 5\%$ frequency dithering (LM(2)5088-1)
- Low I_{Q} shutdown and standby modes
- Dynamic Frequency Scaling (DFS) maintains regulation when V_{IN} drops close to V_{OUT}
- Adjustable output from 1.21V with 1.5% feedback reference voltage
- Hiccup timer for overload protection (LM(2)5088-2)
- Robust 2A peak gate drive
- Synchronizable oscillator operates from 50 kHz to 1 MHz
- Programmable soft-start
- Low I_{Q} shutdown and standby modes
- Available in eTSSOP-16 packaging

LM5088 Uses Spread-Spectrum Technique to Reduce EMI



Non-Synchronous Step-Down (Buck) Switching Controllers

Product ID	V_{IN} Max (V)	V_{IN} Min (V)	V_{OUT} Min (V)	V_{OUT} Max (V)	Feedback Tolerance %	Frequency Range (kHz)	On/Off Pin	PWM Mode	Packaging
LM3475 E	10	2.7	0.8	V_{IN}	1.5	0 to 2000	✓	Hysteretic	SOT23-5
LM3477 E	35	2.97	1.265	30.8	1.5	500 to 500	✓	Current	MSOP-8
LM3485 E, W	35	4.5	1.242	V_{IN}	2	0 to 1400	—	Hysteretic	MSOP-8
LM3489 E	35	4.5	1.239	V_{IN}	2	0 to 1400	✓	Hysteretic	MSOP-8
LM(2)5085/A E	(42), 75	4.5	1.25/0.9	V_{IN}	2	1000	—	COT	MSOP-8, LLP-8
LM(2)5088 E, W	(42), 75	4.5	1.2	(40), 70	1.5	50 to 1000	✓	Emulated Current Mode	eTSSOP-16

Synchronous Step-Down (Buck) Switching Controllers

Product ID	V_{IN} Max (V)	V_{IN} Min (V)	V_{OUT} Min (V)	V_{OUT} Max (V)	Feedback Tolerance %	Frequency Range (kHz)	f_{sync}	On/Off Pin	Topology, PWM Mode	Error Flag	Packaging
LM1770 E, W	5.5	2.8	0.8	4.5	2	300 to 1000	—	—	COT	—	SOT23-5
LM1771 E	5.5	2.8	0.8	4.5	2	300 to 1000	—	✓	COT	—	LLP-6, MSOP-8
LM(2)5119 E, W	42/65	4.5/5.5	0.8	38/59	1.50	50 to 750	✓	✓	Emulated Current Mode	—	LLP-32
LM27402 E, W	20	3	0.6	19	1	200 to 1200	✓	✓	Voltage mode/feed forward	✓	LLP-16, TSSOP-16
LM3743 E	5.5	3	0.8	4.6	1.75	300 to 1000	—	✓	Voltage	—	MSOP-10
LM2727/37 E	16	2.2	0.6	5	1.5	50 to 2000	—	✓	Voltage	✓	TSSOP-14
LM3495 E	18	2.9	0.6	5.5	1	200 to 1500	✓	—	Emulated Current Mode	—	TSSOP-16
LM25115/A	42	4.5	0.75	13.5	1.7	100 to 1000	✓	—	SSPR, Voltage/current-injection	—	TSSOP-16
LM25116 E	42	6	1.215	36	1.5	50 to 1000	✓	✓	Emulated Current Mode	—	eTSSOP-20
LM5115/A E	75	4.5	0.75	13.5	1.7	50 to 1000	✓	—	Voltage/current-injection Valley current mode	—	TSSOP-16
LM5116 E	100	6	1.215	80	1.5	50 to 1000	✓	✓	Emulated Current Mode	—	eTSSOP-20
LM3000	18.5	3.3	0.6	15	1	200 to 1500	✓	✓	Emulated Current Mode	✓	LLP-32
LM3753/54	18	4.5	0.6	3.6	1	200 to 1000	✓	✓	Voltage mode with current sharing	✓	LLP-32

PowerWise® product

E Evaluation board

w WEBENCH enabled

COT=Constant On-Time control

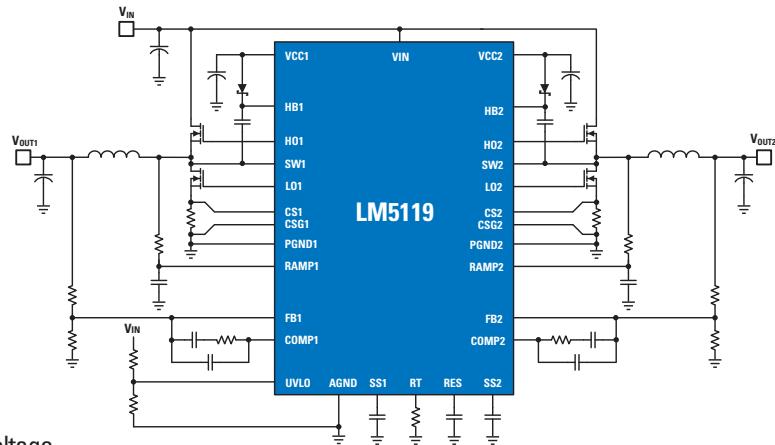
Synchronous Step-Down (Buck) Switching Controllers

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

Features

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

Typical Application Circuit



Applications

Ideal for use in applications requiring a widely changing input voltage and large step-down conversions, such as automotive infotainment, wireless basestations, servers, routers, and DC-DC motor control units

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

Features

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

Applications

Ideal for use in basestations, networking, and POL modules

Synchronous Step-Down (Buck) Switching Controllers (continued)

Product ID	Operating Frequency	Features	Packaging
LM2742 E	50 kHz to 2 MHz	1.5% accuracy 0°C to 125°C, start-up delay	TSSOP-14
LM2743 E, W	50 kHz to 1 MHz	2% accuracy -40°C to 125°C, start-up delay, tracking	TSSOP-14
LM2744 E	50 kHz to 1 MHz	External reference, start-up delay, tracking	TSSOP-14
LM2745 E	50 kHz to 1 MHz	Pre-bias operation, external clock 250 kHz to 1 MHz, tracking	TSSOP-14
LM2747 E	50 kHz to 1 MHz	1% accuracy -40°C to 125°C, pre-bias operation, sync, programmable soft-start, tracking	TSSOP-14
LM2748	50 kHz to 1 MHz	1.5% accuracy -40°C to 125°C, tracking, pre-bias operation , sync, programmable soft-start, tracking	TSSOP-14

LM(2)5116 – Wide Input, 42V/100V Synchronous Buck Controller with ECM

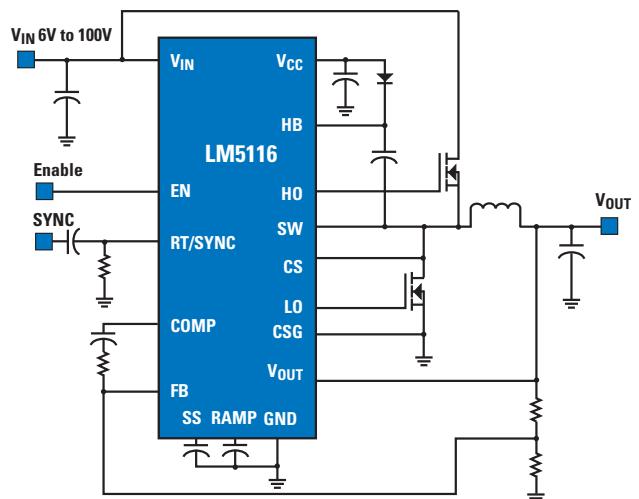
Features

- Ultra-wide input range: 6V to 42V/100V
- Programmable output from 1.215V to 36V/80V
- Less than 10 μ A I_q in shutdown mode
- Frequency adjustable from 50 kHz to 1 MHz with sync capability
- Programmable soft-start
- Drives standard or logic-level MOSFETs
- RDS_{ON} or resistor current sensing
- Available in eTSSOP-20 packaging

Applications

Ideal for use in telecommunications, automotive, and industrial control applications

Typical Application Circuit



Read Analog Edge AN-1628
"Minimizing FET Losses For a High-Input Rail Buck Converter"
national.com/edge

LM3495 – ±1% Accurate, Ultra-High Precision PWM Buck Controller

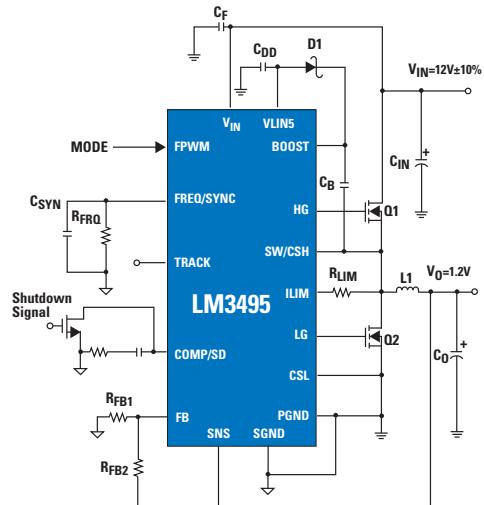
Features

- Input voltage from 2.9V to 18V
- Adjustable output from 0.6V to 5.5V
- Feedback accuracy: ±1% over temperature
- Supports pre-biased startup
- Switch node fault protection
- Hiccup-mode current limit protection for reduced thermal design
- Programmable soft-start and tracking
- Available in TSSOP-16 packaging

Applications

Ideal for use in ASICs, FPGAs, DSPs, embedded controller power supplies, industrial applications, and high-output-current power modules

Typical Application Circuit



Step-Up (Boost) Switching Regulators

LM2735 – Integrated 2.1A Switch, Internal Compensation in Tiny Packages

Features

High Current Density

- 2.1A switch current over full temperature range
- Boost from 5V to 12V at 700 mA

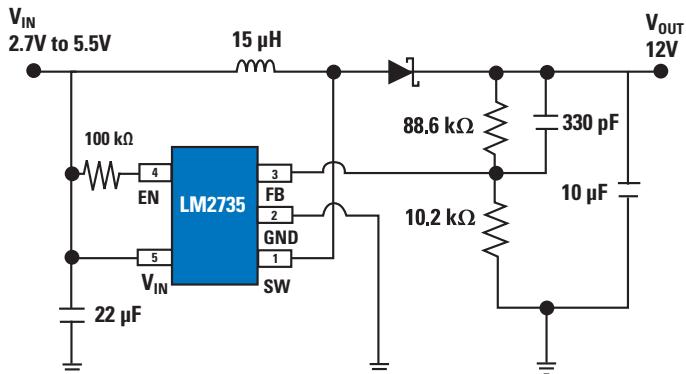
Easy-to-Use, Small Solution Size

- Internal compensation allows for ease-of-use and minimal external components
- 1.6 MHz operating frequency uses tiny passive components
- Available in SOT23-5, LLP-6, and eMSOP-8 packaging

Applications

Ideal for use in space-constrained applications

Typical Application Circuit



Step-Up (Boost) Switching Regulators

Product ID	Switch Current (A)	V _{IN} Min (V)	V _{IN} Max (V)	Frequency Range (kHz)	f _{sync}	V _{OUT} Min (V)	V _{OUT} Max (V)	On/Off Pin	Packaging
LM5002	0.5	3.1	75	50 to 1500	✓	1.26	Set by external feedback network	✓	SOIC-8, LLP-8
LM27313	1.0	2.7	14	1600	—	4	28	✓	SOT23-5
LM2733 E	1.0	2.7	14	600, 1600	—	3	40	✓	SOT23-5
LM3668 E, W	1.0	2.5	5.5	1600 to 2700	✓	2.8	5.0	✓	LLP-12
LM5001 E	1.0	3.1	75	50 to 1500	✓	1.26	Set by external feedback network	✓	SOIC-8, LLP-8
LM4510	1.2	2.7	5.5	85 to 1000	—	2.7	18	✓	LLP-10
LM2698 E	1.35	2.2	12	600 to 1250	—	2.2	17	✓	MSOP-8
LM2731 W	1.5	2.7	14	600, 1600	—	1.23	22	✓	SOT23-5
LM2622 E	1.6	2.0	12	600, 1300	—	1.26	12	✓	MSOP-8
LM3310	2.0	2.5	7.0	660, 1280	—	V _{IN}	20	✓	LLP-24
LM3311	2.0	2.5	7.0	660, 1280	—	V _{IN}	20	✓	LLP-24
LM5000 W	2.0	3.1	40	300 to 1300	—	1.259	Set by external feedback network	✓	LLP-16, TSSOP-16
LM2623	2.2/1.2	0.8	14	300 to 2000	—	1.24	14	✓	LLP-14, MSOP-8
LM2735 E, W	2.25	2.7	5.5	520, 1600	—	3	24	✓	SOT23-5, eMSOP-8, LLP-6
LM3224	2.6	2.7	7.0	615, 1250	—	V _{IN}	20	✓	MSOP-8
LM2585 W	3.0	4.0	40	100	—	1.23	12	—	T0263-5, T0220-5
LM2586 W	3.0	4.0	40	100 to 200	✓	1.23	12	✓	T0263-7, T0220-7
LM2700	3.6	2.2	12	600, 1250	—	1.26	17.5	✓	LLP-14, TSSOP-14
LM2587 W	5.0	4.0	40	100	—	1.23	12	—	T0263-5, T0220-5
LM2588 W	5.0	4.0	40	100 to 200	✓	1.23	12	✓	T0263-7, T0220-7

PowerWise® product

E Evaluation board

W WEBENCH enabled

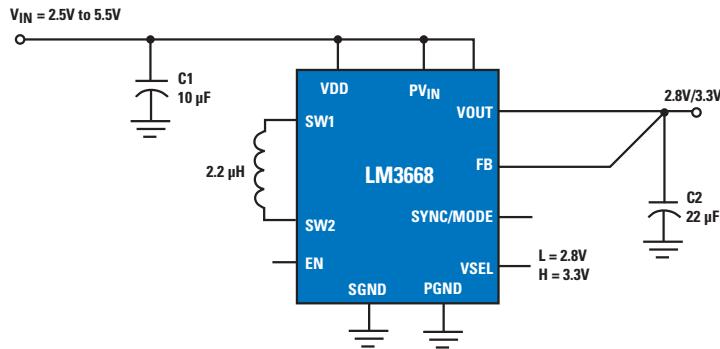
Buck-Boost Regulators

LM3668 – Inductive Buck-Boost DC-DC Converter

Features

- 1A current capability
- Voltage select pin allows output voltage flexibility (2.8V/3.3V)
- Mode pin toggles between automatic PFM/PWM operation or forced PWM operation
- Frequency sync from 1.6 MHz to 2.7 MHz allows customization for lowest noise in system
- V_{IN} range from 2.5V to 5.5V supports Li-Ion batteries
- >90% efficiency maximizes battery life
- Low I_Q (45 μA) in standby mode decreases current leakage in design
- Excellent transient response allows V_{OUT} to stay within regulation under all conditions
- Available in tiny LLP-12 packaging

Typical Application Circuit



Applications

Ideal for use in handset peripherals, MP3 players, pre-regulation for linear regulators, PDAs, portable hard disk drives, and WiMax modems

Buck-Boost Inductive Regulators

Product ID	Switch Current (A)	V_{IN} Max (V)	V_{IN} Min (V)	V_{OUT} Min (V)	V_{OUT} Max (V)	Frequency Range (kHz)	f_{sync}	PWM Mode	Topology	Packaging
LM3668 ^W	1	5.5	2.5	2.8	3.3	1600 to 2700	✓	Auto PWM/PFM	Buck-Boost	LLP-12
LM5015 ^W	1.2	75	4.25	—	—	25 to 750	✓	Current	Two-switch forward	eTSSOP-14
LM2611 ^E	0.9, 1.2	14	2.7	-1.23	—	1400	—	Current	Inverting, CUK	SOT23-5

^E Evaluation board

^W WEBENCH enabled

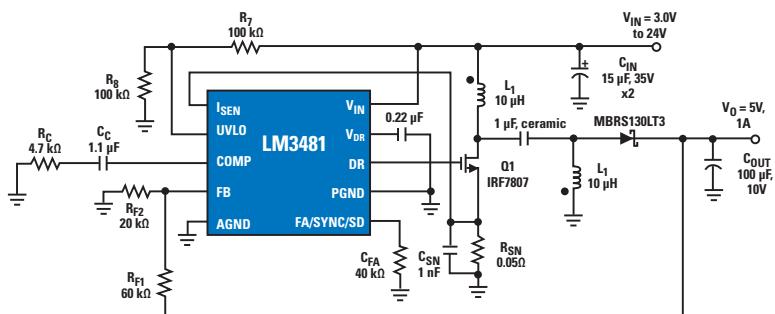
Boost and Buck-Boost Controllers

LM3481 – High-Efficiency Low-Side N-Channel Controller for Switching Regulators

Features

- Wide operating range: 2.97V to 48V
- Internal push-pull driver with 1A peak current capability
- 100 kHz to 1 MHz adjustable and synchronizable clock frequency
- 5 μ A shutdown current (over temperature)
- Adjustable UVLO with hysteresis
- Frequency compensation optimized with a capacitor and a resistor
- 1.5% (over temperature) internal reference
- Available in MSOP-10 packaging

Typical Application Circuit



Applications

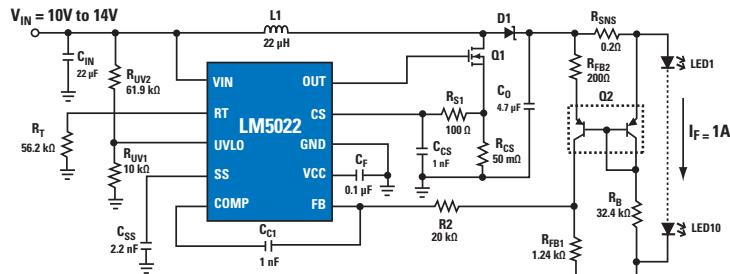
Ideal for use in distributed power systems, offline power supplies, set-top boxes, and portable applications

LM5022 – 60V Low-Side Controller for Boost and SEPIC Regulators

Features

- Internal 60V startup regulator
- 1A peak MOSFET gate driver
- V_{IN} range 6V to 60V
- Duty cycle limit of 90%
- Programmable UVLO with hysteresis
- Cycle-by-cycle current limit
- External synchronizable (AC-coupled)
- Single resistor oscillator frequency set
- Available in MSOP-10 packaging

Typical Application Circuit



Applications

Ideal for use in telecommunications, networking equipment, automotive, and industrial applications

Boost and Buck-Boost Controllers

Product ID	V _{IN} Max (V)	V _{IN} Min (V)	V _{OUT} Min (V)	Frequency Range (kHz)	f _{sync}	On/Off Pin	Topology	Packaging
LM5021	30	8.0	Set by external feedback network	50 to 1000	✓	✓	Flyback, forward	MSOP-8
LM3430	40	6.0	1.25	50 to 2000	✓	—	Boost	LLP-12
LM3478 ^W	40	2.95	1.26	100 to 1000	✓	✓	Boost, SEPIC, flyback	MSOP-8
LM3488 ^W	40	2.95	1.26	100 to 1000	✓	✓	Boost, SEPIC, flyback	MSOP-8
LM3481	48	2.97	1.275	100 to 1000	✓	✓	Boost, SEPIC, flyback	MSOP-10
LM5022/C ^E	60	6.0	1.25	50 to 2000	✓	✓	Boost, SEPIC	MSOP-10
LM5020 ^E	100	13	Set by external feedback network	50 to 1000	✓	✓	Flyback, inverting, buck, boost, forward	MSOP-10, LLP-10
LM(2)5118 ^{E,W}	42/75	3.0	1.23	50 to 500	✓	✓	Buck-boost	eTSSOP-20

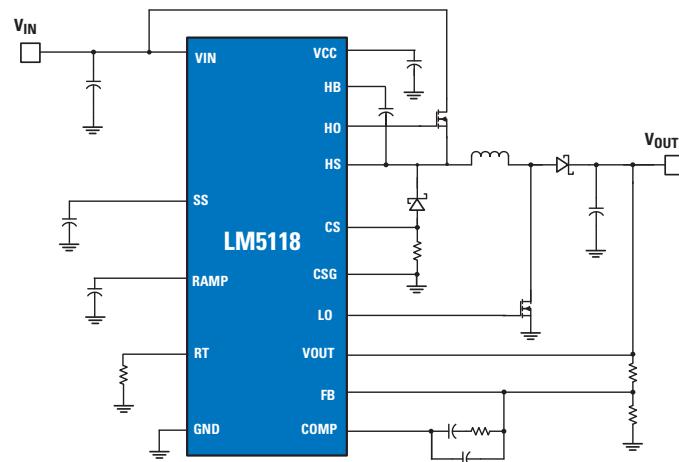
Two-Switch Buck-Boost Controller and Two-Switch Forward Regulator

LM(2)5118 – Wide Voltage Range Buck-Boost Controller

Features

- Ultra-wide 3V to 42V/75V input voltage range
- Emulated Current-Mode (ECM) control provides stable control over wide input
- Smooth transition between step-down and step-up modes
- Low-current sleep mode: 10 μ A shutdown I_Q
- Dual-mode over-current protection
- 1.5% feedback reference accuracy
- Synchronizable switching frequency, settable to 500 kHz
- Integrated 2A gate drivers
- Programmable soft-start and line UVLO
- Achieves up to 95% efficiency
- Available with AEC-Q100 Grade 1 qualification
- Available in TSSOP-20 packaging

Typical Application Circuit



Applications

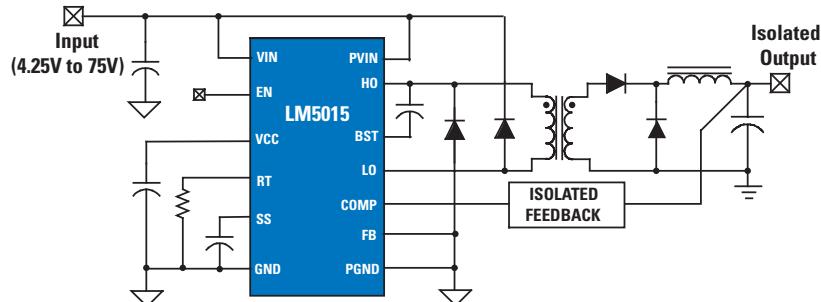
Ideal for use in automotive, telecommunications, and battery-powered systems

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
- Programmable soft-start
- Enable/UVLO pin
- Thermal shutdown
- Available in eTSSOP-14 packaging

Typical Application Circuit



Applications

Ideal for use in basestation power distribution systems, 48V telecom/data storage systems, 24V/48V industrial systems, and Ethernet-powered devices

Multi-Output Switching Regulators

Multi-Output Switching Regulators

Product ID	Charger (mA)	DC-DC 1 (mA)	DC-DC 2 (mA)	DC-DC 3 (mA)	LDO 1 (mA)	LDO 2 (mA)	LDO 3 (mA)
LP3913	1000	600	600	500	150	—	—
LP3910	1000	600	600	1000	150	—	—
LP3906 E	—	1500	1500	—	300	300	—
LP3907 E	—	1000	600	—	300	300	—
LM26480 E	—	1500	1500	—	300	300	—
LM3370 E	—	600	600	—	—	—	—
LM26400Y E	—	2000	2000	—	—	—	—
LM3280 E	—	—	—	800	20	20	20
LM3687 E	—	750	—	—	350	—	—
LM3686 E	—	600	—	—	300	350	—
LM26420 E	—	2000	2000	—	—	—	—

E Evaluation board

LM26420 – High-Frequency 2.0A Step-Down DC-DC Regulator

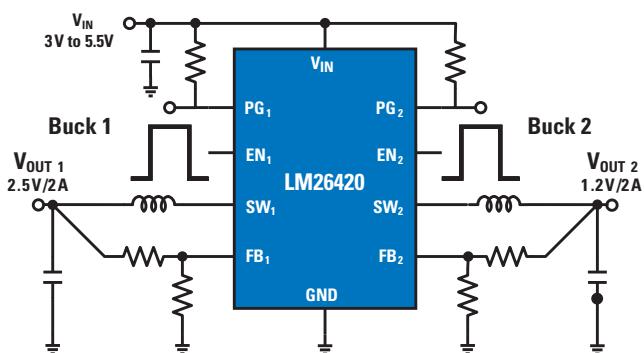
Features

- Input voltage range of 3.0V to 5.5V
- Output voltage range of 0.8V to 4.5V
- High switching frequencies
 - 2.2 MHz (LM26420X)
 - 0.55 MHz (LM26420Y)
- 0.8V, 1.5% internal voltage reference
- Independent precision enable for each output

Applications

Ideal for use in core power hard disk drives, set-top boxes, USB-powered devices, DSL modems, and powering core and I/O voltages for FPGAs, CPLD, and ASICs

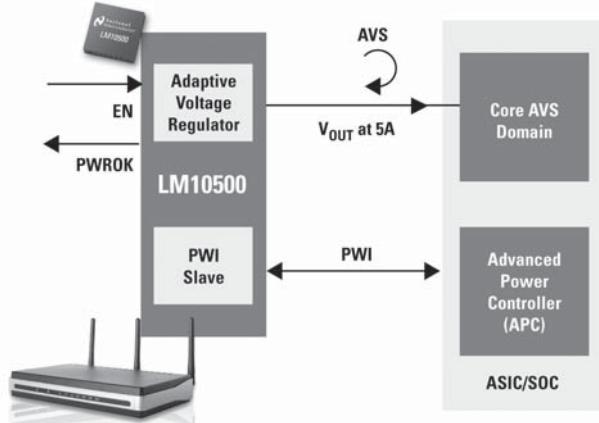
Typical Application Circuit



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.

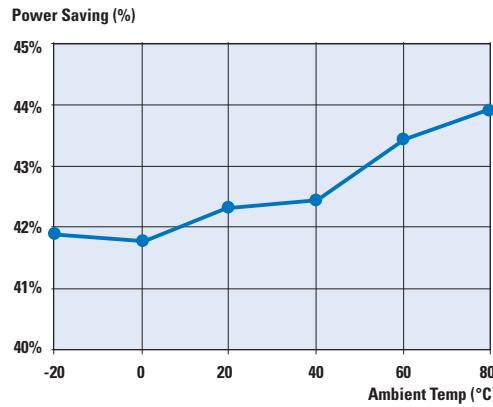
AVS technology is suited to power-constrained applications such as portable devices, USB-powered peripherals, consumer electronics, and high-volume systems including data centers and cellular basestations. Anywhere an ASIC, processor, or SoC is used, designers can implement AVS.



LM10500 – 5A Integrated AVS Energy Management Unit (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

LM10500 Typical Power Savings with AVS



PowerWise® Adaptive Voltage Scaling (AVS)

Product ID	Number of Outputs	Output Voltages and Current	V_{IN} Range (V)	Interface	Packaging
LP5550	4	1 buck: 0.6V to 1.2V, 300 mA; 3 LDOs: 0.6V to 3.3V, up to 250 mA	3.0 to 5.5	PWI 1.0	LLP-16
LP5551	8	2 bucks: 0.6V to 1.2V, 300 mA; 4 LDOs: 0.6V to 3.3V, up to 250 mA; N-well bias: -0.3 to +1V (to supply); P-well bias: -1V to +0.3V (to GND)	2.7 to 5.5	PWI 1.0	LLP-36
LP5552	7	2 bucks: 0.6V to 1.235V, 800 mA; 5 LDOs: 0.6V to 3.3V, up to 250 mA	2.7 to 4.8	PWI 2.0	micro SMD-36
LP5553	7	2 bucks: 0.6V to 1.235V, 800 mA; 5 LDOs: 0.6V to 3.3V, up to 250 mA	2.7 to 4.8	SPMI	micro SMD-36
LM10500	1	1 AVS buck: 0.6V to 1.0V or 0.72V to 1.2V, 5A	3.0 to 18	PWI 1.0 or 2.0	LLP-28

PowerWise® product

Evaluation board

For more information about high-current AVS Energy Management Units, visit: national.com/avs

Multi-Output Switching Controllers

LM3000 Dual Synchronous Controller

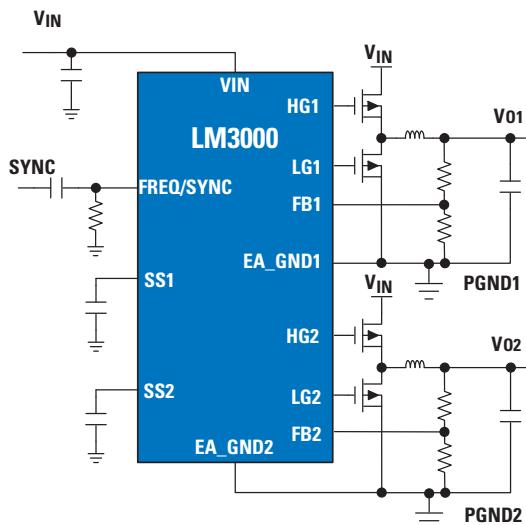
Features

- V_{IN} range 3V to 18.5V
- 25A current capability per phase
- 0.6V, 1.5% accurate V_{REF}
- Outputs 180° out of phase
- CLOCK_OUT (90° out of phase from system clock)
- Separate error amp ground inputs for remote voltage sensing
- Frequency sync from 200 kHz to 1.5 MHz
- Separate EN, SS, and TRACK inputs

Applications

Ideal for use in networking equipment (routers, hubs), DC power distribution systems, 1.8V and 2.5V I/O supplies, ASIC, FPGA, and CPLD power supplies

Typical Application Circuit



Multi-Output Switching Controllers

Product ID	V_{IN} Max (V)	V_{IN} Min (V)	V_{OUT} Min (V)	V_{OUT} Max (V)	Feedback Tolerance %	Frequency Range (Hz)	f_{sync}	On/Off Pin	Error Flag	Channels	Topology, PWM Mode	Packaging
LM2647 ^E	28	5.5	0.6	5.0	1.5	200 to 500	—	✓	✓	2	Voltage with V_{IN} feed forward	LLP-28, TSSOP-28
LM2642 ^E	30	4.5	1.238	27	2.0	300	—	✓	✓	2	Current	TSSOP-28
LM5642 ^{PowerWise®}	36	4.5	1.3	34.5	1.5	150 to 250	✓	✓	—	2	Current	TSSOP-28, eTSSOP-28
LM5642x ^{PowerWise®}	36	4.5	1.3	34.5	1.5	200 to 500	✓	✓	—	2	Current	eTSSOP-28, TSSOP-28
LM3000	18.5	3.3	0.6	15	1.5	200 to 1500	—	✓	✓	2	Emulated current mode	LLP-32

^{PowerWise®} product

^E Evaluation board

Switching Regulators and Controllers for Isolated Applications

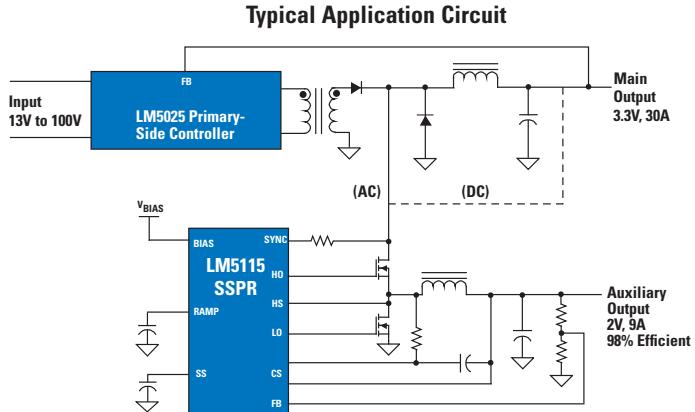
LM5115 – Secondary-Side Post Regulator/Synchronous Step-Down (Buck) Controller

Features

- Self-synchronization to main channel output
- Stand-alone DC-DC synchronous buck mode
- Voltage-mode control with current injection and input line feed forward
- Operates from AC or DC input up to 75V
- Available in TSSOP-16 packaging



Watch our Online Seminar on
"Multiple-Output Switching Regulators
Featuring LM5115 'Dual Personality Controller'"
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Switching Regulators and Controllers for Isolated Applications

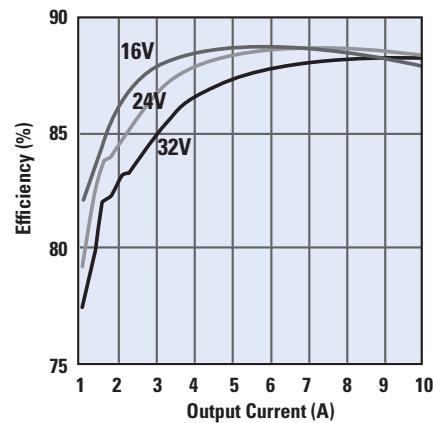
Product ID	V _{IN} Max (V)	V _{IN} Min (V)	Frequency Max (kHz)	f _{sync}	Gate Drive	Current Limit Type	PWM Mode	Topology	Packaging
LM5027	10	13	1000	✓	3/2/1	Cycle-cycle, hiccup	Voltage	Forward active clamp	eTSSOP-20, LLP-24
LM5021	30	8	1000	✓	0.7	Cycle-cycle, hiccup	Current	Flyback, forward	MSOP-8, MDIP-8
LM25115/5115 E	42/75	4.5	1000	✓	2.5	Cycle-cycle	Voltage/current-injection	Synchronous secondary-side post-regulator	LLP-16, TSSOP-16
LM5015 E,W	75	4.25	750	✓	—	Cycle-cycle	Current	Two-switch forward	eTSSOP-14
LM(2)5037 E	75/105	6/13	2000	✓	1.2	Cycle-cycle, hiccup	Feed forward/current	Push-pull, half-bridge, full-bridge	TSSOP-16
LM5025/A/C	90	8	1000	✓	3	Cycle-cycle, hiccup	Voltage/feed forward	Forward active clamp	LLP-16, TSSOP-16
LM5020 E	100	13	1000	✓	1	Cycle-cycle	Current	Flyback, inverting, buck, boost, forward	MSOP-10, LLP-10
LM5025B	100	8	1000	✓	3	Cycle-cycle, hiccup	Voltage/feed forward	Forward active clamp	LLP-16, TSSOP-16
LM5026 E	100	8	1000	✓	3	Cycle-cycle, hiccup	Current	Forward active clamp	LLP-16, TSSOP-16
LM5030 E	100	8	1000	✓	1.5	Cycle-cycle, hiccup	Current	Push-pull, full-bridge, half-bridge	MSOP-10, LLP-10
LM5032	100	13	1000	✓	2.5	Cycle-cycle, hiccup	Current	Dual forward, flyback	TSSOP-16
LM5033 E	100	15	1000	✓	1.5	Hiccup	Voltage	Push-pull, half-bridge, full-bridge, IBC	MSOP-10, LLP-10
LM5034 E	100	13	1000	✓	2.5	Cycle-cycle, hiccup	Current	Dual forward, flyback	TSSOP-20
LM5041/A/B E	100	10	1000	✓	1.5	Cycle-cycle, hiccup	Current	Voltage-fed or current-fed push-pull	LLP-16, TSSOP-16
LM5035/A/B	105	8	2000	✓	2	Cycle-cycle, hiccup	Voltage	Half-bridge	LLP-24, eTSSOP-20

Isolated Controllers

LM25037 – Dual-Mode PWM Controller with Alternating Outputs

Features

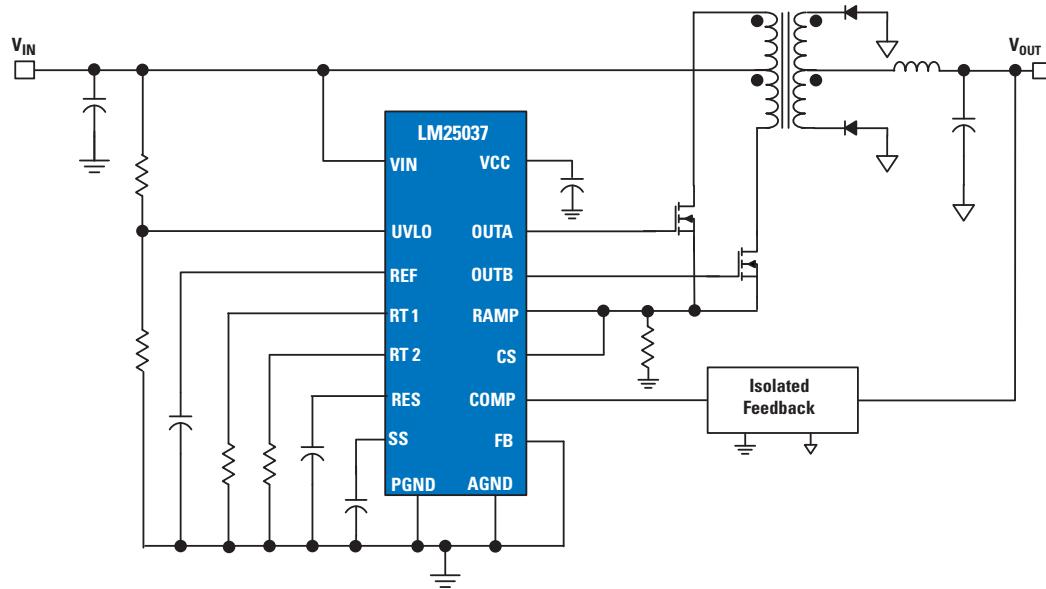
- Ultra-wide input operating range from 5.5V to 75V
- Alternating outputs for double-ended topologies
- Current-mode or feed-forward voltage-mode control
- Programmable maximum duty cycle limit
- Versatile dual-mode over-current protection with hiccup delay timer
- Programmable soft-start
- Precision 5V reference output
- Current sense leading-edge blanking
- Resistor-programmed 2 MHz capable oscillator
- Oscillator synchronization capability with low frequency
- Available in TSSOP-16 packaging



Applications

Ideal for use in telecommunications power converters, industrial power converters, and automotive systems

Typical Application Circuit



LM5035A – PowerWise® High-Performance, Half-Bridge Controller-Driver for Compact, Efficient Converters

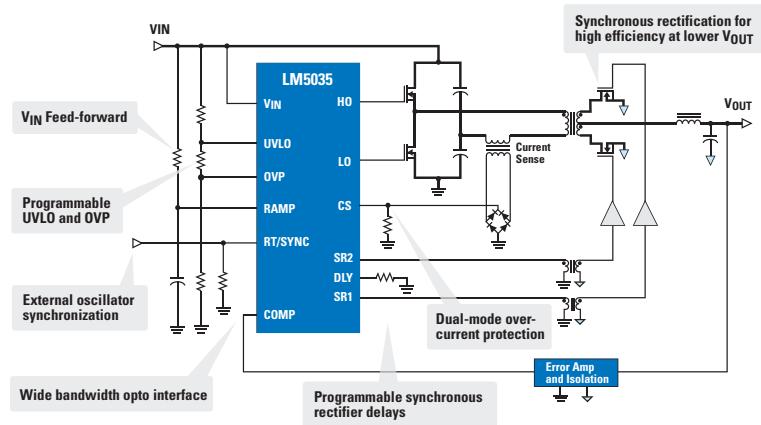
Features

- 105V/2A half-bridge gate drivers
- Synchronous rectifier control outputs with programmable delays
- Oscillator synchronization (patent pending)
- Programmable line UVLO
- Line OVP
- Versatile dual-mode over-current protection with hiccup delay timer
- Direct opto-coupler interface
- Available in TSSOP-20 and LLP-24 packaging

Applications

Ideal for use in telecommunications and data communications systems, industrial power supplies, distributed power systems, and consumer electronics

Typical Application Circuit



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"Half-Bridge Power Converter Design Using the LM5035A"**
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LM5026 – PowerWise® Simplified Forward Power Converter with Active Clamp Reset

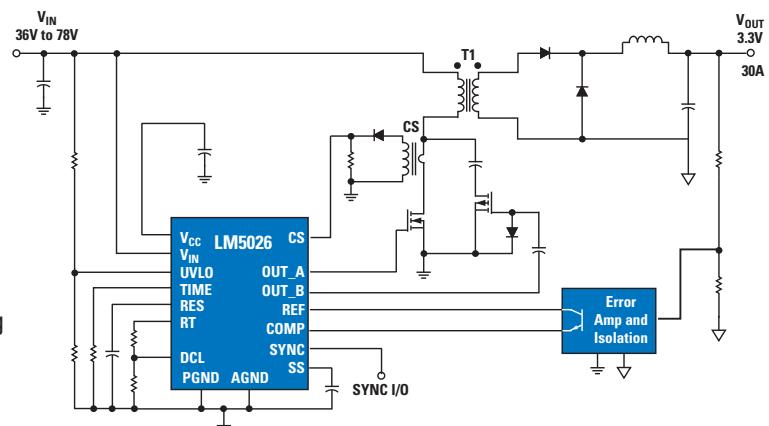
Features

- Current-mode control
- Internal 100V startup bias regulator
- 3A compound main gate driver
- High-bandwidth opto-coupler interface
- Programmable line UVLO with adjustable hysteresis
- Available in TSSOP-16 and LLP-16 packaging

Applications

Ideal for use in telecommunications, automotive, networking equipment, and industrial applications

Typical Application Circuit

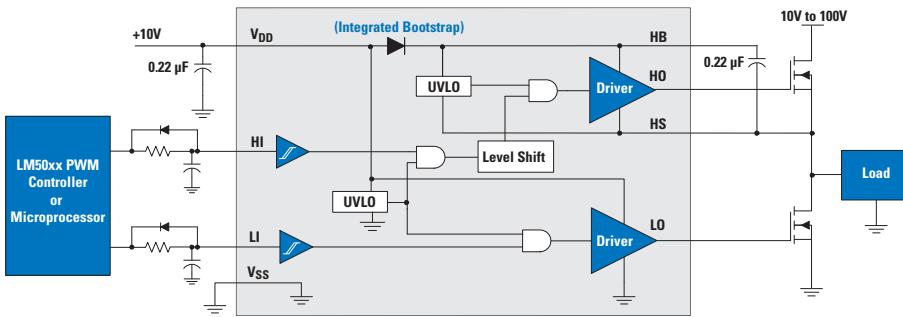


**Watch our Online Seminar on
"Introduction to Forward Power Converters Utilizing Active Clamp Reset"**
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MOSFET Drivers

LM510x – Family of High-Speed FET Drivers

Typical Application Circuit



MOSFET Drivers

Product ID	Sink/Source Current (A)	Topology	V _{IN} Max (V)	Supply Min (V)	Supply Max (V)	Bottom Driver Prop Delay (nS)	Top Driver Prop Delay (nS)	Pulse Width Min	Input Control Type	Packaging
LM5100C	1.0/1.0	Synchronous buck, bridge	100	7.5	14	25	25	50	Dual, independent	SOIC-8
LM5101C	1.0/1.0	Synchronous buck, bridge	100	7.5	14	25	25	50	Dual, independent	LLP-10, SOIC-8
LM5109B	1.0/1.0	Buck, bridge	90	7.5	14	25	25	50	Dual, independent	LLP-8, SOIC-8
LM5107	1.4/1.3	Buck, bridge	100	7.5	14	25	25	50	Dual, independent	LLP-8, SOIC-8
LM5106	1.8/1.2	Synchronous buck, bridge	100	7.5	14	32	32	50	Single PWM	MSOP-10, LLP-10
LM5100B	2.0/2.0	Synchronous buck, bridge	100	7.5	14	25	25	50	Dual, independent	LLP-10, SOIC-8
LM5101B	2.0/2.0	Synchronous buck, bridge	100	7.5	14	25	25	50	Dual, independent	SOIC-8
LM5102	2.0/2.0	Synchronous buck, bridge	100	7.5	14	35	35	50	Dual, independent	MSOP-8
LM5104	2.0/2.0	Synchronous buck, bridge	100	7.5	14	35	35	50	Single PWM	LLP-10, SOIC-8
LM5105	2.0/2.0	Synchronous buck	100	7.5	14	35	35	50	Single PWM	LLP-10
LM5100A	3.0/3.0	Synchronous buck, bridge	100	7.5	14	25	25	50	Dual, independent	LLP-8, SOIC-8, PSOP-8
LM5101A	3.0/3.0	Synchronous buck, bridge	100	7.5	14	25	25	50	Dual, independent	LLP-10, SOIC-8, PSOP-8
LM5110	5.0/2.0	Forward, push-pull, etc	—	3.5	14	25	25	25	Dual, independent	LLP-10, SOIC-8
LM5111	5.0/3.0	Forward, push-pull, etc	—	3.5	14	25	25	25	Dual, independent	SOIC-8
LM5112	7.0/3.0	Forward, push-pull, etc	—	3.5	14	25	N/A	25	Dual, independent	LLP-6

Note: This table sorted by peak sink current

Applications

Ideal for use in telecommunications, networking equipment, automotive, motor driver systems, and industrial applications

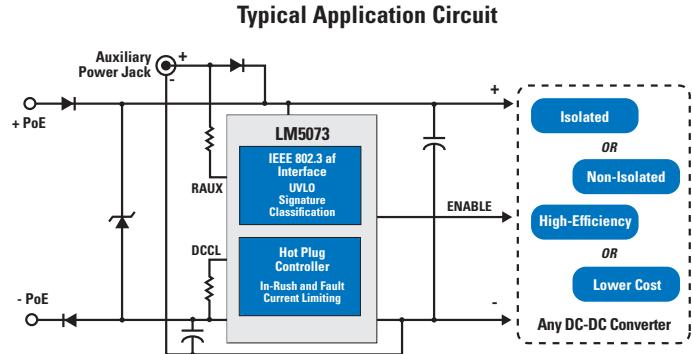
Power-over-Ethernet Controllers

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
- Complementary open drain outputs allow flexible DC-DC regulator selection

Optimizing for:	Pair LM5073 with:
High efficiency	LM5025/26 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



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“Power Supply Design for POE-Powered Devices”
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Applications

Ideal for use in VoIP telephony, security cameras, wireless access points, IEEE 802.3af-compliant PoE-powered devices, non-compliant, application specific devices, and higher-power Ethernet-powered devices

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

Product ID	V _{IN} Max (V)	V _{IN} Min (V)	Hot Swap FET RDS _{ON} Typ (Ω)	Integrated DC-DC Controller	Output Power (W)	Auxiliary Support	Reference Accuracy (+/-)	Current Draw with AUX Winding (typ)	Packaging
LM5070 E	75	1.8	1.0	✓	13	48V front only	2	0.7	LLP-16, TSSOP-16
LM5071 E	75	1.8	1.0	✓	13	48V front only	2	0.7	TSSOP-16
LM5072 E	100	9.0	0.7	✓	25	Fully-configurable front/rear	2	0.7	eTSSOP-16

PowerWise® product ^EEvaluation board

Power-over-Ethernet Powered Device Interface

Product ID	V _{IN} Max (V)	Input Min Voltage (V)	Hot Swap FET RDS _{ON} Typ (Ω)	Integrated DC-DC Controller	Output Power (W)	Auxiliary Support	Packaging
LM5073 E	100	9.0	0.7	—	25	Fully-configurable front/rear	eTSSOP-14

^EEvaluation board

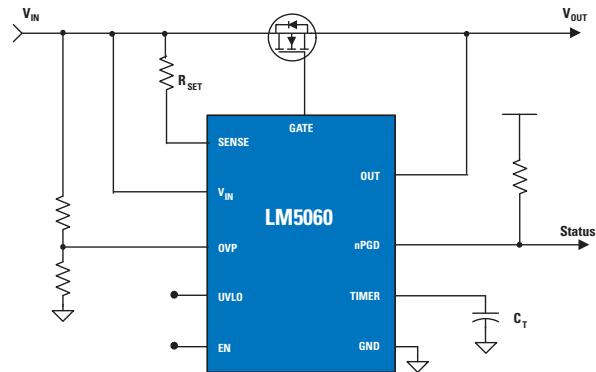
Hot Swap/In-Rush Current Controllers

LM5060 – High-Side Protection Controller with Low Quiescent Current

Features

- V_{IN} range: +5.5V to +65V
- Very low shutdown current: <15 μ A
- Charge-pump gate driver for external NFET
- Programmable circuit breaker fault protection using MOSFET RDS_{ON} — provides system protection without sense resistor power loss
- Programmable input over-voltage and under-voltage detection
- Active low open drain Power GOOD output
- Controlled rise time for safe connection to capacitive loads
- Programmable insertion and fault detection time
- Latches off after load fault is detected

Typical Application Circuit

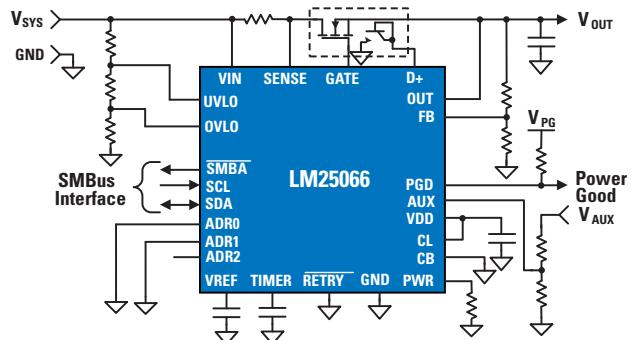


LM25066 – System Power Management and Protection IC with PMBus

Features

- 2.9V to 17V input voltage range
- 25 mV or 50 mV current limit threshold
- Power limited control of hot-swap insertions, in-rush current, and circuit breaker functions
- Real-time system telemetry monitoring
- True power measurement: simultaneous sampling of V_{IN} and I_{IN}
- Power averaging and peak hold
- Multi-level configuration and monitoring of system fault conditions via PMBus
- I²C compliant/SMBus interface and PMBus-compliant command structure

Typical Block Diagram



Applications

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

Hot Swap/In-Rush Current Controllers

Product ID	V_{IN} Range (V)	Power GOOD	Adjustable UVLO	Adjustable OVLO	Active In-Rush Current Limiting	Active Power Limiting	Fault Latch-Off/Auto Retry	Packaging
LM5067 E	-9 to -80	V_{DS}	✓	✓	Sense resistor	✓	Both	MSOP-10, LLP-10
LM5069 E	9 to 100	V_{DS}	✓	✓	Sense resistor	✓	Both	MSOP-10
LM25061 E	2.9 to 16	V_{OUT} (adj.)	✓	—	Sense resistor	✓	Both	MSOP-10
LM25069 E	2.9 to 16	V_{DS}	✓	✓	Sense resistor	✓	Both	MSOP-10
LM5060 E	5.5 to 65	V_{DS}	✓	✓	V_{DS} sense	—	Latch-Off	MSOP-10
NEW LM25066	2.9 to 17	✓	✓	✓	Sense resistor	✓	Both	LLP-24

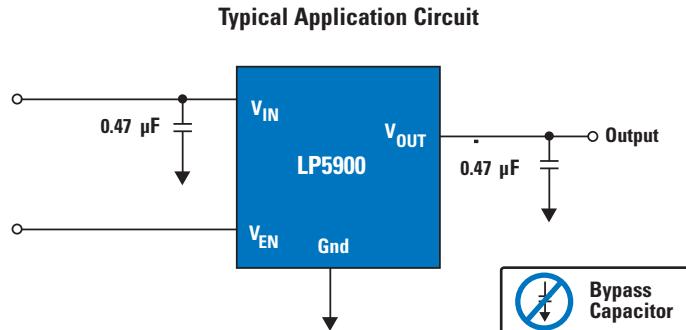
Low-Noise LDOs to Power RF and Analog Circuits

LP5900 – Low-Noise, 150 mA CMOS LDO

Features

- Industry's lowest noise ($6.5 \mu\text{V}_{\text{RMS}}$) combined with 85 dB of 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® packaging

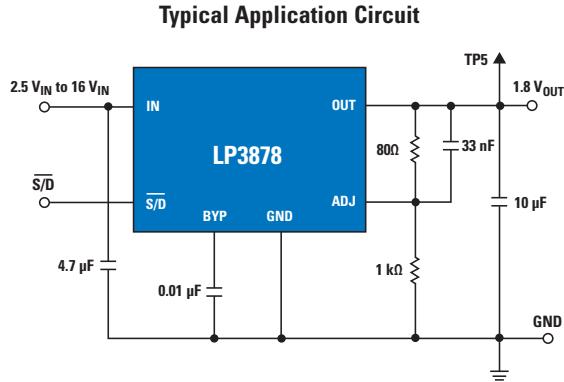
See also LP8900 for dual 200 mA, low-noise LDO



LP3878 – Low-Noise, 800 mA Low-Noise LDO Powers Noise-Sensitive Analog Loads

Features

- Low $18 \mu\text{V}_{\text{RMS}}$ noise, 60 dB PSRR
- Input voltage up to 16 V
- 1.0V to 5.5V output
- Designed for use with low-Equivalent Series Resistance (ESR) ceramic capacitors
- < $10 \mu\text{A}$ quiescent current in shutdown
- Low ground-pin current at all loads
- Over-temperature/over-current protection
- 40°C to $+125^{\circ}\text{C}$ operating junction temperature range



Low-Noise LDOs for Low-Power, Space-Constrained Applications

Product ID	Output Current (mA)	V_{IN} Max (V)	V_{IN} Min (V)	Dropout Voltage (V)	Output Voltage (V)	Adjustable Output	On/Off Pin	Quiescent Current (mA)	PSRR (dB)	Voltage Noise (rms)	Packaging
LP3999	150	6.0	2.5	0.06	1.5, 1.8, 2.4, 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 E	200	5.5	2.2	0.15	0.8 to 3.6	—	—	0.03	55	60	micro SMD-4
LP3871/74	800	7.0	2.5	0.24	1.8 to 5	✓	✓	5.0	73	150	T0263-5, SOT-223-5, T0220-5
LP3878	800	16	2.5	0.475	1.0 to 5.5	✓	✓	0.18	60	18	LLP-8, PSOP-8
LP3879	800	6.0	2.5	—	1.2, 1	—	✓	0.2	60	18	LLP-8, PSOP-8
LP3875	1500	7.0	2.5	0.38	1.8, 2.5, 3.3	✓	✓	6.0	73	150	T0263-5, SOT223-5
LP3876	3000	7.0	2.5	0.8	2.5, Adj	✓	✓	6.0	73	150	T0263-5

PowerWise® product ^E Evaluation board

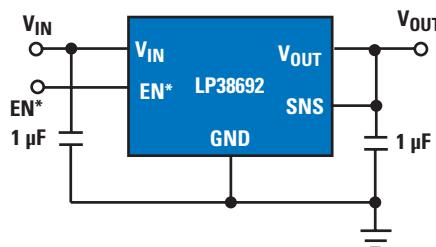
Low-I_q and Negative LDOs

LP3869x – Low Dropout, Low Quiescent Current CMOS Linear Regulators

Features

- LP38690/92 - 1A output current, LP38691/93 - 500 mA
- Wide input voltage range: 2.7V to 10V
- 55 μ A quiescent current at full load
- <1 μ A off-state quiescent current
- LP38692/93 - enable pin*
- Output sense pin for remote sensing at load
- Guaranteed specs for -40°C to +125°C

Typical Application Circuit



Low Quiescent Current LDOs

Product ID	Output Current (mA)	V _{IN} Max (V)	V _{IN} Min (V)	Dropout Voltage (V)	Quiescent Current (mA)	On/Off Pin	Output Voltage (V)	Packaging
LP3983	5.0	6.0	2.5	—	0.014	✓	1.6, 2.5	micro SMD-5
LP2936	50	60	4.0	0.2	0.009	—	3.0, 3.3, 5.0	SOIC-8, TO252-3, SOT223-4, TO92-3
LP3990	150	6.0	2.0	0.06	0.043	✓	0.8, 1.2, 1.35, 1.5, 1.8, 2.5, 2.8	micro SMD-4, SOT23-5, LLP-6
LP3984	150	6.0	2.5	0.06	0.08	✓	1.5, 1.8, 3.1	micro SMD-4, SOT23-5
LP3985	150	6.0	2.5	0.06	0.085	✓	2.5, 2.8, 3, 3.3, 4.7, 5	micro SMD-5, SOT23-5
LP3987	150	6.5, 6	V _{OUT} + .200	0.06	0.085	✓	2.5, 2.6, 2.8, 2.85, 3.0	micro SMD-5
LP3988	150	6.0	2.5	0.08	0.085	✓	1.85, 2.5, 2.6, 2.85, 3.0	micro SMD-5, SOT23-5
LP3991 E	300	3.6	1.65	0.075	0.05	✓	0.8, 1.2, 1.3, 1.5, 1.8, 2.5, 2.8, 3.0	micro SMD-4
LP38691/93 E	500	10	2.7	0.12, .25	0.055	✓	1.8, 2.5, 3.3, 5, Adj.	LLP-8, MSOP-8
LP38690/92 E	1000	10	2.7	0.45	0.055	✓	1.8, 2.5, 2.8, 3.3, 5.0, Adj.	LLP-6, MSOP-8
LP8340	1000	10	2.7	0.54	0.019	—	Adj. down to 1.25V	LLP-6

E Evaluation board

Negative Output Linear Regulators

Product ID	Output Current (A)	Adj (V)	Other Available Voltages (V)	V _{IN} Min (V)	V _{IN} Max (V)	V _{DROPOUT} Max (V)	V _{OUT} Tolerance (%)	I _q Max (mA)	Shutdown	Temp Range (°C)	Packaging
LM2990	1	—	-5, 5.2, -12, -15	—	-26	0.6	2	5	—	-40 to 125	TO220-3, TO263-3, TSSOP-16, CERDIP-16
LM2991	1	-2 to -25	—	—	-26	0.6	2	5	✓	-40 to 125	TO220-5, TSSOP-16, TO223-5, CERDIP-16, D, W

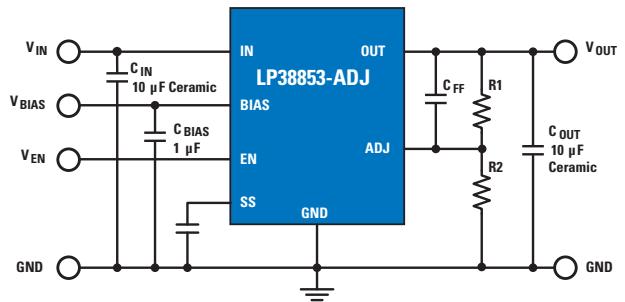
Low-Input/Low-Output LDOs for Powering Digital ICs

LP3885x – Low-Input-Voltage and High-Efficiency LDOs

The LP3885x LDOs provide ultra-low dropout for high efficiency and power throughput.

- Designed for conversions from 1.8V rails and below
- Adjustable output voltage down to 0.8V
- Load currents of 800 mA, 1.5A, or 3A
- Typical dropout, 115 mV at 800 mA
- Efficiency of up to 80% for 1.5V to 1.2V conversion
- 2% accuracy over line, load, and temperature (0°C to 125°C)
- Enable pin option
- Soft-start pin option
- Available in TO220-7, TO263-7, or PSOP-8 packaging

Typical Application Circuit



Product ID	Output Current (mA)	V _{IN} Max (V)	V _{IN} Min (V)	Dropout Voltage (V)	Soft-Start Pin	Output Voltage (V)	On/Off Pin	Packaging
LP38851*	80	5.5	0.915	0.115	✓	Adj. 0.8 to 1.8	✓	PSOP-8, TO263-7
LP3990	150	6	2	0.06	—	0.8, 1.2, 1.8, 2.5, 2.8	✓	SOT23-5, micro SMD-4
LP5951 E	150	5.5	1.8	0.029	—	1.3, 1.5, 1.8, 2.0, 2.5, 2.8, 3, 3.3	✓	SOT23-5, SC70-5
LP3991 E	300	3.6	1.65	0.075	—	0.8, 1.2, 1.3, 1.5, 1.55, 1.7, 2.5, 2.8, 3.0	✓	micro SMD-4
LP5952 E *	350	4.5	0.9	0.061	—	0.7, 1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.8, 2.0	✓	micro SMD-5
LP38841*	800	5.5	V _{OUT} + V _{DO}	0.075	—	Adj.	—	TO263-5, TO220-5
LP3891*	800	5.5	V _{OUT} + V _{DO}	0.1	—	1.2	✓	TO263-5, TO220-5, PSOP-8
LP38852 E *	1500	5.5	0.93	0.18	✓	Adj. 0.8 to 1.8	✓	PSOP-8, TO263-7
LP38855*	1500	5.5	1.04	0.18	—	0.8, 1.2	✓	TO263-5, TO220-5
LP38858*	1500	5.5	0.98	0.18	✓	0.8, 1.2	—	TO263-5, TO220-5
LP3882*	1500	6	V _{OUT} + V _{DO}	0.11	—	1.2	✓	TO263-5
LP38842*	1500	5.5	V _{OUT} + V _{DO}	0.115	—	1.2, Adj.	—	TO263-5, PSOP-8
LP3892*	1500	5.5	V _{OUT} + V _{DO}	0.14	—	1.2, 1.5	✓	TO263-5, TO220-5, PSOP-8
LP3852/55	1500	7	2.5	0.24	—	5.0, 1.8, 2.5, 3.3, Adj.	✓	TO263-5, SOT223-5, TO220-5
LP38853 E *	3000	5.5	1.15	0.45	✓	Adj. 0.8 to 1.8	✓	PSOP-8, TO263-7
LP38856 E *	3000	5.5	0.98	0.45	—	0.8, 1.2	✓	TO263-5, TO220-5
LP38859 E *	3000	5.5	1.15	0.45	✓	0.8, 1.2	—	TO263-5, TO220-5
LP3883*	3000	5.5	V _{OUT} + V _{DO}	0.21	—	1.2	✓	TO263-5
LP3853/56	3000	7	2.5	0.39	—	2.5, 5.0	✓	TO263-5

E Evaluation board

* Dual input rail devices: V_{IN} and V_{BIA}S

Wide-Input-Voltage and Multi-Output LDOs

Wide-Input-Voltage LDOs

Product ID	Load (mA)	V _{IN} Max (V)	V _{IN} Min (V)	Dropout Voltage (V)	Enable Pin	V _{OUT}	Packaging
LP2980	50	16	2.1	0.12	✓	2.5, 3.3, 4.7, 5, Adj	SOT-23-5
LP2982	50	16	2.1	0.12	✓	3, 3.3, 5, Adj	SOT-23-5
LP2981	100	16	2.1	0.2	✓	3, 3.3, 3.6, 5	SOT-23-5
LP2983	150	16	2.2	1.3, 1, 1.2	✓	1, 1.2, 3.3	SOT-23-5
LP2985LV	150	16	2.2	0.28	✓	1.5, 1.8, 2.0, 2.85, 3.0, 3.3	SOT-23-5, micro SMD-5
LP2985	150	16	2.5	0.28	✓	2.5, 2.6, 2.7, 2.8, 2.9, 3, 3.1, 3.2, 3.3, 3.6, 3.8, 4, 4.5, 5, 6.1	SOT-23-5, micro SMD-5
LP2986	200	16	2.1	0.18	✓	3, 3.3, 5, Adj	MSOP-8, LLP-8, SOIC-8 Narrow
LP2987	200	16	2.1	0.18	✓	5	MSOP-8, LLP-8, SOIC-8 Narrow
LP2988	200	16	2.1	0.18	✓	3, 3.3, 3.8, 5	MSOP-8, LLP-8, SOIC-8 Narrow
LP2992	250	16	2.5	0.45	✓	1.5, 5, 1.8, 2.5, 3.3	SOT-23-5, LLP-6
LP2989	500	16	2.1	0.31	✓	2.8, 3, 3.3, 5	MSOP-8, LLP-8, SOIC-8 Narrow
LP2989LV	500	16	2.1	0.31	✓	1.8	MSOP-8, LLP-8, SOIC-8 Narrow
LP38691	500	10	2.7	0.25	—	1.8, 2.5, 3.3, 5 Adj	SOT223-5, LLP-6
LP38693	500	10	2.7	0.25	✓	3.3 Adj	SOT223-5, LLP-6
LP3878	800	16	2.5	0.475	✓	Adj	LLP-8, PSOP-8
LM2991	1000	0.3	-26	0.6	✓	Adj	TO-263-5, TO-220-5
LP38690	1000	10	2.7	0.45	—	1.8, 3.3, Adj	SOT223-5, LLP-6
LP38692	1000	10	2.7	0.45	✓	3.3, 5.0, Adj	SOT223-5, LLP-6
LM2990	1500	0.3	-26	0.6	—	-5, -12, -15	TO-263-3, TO-220-3
LP2975	Note 1	24	1.8	—	✓	5.0	MSOP-8

Note 1: LDO Controller

Multi-Output LDOs

Product ID	V _{IN} Max (V)	V _{IN} Min (V)	Output1 V _{OUT} Min (V)	Output2 V _{OUT} Min (V)	Output1 I _{OUT} Max (mA)	Output2 I _{OUT} Max (mA)	Dropout Voltage (V)	Quiescent Current (mA)	Error Flag	Power on Reset	Packaging
LP2966	7.0	2.7	1.8	1.8	150	150	0.135	0.34	✓	—	LLP-16, PSOP-8, SOIC-8
LP2967	16	2.1	1.8	2.5	150	150	0.275	0.2	—	—	micro SMD-8, MSOP-8
LP3986	6.0	2.5	2.5	2.8	300	150	0.06	0.115	—	—	micro SMD-8
LP3996 ^E	6.0	2.0	0.8	0.8	150	300	0.21	0.035	✓	✓	LLP-10
LP5996 ^E	6.0	2.0	0.8	0.8	150	300	0.21	0.035	—	—	LLP-10
LP8900	5.5	1.8	2.7	1.8	280	280	0.11	0.085	—	—	micro SMD-6

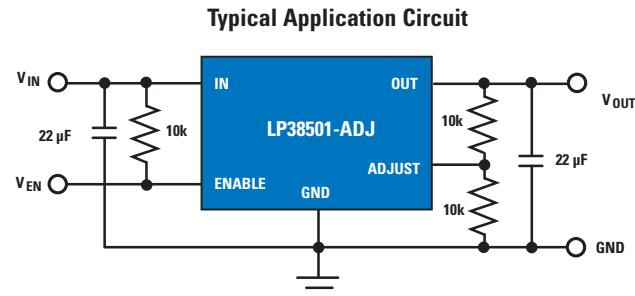
^E Evaluation board

Low-Dropout (LDO) Linear Regulators

LP3850x – FlexCap LDOs Provide Flexibility and Simplicity

The LP3850x FlexCap family of LDOs features unique compensation that allows the use of any type of capacitor with no limits on minimum or maximum ESR.

- Optimized for conversions from 3.3V or 5V rails
- Outputs as low as 0.6V
- Load currents of 1.5A or 3A
- Typical dropout voltage, 450 mV at 3A
- Ultra-low, 25 nA, shutdown current
- Stable with ceramic, tantalum, or aluminum electrolytic capacitors
- Available in TO263-5 or LLP-8 packaging



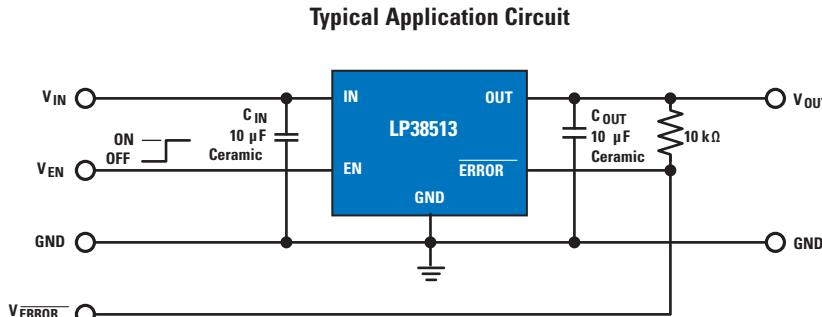
Product ID	Load Current (A)	V _{IN} Min (V)	V _{IN} Max (V)	V _{OUT} (V)	Typical Dropout (mV)	Enable	Packaging
LP38500	1.5	2.7	5.5	Adj down to 0.6	220	—	TO263-5, LLP-8
LP38502 ^E	1.5	2.7	5.5	Adj down to 0.6	220	✓	TO263-5, LLP-8
LP38501 ^E	3.0	2.7	5.5	Adj down to 0.6	450	✓	TO263-5
LP38503	3.0	2.7	5.5	Adj down to 0.6	450	—	TO263-5

^E Evaluation board

LP3851x – Fast Transient-Response LDOs and Ultra-Low Dropout

The LP3851x fast transient-response family of LDOs offers the highest performance in meeting AC and DC accuracy requirements for digital cores.

- Ideal for conversions from 2.5V, 3.3V, or 5V rails
- Fixed 1.8V output
- Output currents of 800 mA, 1.5A, or 3A
- Typical dropout voltage: 275 mV at 3A
- Proprietary control loop enables extremely fast transient response
- High accuracy of 2.5% over line, load, and temperature (-40°C to 125°C)
- Stable with 10 μF ceramic capacitors
- Error flag feature
- Available in TO220-5 or TO263-5 packaging



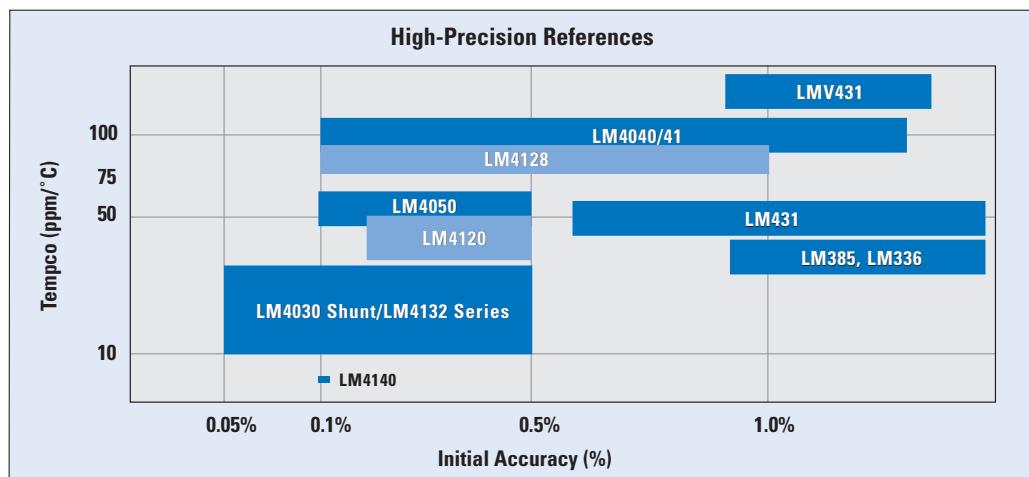
Product ID	Load Current (A)	V _{IN} Min (V)	V _{IN} Max (V)	V _{OUT} (V)	Error Flag	Enable	Packaging
LP38511 ^E	0.8	2.25	5.5	1.8, Adj down to 0.8V	✓	✓	TO263-5
LP38512 ^E	1.5	2.25	5.5	1.8, Adj down to 0.8V	✓	✓	TO263-5, LLP-8
LP38513 ^E	3.0	2.25	5.5	1.8, Adj down to 0.8V	✓	✓	TO263-5

^E Evaluation board

To see a more complete list and to learn more about LDOs, visit:
national.com/LDO

Voltage References

LM4140 – High-Precision Series Reference, Targeted at 16-Bit Precision Signal Conditioning Requirements, Features Ultra-Low Noise at 2.2 UVpp (0.1 Hz to 10 Hz), 3 ppm/°C Tempco, and 0.1% Initial Accuracy



Voltage References

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

* Available in AEC-Q100

Power Sequencers and Supervisors

LM3880 – Industry's Easiest and Smallest Solution for Multiple-Rail Power Sequencing

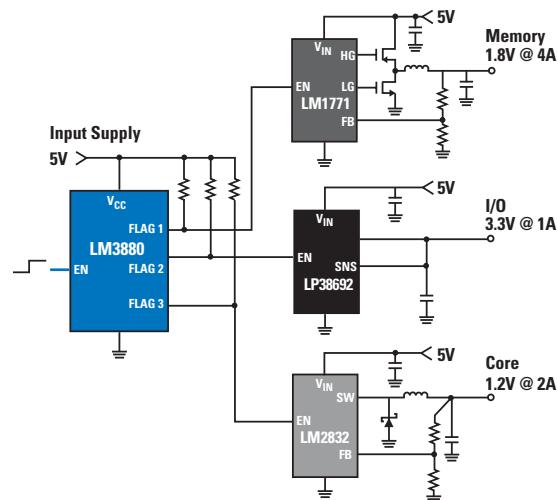
Features

- Easiest method to sequence rails
- Input voltage range of 2.7V to 5.5V
- Standard timing options: 10 ms, 30 ms, 60 ms, 120 ms
- 1-2-3 powerup and reverse-power down 3-2-1 control
- Customization of timing and sequence available through factory programming
- Available in tiny SOT23-6 packaging

Applications

Ideal for use in sequencing power rails of digital logic devices (ASICs, FPGAs, DSPs, microcontrollers) to avoid latch-up conditions, and systems with multiple rails

Typical Application Circuit

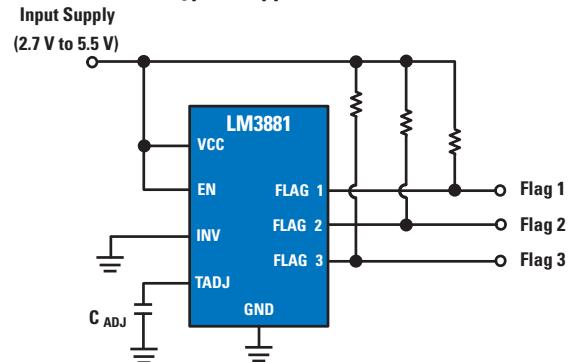


LM3881 – Adjustable Power Sequencer

Features

- 2.7V to 5.5V input voltage
- 20 μ A quiescent current
- 3 output flags
- Master sequence enable pin
- Powerup and powerdown control
- Digital logic invert pin
- Adjustable timing pin
- Available in MSOP-8 packaging

Typical Application Circuit



Supervisors

Product ID	Active Reset	Voltage Rails Supervised ¹ (V)	Reset Timeout Period (ms)	I _Q (μ A)	Manual Reset	Low Line Output	PFI Comparator	WATCHDOG	Temp Range (°C)	Packaging
LM3724	Low (open drain)	2.5, 3.3, 5.0	190	6.0	✓	—	—	—	-40 to 125	SOT23-5
LM3710	Low	2.5, 3.3, 4.8, 5.0	1.4, 28, 200, 1600	28	✓	✓	✓	✓	-40 to 85	micro SMD-9, MSOP-10
LM3713	High	3.3	1.4, 28, 200, 1600	28	✓	—	✓	✓	-40 to 85	micro SMD-9

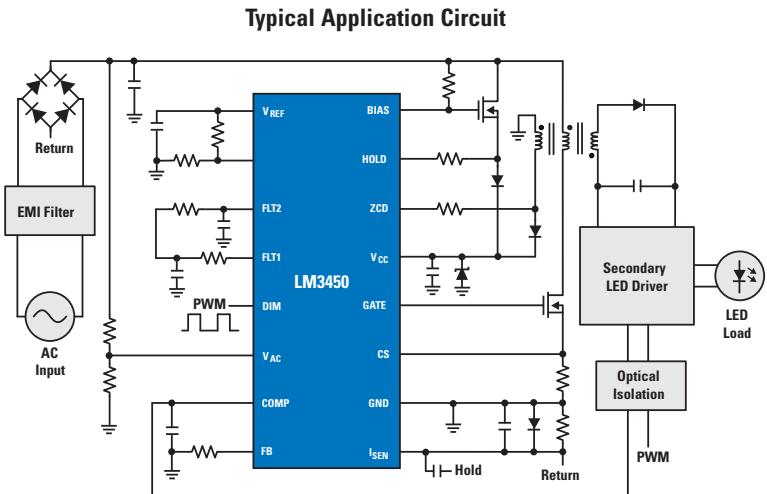
¹Most parts can monitor additional voltage rails in the 0.5V to 2.0V or the 2.2V to 5.0V range. For these custom threshold voltages, contact your National sales representative.

High-Performance TRIAC Dimmable LED Drivers

LM3450 – LED Driver with Power Factor Correction and Phase-Dimming Decoder

Features

- Solution accepts universal line voltages
- Active power factor correction IC with phase-dimmer decoder
- Unique dynamic hold circuitry allows for high-performance, smooth dimming without flicker
- Compatible with both forward-phase (TRIAC) and reverse-phase dimmers
- 70:1 PWM decoded from phase dimmer
- Up to 100W output power
- Programmable dimming range
- Analog adjust pin allows for interface to sensors, thermal foldback, analog dimming, or dimmer range adjust
- Can be used in either single- or two-stage configurations for tradeoffs between solution size, efficiency, and noise immunity
- Over-voltage protection
- Feedback short-circuit protection
- Available in TSSOP-16 packaging



Applications

Ideal for use in phase-dimmable LED fixtures (10W to 100W output power)

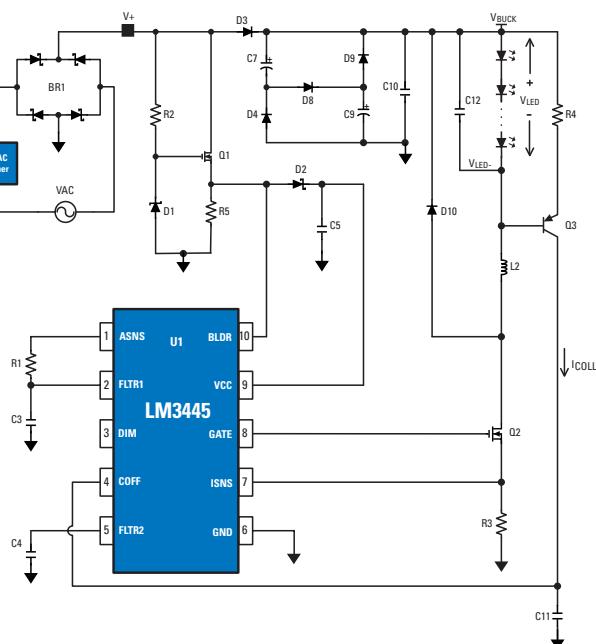
LM3445 – TRIAC-Dimmable LED Driver

Features

- Solution accepts universal line voltages
- Application voltage range from 80 VAC to 277 VAC
- Angle detector/decoder enables wide (100:1) full range dimming
- Integrated 300Ω bleeder resistor to ensure proper TRIAC signal decoding
- Patent-pending control architecture allows for constant ripple current which extends the life of the LEDs
- Scalable output current up to and greater than 1A
- Master/slave control for uniform dimming across multi-channel applications

Applications

Ideal for use in LED bulbs up to 10W to 15W output power



Product ID	Application V _{IN} Range (V)	Output Power (W)	I ₀ (A)	Number of LEDs	Features
LM3445 E, W	80 VAC to 277 VAC	Up to 15	1+	1 to 14	Integrated TRIAC dim decoder circuit for LED dimming. No flicker
LM3450 E, W	80 VAC to 277 VAC	10 to 100	1+	—	Active power factor controller with phase dimmer decoder. Dynamic hold circuitry for high-performance dimming. Analog adjust pin for thermal foldback, interface to sensors, analog dimming, or dimmer range adjust

WEBENCH® LED Architect

Create Complex Lighting Systems

1. Start Your Design

Enter your desired lumen output and input voltage supply. WEBENCH LED Architect automatically selects the optimal design from an extensive library of 350 LEDs, 30 heat sinks, 35 National PowerWise® LED drivers, and 21,000 electrical passive components to generate multiple design choices based on cost, size, and efficiency tradeoffs.

2. Complete Your Design

Real-time design tradeoffs let you “dial in” preferences for footprint, conversion efficiency, and cost

3. Verify Your Design

Use the electrical simulator to verify circuit stability and operation, and visualize circuit behavior under dynamic conditions including Pulse-Width Modulation (PWM) dimming

4. Order a Customized Prototype Kit

Guaranteed to ship in one business day

Watch Analog by Design

“Driving High-Power LEDs Without Getting Burned”

www.national.com/analog/nationalTV

Try the WEBENCH LED Designer tool, visit:

national.com/LED

The screenshot displays the WEBENCH LED Architect software interface. It includes several windows: 1. Top-left: 'Optimization Tuning' window with a dial for 'FootPrint' (266 mm²) and 'Efficiency' (87%), and buttons for 'Decrease Footprint' and 'Increase Efficiency'. 2. Top-right: 'SUMMARY' window showing a schematic diagram and component list. 3. Middle-left: 'Design Requirements' table listing parameters like Input Voltage, Output Power, and LED Type. 4. Middle-right: 'Configure LED' window showing LED selection criteria. 5. Bottom-left: 'Analysis & Plotting' window showing a graph of Power Dissipation vs. LED Temperature. 6. Bottom-right: 'Bill of Materials' table listing components with part numbers, descriptions, prices, and quantities. A 'Click here to Select an LED' button is also visible.

Applications for High-Brightness LED Drivers

National Offers a Diverse Portfolio of Constant-Current Regulators for Driving LEDs

Features

- PowerWise® energy-efficient solutions
 - Providing the best power-to-performance ratios
 - Enabling reliable and robust solutions
- Cutting-edge features including dimming, thermal management, fault protection, and more
- Low external component count and small solution sizes
- Easy-to-use tools and resources:
 - WEBENCH® LED Designer
 - Reference designs
 - Application notes

Applications

LED Driver	LED Bulbs	Outdoor High-Power Wide Area	Down Lights	Automotive	Display Backlighting	Medical	Entertainment	Portable Consumer	Portable Projectors
LM3401		✓		✓		✓	✓	✓	
LM3402/HV		✓		✓		✓	✓		
LM3404/HV		✓		✓		✓	✓		
LM3405/A		✓		✓		✓		✓	
LM3406/HV		✓		✓		✓	✓		
LM3407		✓		✓		✓		✓	
LM3409/HV		✓	✓	✓		✓	✓	✓	
LM3410		✓		✓	✓	✓			✓
LM3414/HV		✓	✓	✓		✓	✓		
LM3421/23		✓	✓	✓		✓	✓		✓
LM3424		✓	✓	✓	✓	✓	✓		✓
LM3429		✓	✓	✓		✓	✓		✓
LM3430/32					✓				
LM3431				✓	✓	✓			
LM3433						✓	✓		✓
LM3434						✓	✓		✓
LM3444	✓		✓			✓			
LM3445	✓		✓						
LM3450	✓		✓						
LM3464		✓							
LM3492									

LED Drivers

Inductive-Boost Backlight LED Drivers

Product ID	Max LED Current (mA)	Input Voltage Range (V)	Maximum Output Voltage (V)	Number of LEDs	Switching Frequency (MHz)	Dimming Control Type	Features	Packaging
LM3519 E	20	2.7 to 5.5	18	4	2.0 to 8.0	PWM	Variable switching frequency	SOT23-6
LM3500 E	30	2.7 to 7	16, 21	5	1.0	PWM	Low feedback voltage; no external Schottky diode	micro SMD-8
LM3501 E	30	2.7 to 7	16, 21	5	1.0	Analog	No external Schottky diode	micro SMD-8
LM3502 E	30	2.5 to 5.5	16, 25, 35, 44	10	1.0	PWM	2 LED banks for dual-display backlighting	micro SMD-10, LLP-16
LM3503 E	30	2.5 to 5.5	16, 25, 35, 44	10	1.0	Analog	2 LED banks for dual-display backlighting	micro SMD-10, LLP-16
LM3508 E	30	2.7 to 5.5	17.5	4	0.85	PWM	Adjustable PWM signal up to 100 kHz; no external Schottky diode	micro SMD-9
LM3557 E	30	2.7 to 7.5	26	5	1.25	PWM	Input under-voltage protection; cycle-by-cycle current limit	LLP-8
LM3509 E	30 per string	2.7 to 5.5	21.2	10	1.27	I ² C compliant	Dual-current sinks; 32 exponential dimming steps; 800:1 dimming ratio	LLP-10
LM3528 E	30 per string	2.7 to 5.5	20	10	1.27	I ² C compliant	Dual-current sinks, 128 logarithmic dimming steps; 800:1 dimming ratio	micro SMD-12
LM3430/32 E	40 per string	6.0 to 40	80+	100+	Adjustable up to 2 MHz	Analog, PWM	Dynamic headroom control for balanced current through up to 6 strings of LEDs	LLP-12, eTSSOP-28, LLP-24
LP8543	60	5.5 to 22	40	—	1.25/0.6	PWM	PWM phase shift control, two-wire, SMBus/I ² C compliant control interface, PWM frequency	LLP-24
LM4510 E	280	2.7 to 5.5	18	—	1.0	—	Power supply for OLED display; no external Schottky diode	LLP-10
LM2731/33 E	1A/1.5A	2.7 to 14	Adj up to 20/40	9	600 kHz	PWM	Internal compensation, cycle-by-cycle current limit	SOT23-5

Switched-Capacitor Boost Backlight LED Drivers

Product ID	Input Voltage Range (V)	Output Voltage (V)	Max LED Current (mA)	Number of LEDs	Switching Frequency (MHz)	Dimming Type	Features	Packaging
LM2755 E	3.0 to 5.5	5.0	90	3	1.25	I ² C compliant	Independently-controlled RGB outputs; programmable trapezoidal waveforms	micro SMD-18
LM2750 E	2.9 to 5.6	5.0, Adj (3.8 to 5.2)	120	10	1.7	PWM	Pre-regulation minimizes input ripple	LLP-10
LM27951/52 E	3.0 to 5.5	5.0	120	4	0.75	PWM	Regulated current sources with 0.2% matching	LLP-14
LM2751	2.8 to 5.5	4.5, 5.0	150	10	0.01 to 0.725	PWM	Programmable switching frequencies	LLP-10
LM2756 E	2.7 to 5.5	4.6	180	8	1.3	I ² C compliant	3 independent LED banks with 2 variable drivers; 32 exponential dimming steps; 800:1 dimming ratio	micro SMD-20
LM27964 E	2.7 to 5.5	5.0	180	7 (3 banks)	0.7	I ² C compliant	3 independent LED banks (Group A = 4 LEDs, Group B = 2 LEDs, Group C up to 80 mA); dedicated keypad LED driver	LLP-24
LM27965 E	2.7 to 5.6	5.0	180	9 (3 banks)	1.27	I ² C compliant	3 independent LED banks (Group A = 5 LEDs, Group B = 3 LEDs, Group C = 1 LED)	LLP-24
LM27966 E	2.7 to 5.7	5.0	180	6 (2 banks)	1.27	I ² C compliant	2 independent LED banks (Group A = 5 LEDs, Group B = 1 LEDs)	LLP-24
LM2757 E	2.7 to 5.5	4.1, 4.5, 5.0	180	10	1.25	No dimming	Pre-regulation minimizes input ripple; true input-output and output-input disconnect; high impedance output in shutdown	micro SMD-12

Flash LED Drivers

Product ID	Input Voltage Range (V)	Output Voltage (V)	Max LED Current (mA)	Number of LEDs	Switching Frequency (MHz)	Topology	Features	Packaging
LM2754 E	2.8 to 5.5	5.0	800	4	1.0	Switched capacitor	TX input ensures synchronization with RF power amplifier pulse	LLP-24
LM2758/59 E	2.7 to 5.5	5.0	700/1000	1	1.2/1.0	Switched capacitor	Indicator, torch, and flash modes; flash timeout protection	micro SMD-12/ LLP-12
LM3551/52 E	2.7 to 5.5	11	1000	4	1.25	Inductive boost	Flash timeout protection; shutdown mode via SD pin (LM3551) or EN pin (LM3552)	LLP-14
LM3553 E	2.7 to 5.5	19	1200	2	1.3	Inductive boost	Indicator, torch, flash modes, and voltage mode; 128 current levels	LLP-12

 PowerWise® product  Evaluation board

LED Drivers

High-Brightness LED Drivers

Product ID	Max LED Current (mA)	Input Voltage Range (V)	Maximum Output Voltage (V)	Maximum Number of LEDs in Series	Switching Frequency (MHz)	Topology	Features	Packaging
LM3444	1000+	80 VAC to 277 VAC	Adj.	Up to 14	1	Buck	MSOP-10 package, pin-pin compatible with LM3445	MSOP-10
LM3445	1000+	80 VAC to 277 VAC	Adj.	Up to 14	1	Buck	Integrated TRIAC dim decoder circuit for LED dimming. No flicker	MSOP-10 SOIC-14
LM3450	1000+	80 VAC to 277 VAC	Adj.	—	—	Buck, Boost	Power factor correction and phase-dimming decoder	TSSOP-16
LM3464/A	1000+	12 to 80/ 12 to 95	80/95	20	Up to 1 MHz	Boost	Dynamic headroom control, 4 output channels	eTSSOP-28
LM3414/HV	1000	4.5 to 42/ 4.5 to 65	80/95	16	Up to 1 MHz	Buck	Thermal foldback, analog and PWM dimming	ePSOP-8 or LLP-8
LM3492	200	4.5 to 65	65	17	Up to 1 MHz	Boost	Dynamic headroom control, 2 output channels, 1000:1 dimming contrast ratio	eTSSOP-20
LM3431 E, W	150 per string	5.0 to 36	40+	30	1	Analog, PWM	3-string output	TSSOP-28, LLP-28
LM3402/02HV E, W	500	6.0 to 42 / 6.0 to 75	40/70	9/15	Adjustable up to 1 MHz	Buck	Fast PWM dimming, no control loop compensation, supports ceramic capacitor and capacitor-less outputs	MSOP-8, PSOP-8
LM3404/04HV E, W	1000	6.0 to 42 / 6.0 to 75	40/70	9/15	Adjustable up to 1 MHz	Buck	Fast PWM dimming, no control loop compensation, supports ceramic capacitor and capacitor-less outputs	SOIC-8, PSOP-8
LM3410 E, W	1000	2.7 to 5.5	24	6	525 kHz / 1.6 MHz	Boost, SEPIC	PWM dimming, small footprint, low external component count	SOT23-5, LLP-6
LM3406/06HV E, W	1500	6.0 to 42/ 6.0 to 75	40/70	1-10/20	Adjustable to 1 MHz	Buck	Fast PWM dimming, no control loop compensation, supports ceramic capacitor and capacitor-less outputs	eTSSOP-14
LM3421/23/29 E, W	>2000	4.5 to 75	75	20	Adjustable to 2 MHz	Boost, SEPIC	Fast PWM dimming, LED ready, broken open check overvoltage protection, FLT, cycle-by-cycle current limit	eTSSOP-16/20/14
LM3433/34 E, W	6000+	-9.0 to -14	-6	1	Adjustable up to 1 MHz	Buck	Drives common-anode LEDs, analog and fast PWM dimming	LLP-24
LM3409/HV E, W	5000	6.0 to 42 / 6.0 to 75	42/75	9/15	1 MHz	Buck	PWM and analog dimming, high-side current sense, 100% duty cycle achievable	eMSOP-10
LM3424 E, W	3000+	3.5 to 75	75	18	Adjustable to 2 MHz	Boost, SEPIC	Temperature foldback, synchronizable 50 KHz max PWM dimming	eTSSOP-20

Lighting Management Units

Product ID	Description	V _{IN} Range (V)	Drive Current for All	Current for Flash Mode	Current Matching	Temp Range (°C)	Packaging
LP5522 E	Autonomous single LED controller with one-wire interface	2.7 to 5.5	20 mA	—	—	-30 to 85	micro SMD-6
LP3943 E	LED controller for RGB/white/blue LEDs	2.3 to 5.5	25 mA/LED	—	—	-40 to 125	LLP-24
LP3944 E	LED controller for RGB/white/blue LEDs	2.3 to 5.5	25 mA/LED	—	—	-40 to 125	LLP-24
LP8501 E	9-channel LED driver with integrated SRAM memory and 3 light engines	2.7 to 5.5	25.5 mA	—	1%	-30 to 85	micro SMD-25
LM4970	LED controller with LED lighting effects synchronized to audio	2.7 to 5.5	42 mA	—	—	-40 to 85	LLP-14
LP3958	Lighting management unit for controlling 4+2 white LEDs for main and sub-display and 3 sets of white LEDs for keypad	3.0 to 5.5	70 mA total	—	3% (Key)	-30 to 85	micro SMD-25
LP5521 E	Fully programmable 3-channel color LED driver with advanced power-save features	2.7 to 5.5	75 mA	—	1%	-30 to 85	micro SMD-20
LP5524 E	Parallel LED driver with PWM brightness control	2.7 to 5.5	100 mA	—	1%	-40 to 85	micro SMD-9
LP5526 E	Lighting management unit with high-voltage boost converter with up to 150 mA serial flash LED driver	3.0 to 5.5	150 mA total	150 mA	2% (RGB)	-30 to 85	micro SMD-25
LP5520	RGB backlight driver with white balance compensation	2.9 to 5.5	180 mA	—	0.20%	-30 to 85	micro SMD-25
LP3952	6-channel color LED driver with audio synchronization	3.0 to 5.5	240 mA	—	5%	-30 to 85	micro SMDxt-36
LP3950	Color LED driver with audio sync	3.0 to 7.2	300 mA	—	3%	-40 to 125	Laminate TCSP-32
LP39542	Lighting management unit for 4+2 white LEDs, 2 sets RGB LEDs with audio sync and pattern control, and a flash LED driver	3.0 to 5.5	400 mA	400 mA	0.2% (White LED), 5% (RGB)	-30 to 85	micro SMDxt-36
LP55281 E	Quad RGB LED driver with boost converter and LED connectivity test	3.0 to 5.55	400 mA	—	5%	-30 to 85	micro SMDxt-36
LP5527	Tiny LED driver for camera flash and 4 LEDs with I ² C compliant programmability, connectivity test and audio synchronization	3.0 to 5.5	1 A total	—	1%	-30 to 85	micro SMD-30

For a complete list of LED drivers, visit: national.com/LED

PowerWise® product

E Evaluation board

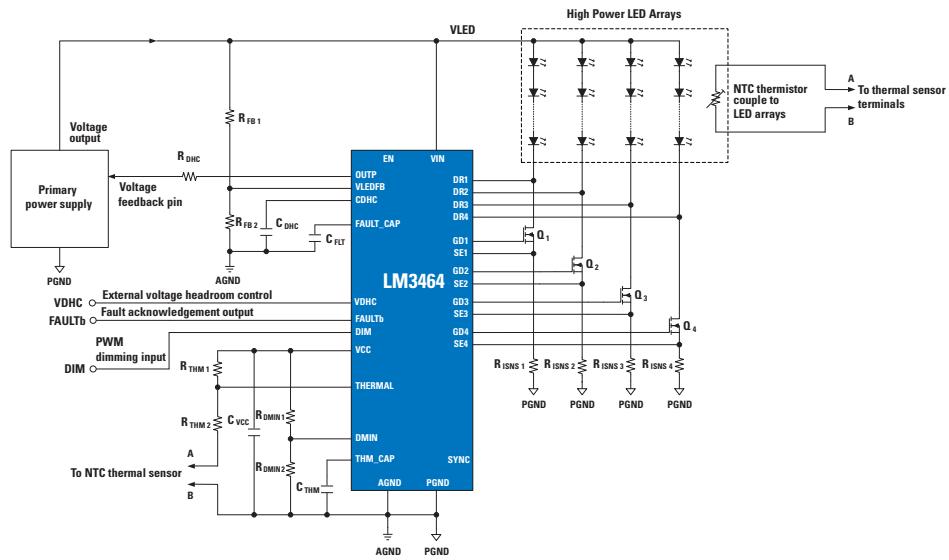
W WEBENCH enabled

High-Brightness LED Drivers

LM3464 – LED Driver with Dynamic Headroom Control and Thermal Control Interfaces

Features

- Wide input voltage range (12V to 80V)
- Dynamic headroom control ensures maximum efficiency
- 4 output channels with individual current regulation
- High channel-to-channel accuracy
- Digital PWM/analog dimming control interface
- Resistor-programmable dimming frequency and minimum duty cycle (analog dimming mode)
- Direct interface to thermal sensor
- Fault detection
- Over-temperature protection
- Thermal shutdown
- Under-voltage lockout
- Available in thermally-enhanced eTSSOP-28 packaging



Applications

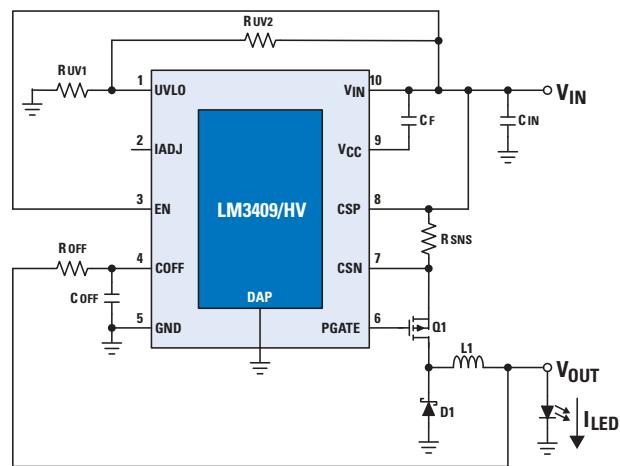
Ideal for use in high-power white applications such as street lamps, parking garage lamps, and warehouse lighting

LM3409 – PowerWise® PFET Buck Controller for High-Power LED Drivers

Features

- 2.0 Ω MOSFET gate drive
- V_{IN} range 6V to 42V (LM3409)
- V_{IN} range 6V to 75V (LM3409HV)
- Differential, high-side current sensing
- No control-loop compensation required
- Cycle-by-cycle current limit
- 10,000:1 PWM dimming range
- 250:1 analog dimming range
- Low power shutdown
- Supports all-ceramic output capacitors and capacitor-less outputs
- Thermal shutdown protection
- Available in thermally-enhanced eMSOP-10 packaging

Typical Application Circuit



Applications

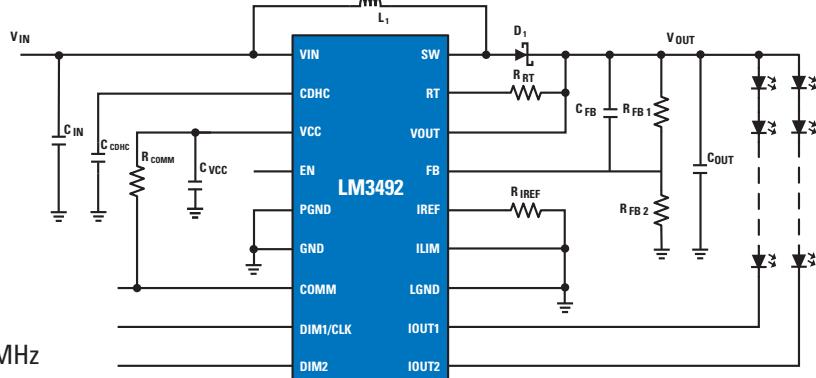
Ideal for use in LED drivers, constant-current sources, automotive lighting, general illumination, and industrial lighting

High-Brightness LED Drivers

LM3492 – Two-Channel Individual Dimmable LED Driver with Boost Converter and Fast Current Regulator

Features

- 4.5V to 65V input voltage range
 - Two individual dimmable LED strings up to 65V
 - Programmable LED current from 50 mA to 200 mA
 - Dynamic headroom control maximizes efficiency
 - 1000:1 contrast ratio at a dimming frequency of more than 3 kHz
 - Programmable soft-start
 - No loop compensation required
 - Stable with ceramic and other low-ESR capacitors with no audible noise
 - Switching frequency programmable from 200 kHz to 1 MHz
 - Over-power protection
 - $\pm 3\%$ current accuracy
 - Precision enable
 - COMM I/O pin for diagnostic and commands
 - Thermal shutdown protection
 - AEC-Q100 grade 1 qualified
 - Available in thermally-enhanced eTSSOP-20 package



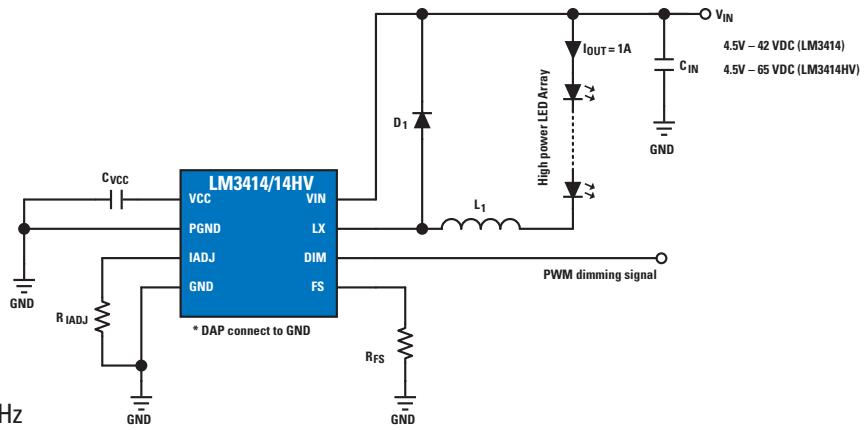
Applications

Ideal for use in ultra-high contrast ratio 6.5" to 10" LCD display backlight up to 28 LEDs and automotive or marine GPS displays

LM3414 – 1A 60W Common-Mode-Capable Constant-Current Buck LED Driver

Features

- Wide input voltage ranges:
 - 4.5V to 42V (LM3414)
 - 4.5V to 65V (LM3414HV)
 - Supports output powers up to 60W
 - Adjustable LED current from 350 mA to 1A
 - Analog and PWM dimming
 - Thermal foldback
 - Requires no external current sensing resistor
 - $\pm 3\%$ LED current accuracy
 - Up to 96% efficiency
 - Integrated low-side N-channel MOSFET
 - Switching frequency adjustable from 250 kHz to 1 MHz
 - Thermal shutdown protection
 - Available in power-enhanced ePSOP-8 or LLP-8 (3mm x 3mm)



Applications

Ideal for use in space-constrained general illumination applications, MR16 replacement lamps, and LED fixtures.

Linear Regulators for DDR Termination

LP2998 – Double Data Rate (DDR) Termination Regulator

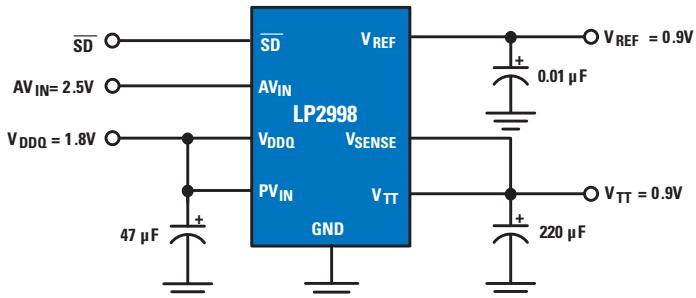
Features

- Linear topology
- Load current up to 0.5A (DDR-II)/1.5A (DDR-I)
- Source and sink current
- Thermal shutdown
- Suspend to RAM (STR) functionality
- Active low shutdown
- -40°C to +125°C operation

Applications

Ideal for use in DDR-I and DDR-II termination voltage, SSTL-2 and SSTL-3 termination, and HSTL termination

Recommended DDR-II Termination



Linear Regulators for DDR Termination

Product ID	Output Current (mA)	V _{IN} Max (V)	Input (PV _{IN}) Min Voltage (V)	Standards	External Components	Quiescent Current	On/Off Pin	Suspend to RAM shutdown	Packaging
LP2997	500	5.5	1.8	DDR-II	3	0.32	✓	✓	PSOP-8, SOIC-8
LP2995	1500	5.0	2.2	DDR	3	0.25	—	—	LLP-16, PSOP-8, PSOP-8, SOIC-8
LP2996	1500	5.5	1.8	DDR, DDR-II	3	0.32	✓	✓	LLP-16, PSOP-8, PSOP-8, SOIC-8
LP2998	1500	5.5	1.8	DDR, DDR-II	3	0.32	✓	✓	PSOP-8, PSOP-8, SOIC-8

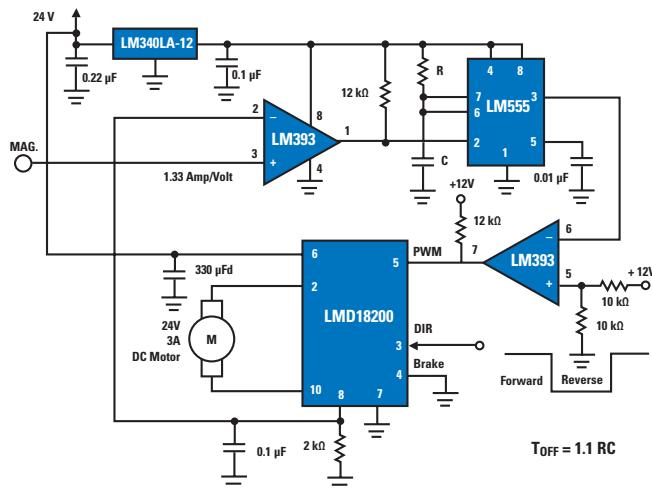
Motor and Motion Controllers

LMD18200 – 3A, 55V H-Bridge Controller

Features

- Delivers up to 3A continuous output
- Operates at supply voltages up to 55V
- Low RDS_{ON} typically 0.3Ω per switch
- TTL- and CMOS-compatible inputs
- No “shoot-through” current
- Thermal warning flag output at 145°C
- Thermal shutdown (outputs off) at 170°C
- Internal clamp diodes
- Shorted load protection
- Internal charge pump with external bootstrap capability

Typical Application Circuit



Half-Bridge Drivers for Motor Control

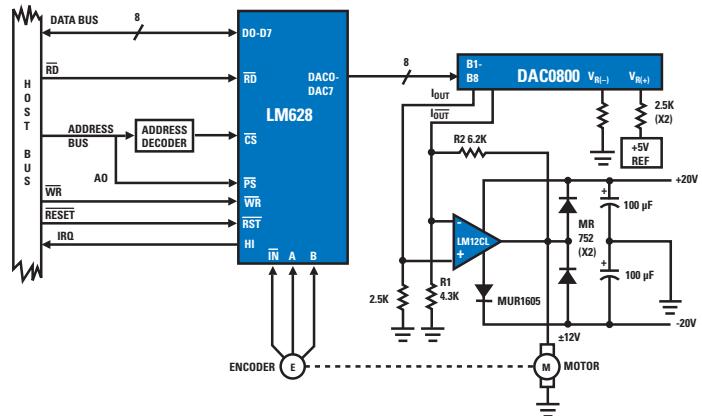
Product ID	I_{OUT} (A)	V_{IN} Max (V)	V_{IN} Min (V)	Thermal Shutdown ($^\circ\text{C}$)	Features	Packaging
LMD18200	3.0	55	12	170	Thermal warning flag at 145°C , low-loss internal current sense circuitry, shorted load protection	TO220-11
LMD18201	3.0	55	12	170	Thermal warning flag at 145°C	TO220-11
LMD18245	3.0	55	12	155	Low-loss internal current sense circuitry, 4-bit digital motor current control	TO220-15

LM628 – Precision Motion Controller

Features

- 32-bit position, velocity, and acceleration registers
- Programmable digital PID filter with 16-bit coefficients
- Programmable derivative sampling interval
- 8- or 12-bit DAC output data (LM628)
- 8-bit sign-magnitude PWM output data (LM629)
- Internal trapezoidal velocity profile generator
- Velocity, target position, and filter parameters may be changed during motion
- Available in MDIP-28 packaging or SOIC-24 packaging (LM629 only)

Typical Application Circuit



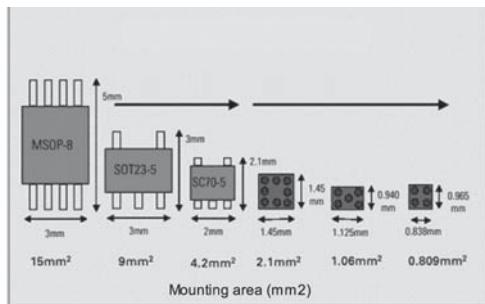
Digital Controllers for Motion Control

Product ID	Max Frequency	Features	Output Data	Packaging
LM628	6 MHz or 8 MHz	Digital PID filter, 32-bit velocity, position, acceleration registers	8-bit or 12-bit DAC	MDIP-28
LM629	6 MHz or 8 MHz	Digital PID filter, 32-bit velocity, position, acceleration registers	8-bit sign-magnitude PWM to drive H-bridge	DIP-28 or SOIC-24

Advanced Packaging Technologies

National Semiconductor meets the requirements for pin count and size across all standard package types. In addition to providing advanced packages, National has taken steps to reduce or completely eliminate environmentally unfriendly and hazardous substances from its products. National is compliant with the European Union's RoHS Directive (an EU directive restricting the use of specific hazardous substances contained in electronic products). In addition, National has taken the environmental initiative to move to halogen-free products.

Comparison of Packages Sizes



National has led the industry in developing ground-breaking new packages that meet the needs of the mobile era. Typical examples include micro SMD and LLP®.

Features of National's Chip-Scale Package (CSP)

micro SMD: "The die is the package"

The micro SMD package is ideal for high-performance mobile devices and applications with space-constraint issues.

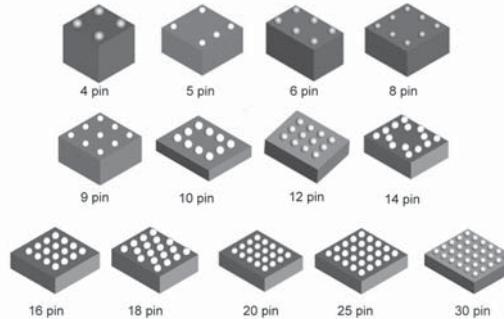
micro SMD packaging also features the following benefits:

- Minimum mounting area relative to the number of I/O pins
- Excellent electrical characteristics and heat dissipation performance, level 1 moisture resistance, and low noise
- Two different types of solder bump are available (large bump: 300 µm, small bump: 170 µm)
- Pad pitches available at 0.5, 0.4, and 0.3 mm
- Standard (0.85 mm to 1.05 mm) or thin (0.5 mm to 0.6 mm) package thickness
- Supplied as standard embossed taping

The micro SMD is available for pin counts from 4 to 30. For pin counts from 30 to 100, the micro SMDxt is used. Package form factor and assembly operations are identical between the two packages. In the xt package form factor, however, different types of solder balls are used to enhance board-level reliability for drop testing and thermal cycling.

National has adopted micro SMD technology for a wide range of products including power management, audio, amplifier, and temperature management ICs.

micro SMD Package Range



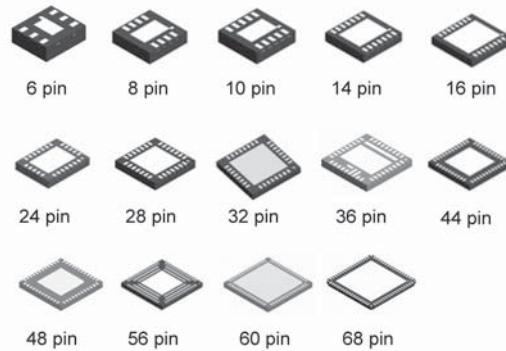
LLP Packages Feature Excellent Heat Dissipation Characteristics:

A key feature of the LLP package is that the large heat dissipation area provided by the die attach pad reduces thermal resistance and delivers excellent heat dissipation characteristics. At the same time, the package reduces board mounting area and enables high density mounting. The main features of LLP packaging are listed below.

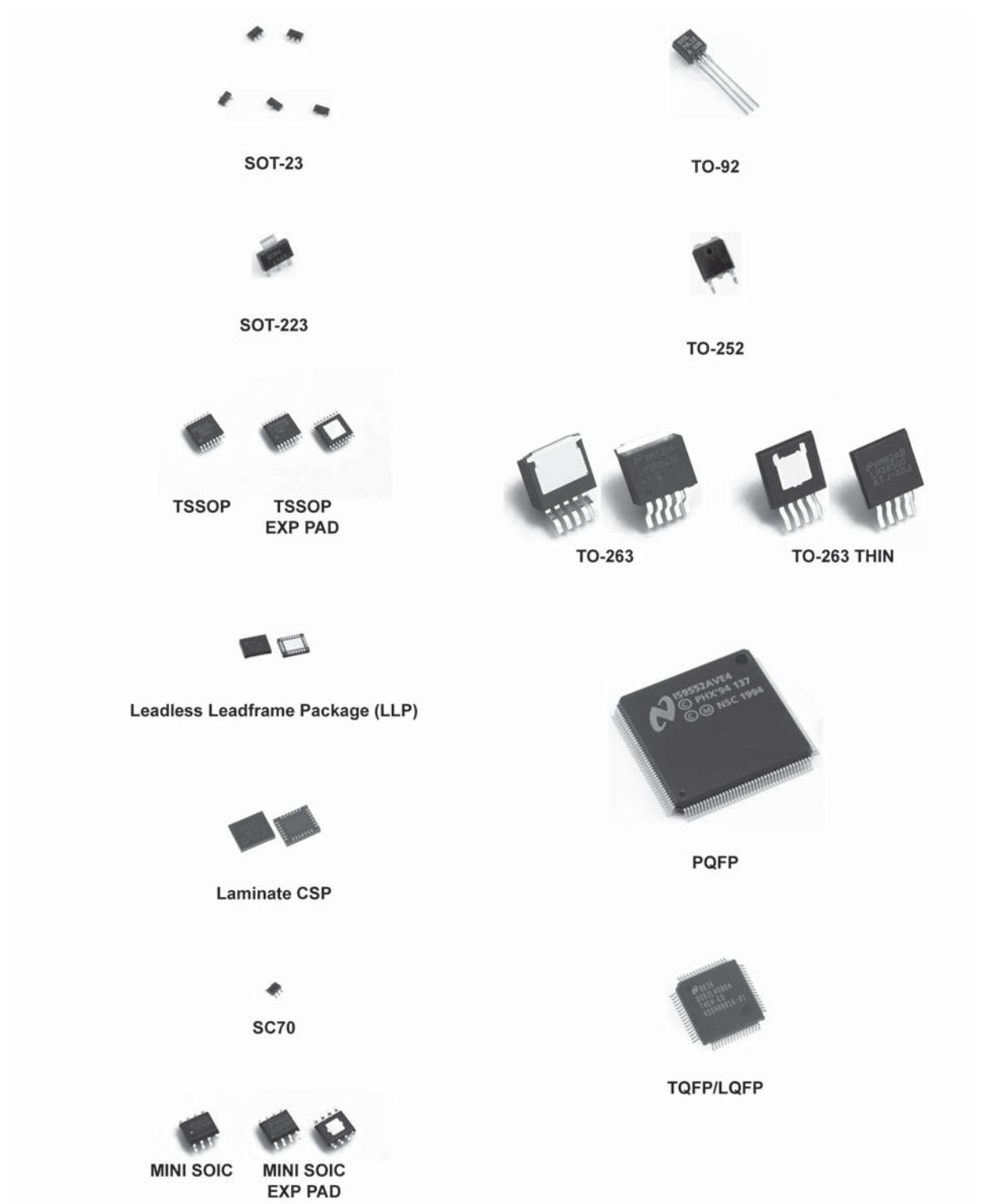
- Provides better heat dissipation characteristics due to direct contact of the die attach pad to the board and thermal vias
- Makes effective use of circuit board area with low package height and weight
- Affords low parasitic capacitance
- Maintains coplanarity
- Delivers faster signal transmission speed with minimal cross-talk and ground balance

The small dimensions and thin profile of the LLP package make it ideal for application in small devices such as mobile phones and PDAs that are heat-sensitive.

LLP Package Range



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Power Management

National's broad range of power management solutions is supported by reference designs, covering a broad array of applications and topologies. This includes output voltage range of -52V to +100V, for load currents of up to 30A.

national.com/refdesigns

Altera

National offers designers the Power-Expert software tool, power design guide, reference designs, and application notes to help them easily select and implement the best power management solutions for Altera FPGA or CPLD designs.

national.com/altera

Xilinx

Power solutions also include a downloadable power design guide for Xilinx FPGAs and application notes to help guide the engineer toward a typical solution for their Xilinx design.

national.com/xilinx

LVDS

LVDS evaluation boards are available

national.com/lvds

LED Lighting

Inductive LED driver reference designs are available for powering a wide variety of white LED types of multiple colors and configurations with high power efficiency. Many designs offer high output current for multiple LEDs in series, LED flash, or high-power LEDs.

national.com/refdesigns

Analog Signal Path (ADC + Amp + Clock)

National's signal path reference designs include:

- Low IF receiver subsystem with large/small signal SNR of 75.8/78 dBFS and SFDR greater than 84/94 dBFS - ADC16V130
- Lowest power 8-bit 3 GSPS data acquisition system
- Low intermediate frequency receiver system

Serial Digital Interface

- Triple-rate SDI and video clocking daughter card for Altera Cyclone III FPGAs
- Triple-rate SDI and video clocking daughter card for Xilinx Spartan-3A/3E FPGAs
- High-performance video clock module for Xilinx Virtex-5 LXT FPGAs
- LMH0303/07 triple-rate single/dual SDI cable driver with cable detect

national.com/sdi

Ethernet

- 10/100 reference designs - including microcontroller- and FPGA-based systems and IEEE1588 solutions

national.com/ethernet

- MotionFire motion control reference design. National, in collaboration with Arrow Electronics and Altera, developed a complete FPGA-based motor control platform with industrial communications interface

national.com/altera

The screenshot shows the National Semiconductor website's "REFERENCE DESIGNS" page. At the top, there are five thumbnail images of reference designs: "Ambient Light Adaptive LED Driver", "High-Efficiency Portable Music Player Dock", "Load-detecting Power Supply", "CFL to LED Conversion Power Supply", and "High-Performance SerDes Module with Easy FPGA Interface and Cable Detect". Below these thumbnails, there is a section titled "PowerWise Reference Designs Receive eg3 Editor's Tech Choice Award" featuring a quote from Rick Zarr and a "Tech Choice" award logo.

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