

Industrial Systems

Solutions Guide

national.com/industrial

2010 Vol. 1

Industrial Applications

Amplifiers

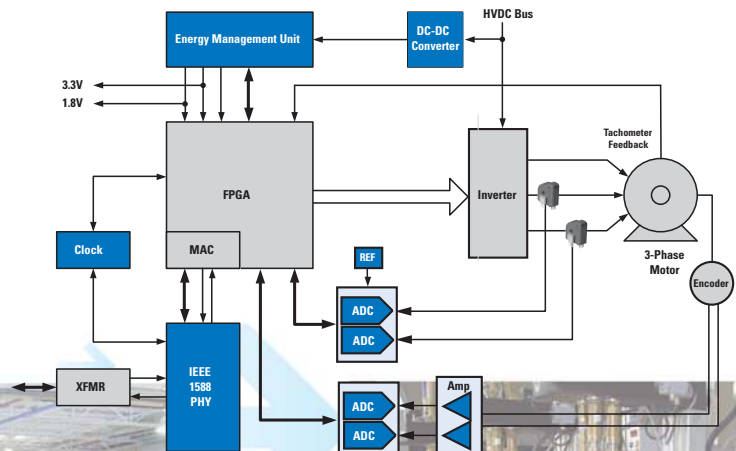
Data Converters

Clock and Timing Solutions

Interface Solutions

Thermal Management

Power Management



 **National**
Semiconductor

Industrial Solutions

national.com/industrial

National Semiconductor is a technology pioneer with a broad, low-power analog product portfolio of trusted, innovative solutions that offer added flexibility and easy design. National's highest-standard quality, reliable production, and world-class supply-chain management make National the clear choice in analog semiconductor products for a variety of industrial applications.

National's analog and power management products and subsystems deliver robust system performance with lower power consumption, diagnostics, precise timing control, and high-accuracy signal processing. The company's energy-efficient products and reference designs, address process sensing and measurement, motor control, automation control



networks, imaging and display, and machine vision applications. National's WEBENCH® Designer tools allow engineers to easily create designs that can be optimized for cost, efficiency, or size.

Automation Control Networks

National's precision PHYTER® 10/100 Ethernet PHY solutions provide high-bandwidth, low-latency networked solutions that enhance system reliability over temperature. The PHYTER transceiver with IEEE 1588 Precision Time Protocol (PTP) enables distributed control and provides high-precision timing synchronization.

Motor Control Sensing

National's precision amplifiers, data converters, temperature sensors, power management, and PHYTER transceivers enable higher-quality products at higher speeds via improved motor control, finer production control, and lower power consumption to reduce production costs. National solutions support high-performance simultaneous-sampling AC and servo motor control.

Industrial Imaging and Displays

National's products offer customers the capability to reduce component count and system size, decreasing development time and costs. National's industry-standard Channel Link products offer design flexibility to efficiently transfer higher-resolution images over longer cables in rugged environments such as security and surveillance, machine vision, display signage, and flat-panel display applications.

Machine Vision

The company's camera synchronization solutions enable distribution and synchronization of high-resolution video content, while the wide industrial-grade portfolio enables smart cameras, nano-heads, and processing nodes.

Sensing Applications

National's analog solutions support all key sensing applications.

Precision amplifiers and data converters provide accuracy and speed to enable better process control and more uniform products, less fallout, and quicker response times. The WEBENCH® Sensor Designer tool significantly reduces design time and cost by configuring a complete sensor signal path solution with just a few key strokes.



Powering Industrial Applications

National's broad family of voltage references and Low-Dropout (LDO) linear regulators drive sensitive analog and digital loads. Its regulators and controllers convert wide input voltage ranges down to low output voltages needed at the Point of Load (PoL), and in-rush current controllers offer an additional layer of protection in over-current or short circuit events. The SIMPLE SWITCHER® power modules deliver powerful system performance, low EMI, and high reliability for production facilities and factory floor machinery.

To see all of National's industrial solutions, **visit:**
national.com/industrial



Industrial Products

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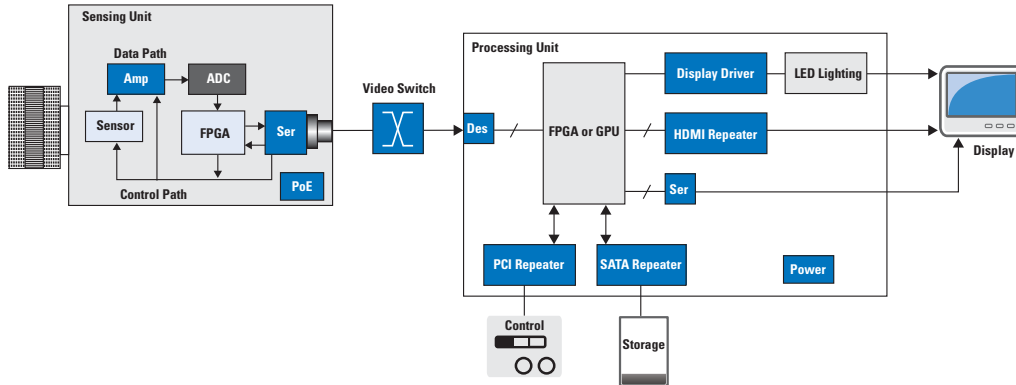
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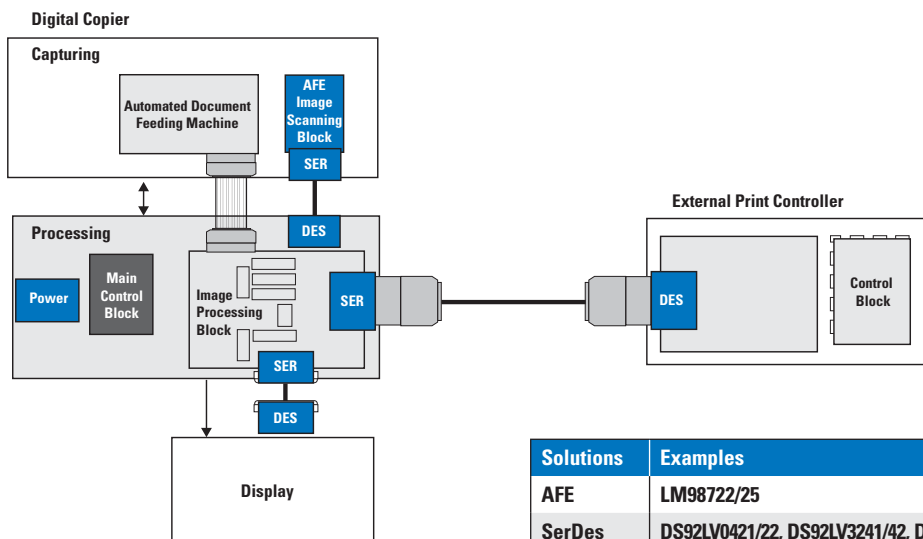
Imaging and Displays

Security/Factory Automation/Machine Vision



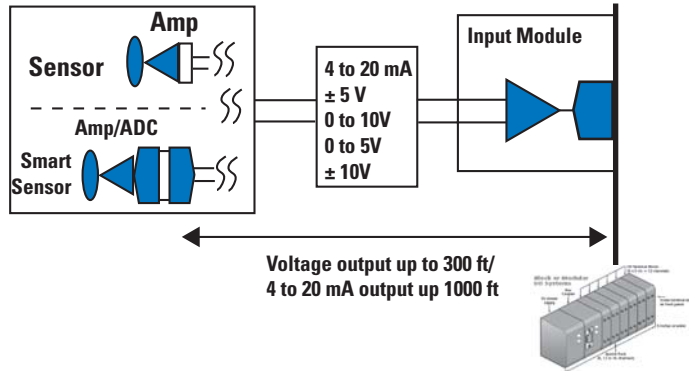
Solutions	Examples	Pages
Amplifier	LMV791	16
Crosspoint	LMH658x, DS25CP104A	27
SerDes	DS92LV2421/22, DS92LX1621/22, DS32ELX0421/0124	37
Power	LP5900, LMZ10505, LM5072/73	33, 45, 53
Ethernet	DP83640, DP83848	34, 35

Multifunction Printer

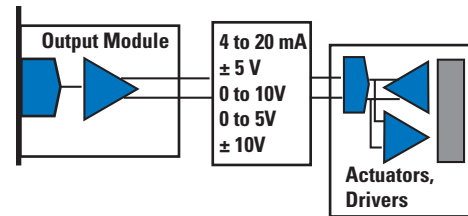


Solutions	Examples	Pages
AFE	LM98722/25	27
SerDes	DS92LV0421/22, DS92LV3241/42, DS92CR483A/84A	37
Power	LP38691-ADJ, LMZ12003	45, 53

Input to I/O Module



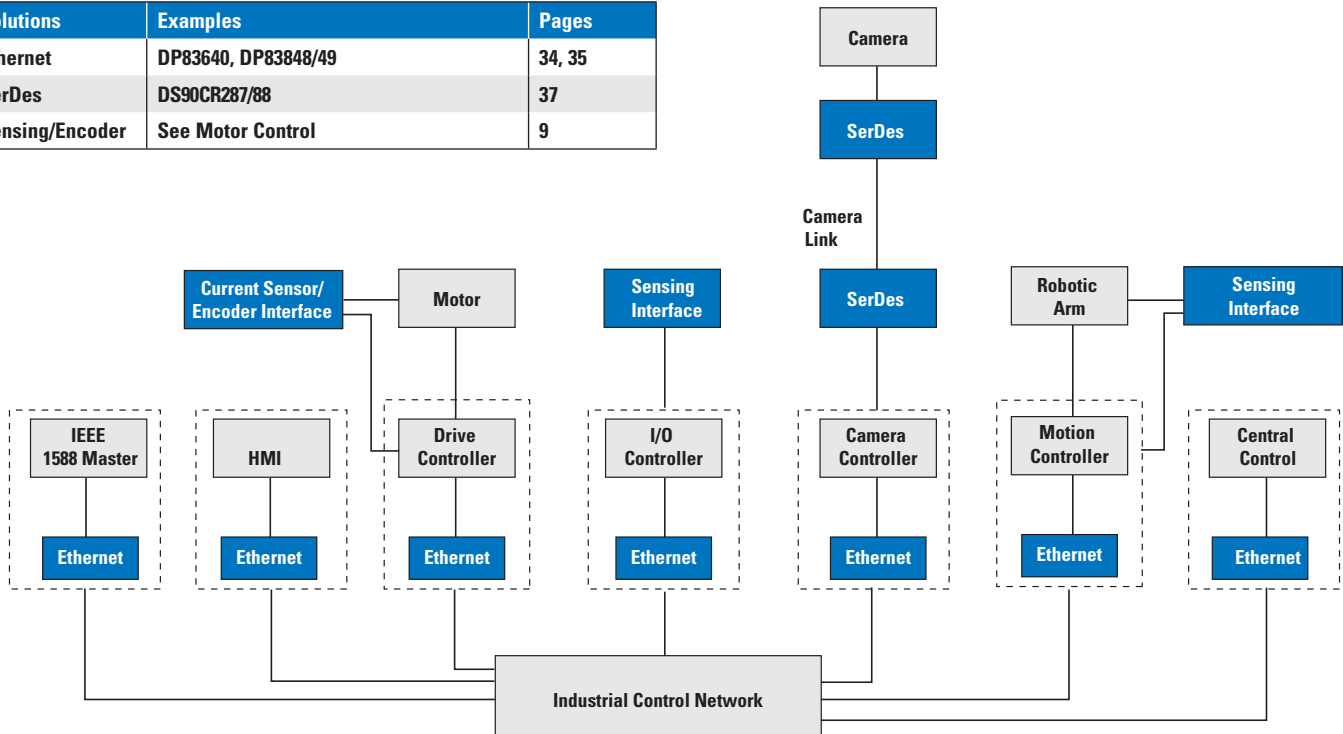
Output from I/O Module



Solutions	Examples	Pages
Amplifier	LMP7715/16, LMP7701, LMP2021, LMP7312	13, 14
ADC	ADC121S021, ADC128S052, ADC121S625, ADC141S626, ADC161S626	21, 22
DAC	DAC121S101, DAC122S085, DAC124S085	23
Power	LM5009A, LM5008A	47

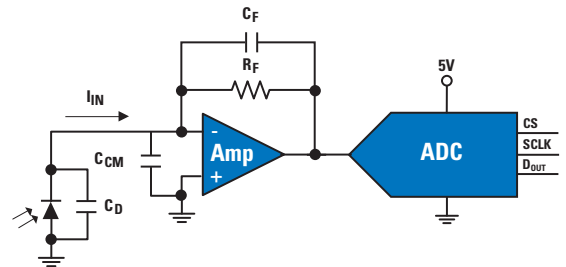
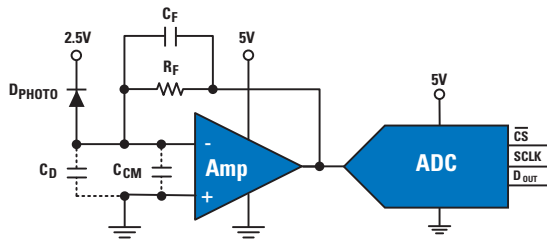
Industrial Control Networks

Solutions	Examples	Pages
Ethernet	DP83640, DP83848/49	34, 35
SerDes	DS90CR287/88	37
Sensing/Encoder	See Motor Control	9



Precision Sensing

Photoconductive/Photovoltaic



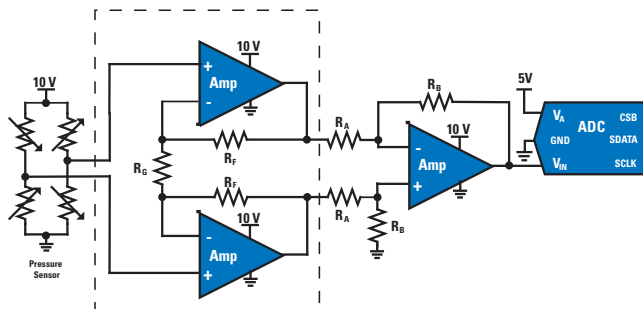
Photoconductive diode is biased, provides faster response

Photoconductive diode is biased, provides faster response

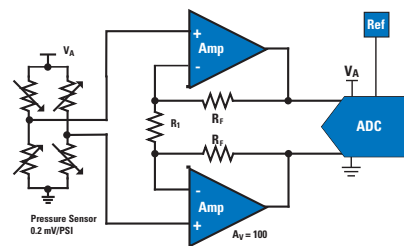
Solutions	Examples	Pages
Amplifier	LMP7701, LMV851, LMP7715, LMV841	14, 17, 19
ADC	ADC101Sxx1, ADC101C02x, ADC121Sxx1, ADC121C02x	21, 22
Power	LM284x, LM500x	47
Reference	LM4030, LM4132/40	54

Pressure, Load, Force

Instrumentation Amplifier Configuration



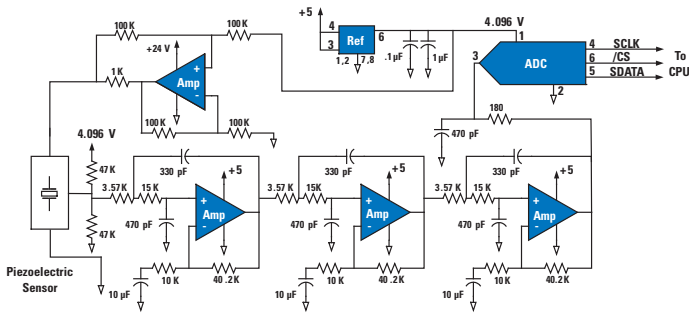
Differential Amplifier Configuration



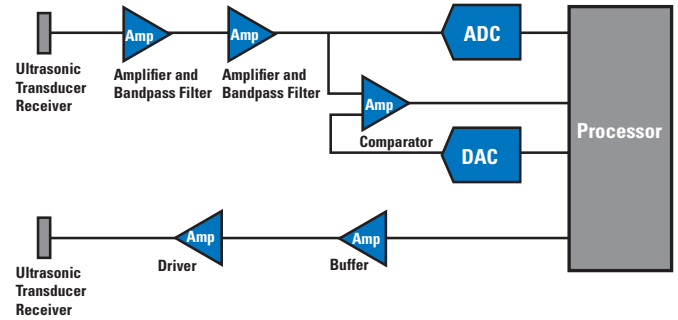
Solutions	Examples	Pages
Amplifier	LMP7715/16, LMP2231	14
In Amp	LMP8358	13
ADC	ADC101S021, ADC101C02x, ADC121S021, ADC121C02x	21, 22
Reference	LM4030, LM4132/40	54

Solutions	Examples	Pages
Amplifier	LMP7715/16, LMP2021/22	14
In Amp	LMP8358	13
ADC	ADC161S626, ADC141S626	22
Reference	LM4030, LM4132/40	54

Vibration



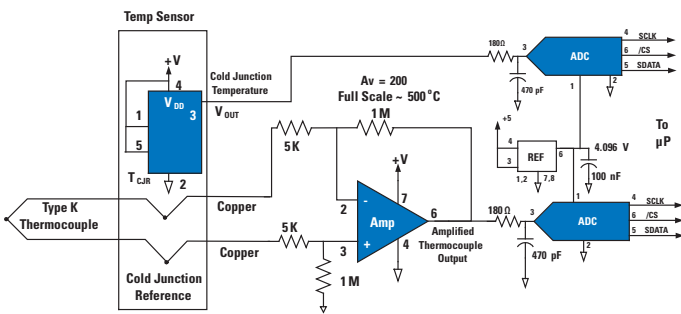
Ultrasonic Speed Sensing



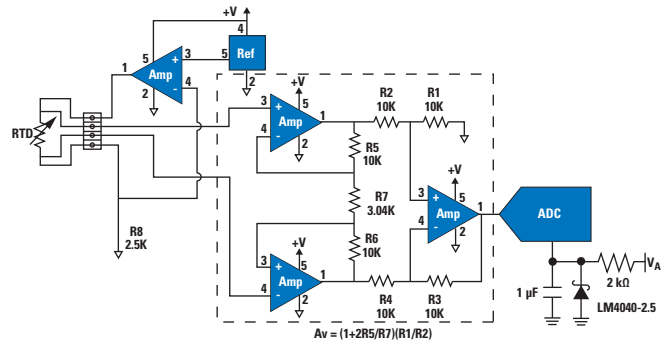
Solutions	Examples	Pages
Amplifier	LMP2021/22, LMP7731/32	14
ADC	ADC141S626, ADC161S626	22
Power	LM284x, LM500x	47
Voltage reference	LM4030, LM4132/40	54

Solutions	Examples	Pages
Amplifier	LMV771, LMV791	16, 18
ADC	ADC121S101	21
DAC	DAC121S101	23
Comparator	LMV7219	15
Power	LM284x, LM500x	47
Reference	LM4030, LM4132/40	54

Temperature-Thermocouple Interface



Temperature-RTD

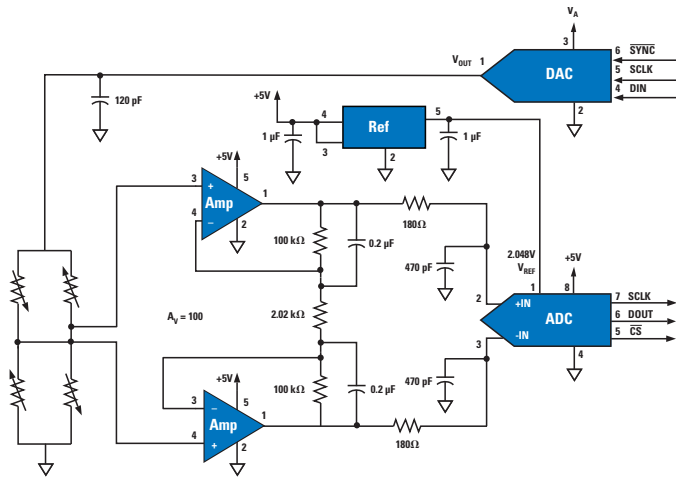


Solutions	Examples	Pages
Amplifier	LMP7701, LMP7715	16
ADC	ADC122S021, ADC121S021, ADC102S021, ADC121C02x	21, 22
Temp sensor	LM94022	28
Reference	LM4030, LM4132/40	54

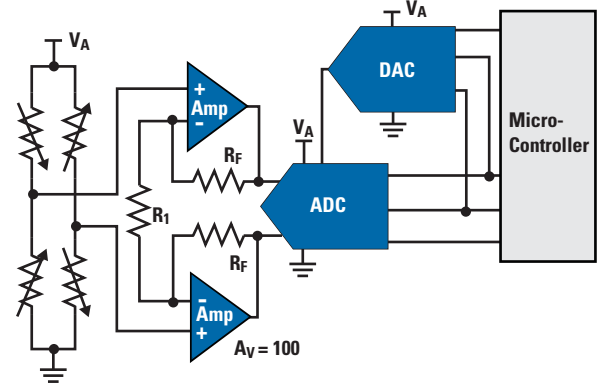
Solutions	Examples	Pages
Amplifier	LMP7704, LMP7716	14
In Amp	LMP8358	13
ADC	ADC121S021, ADC121C02x	21, 22
Reference	LM4030, LM4132/40	54
Power	LM284x, LM500x	47

Setting Control Points/Sensor Drive

Variable Sensor Voltage Drive (adjusts sensor output)



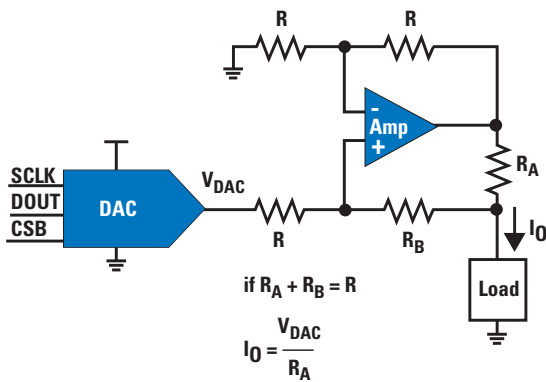
Adjustable ADC Reference (adjusts ADC range)



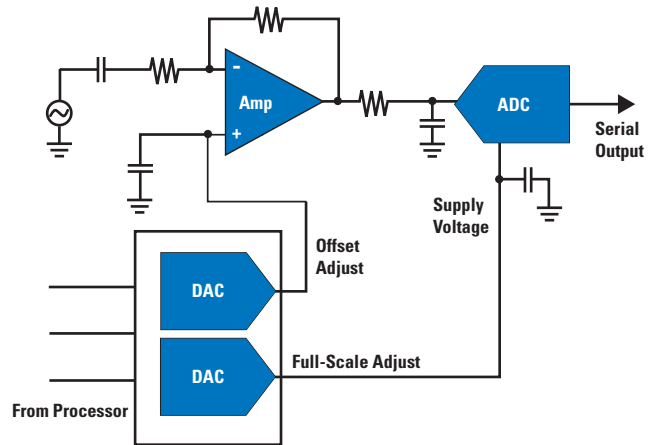
Solutions	Examples	Pages
Amplifier	LMP7701/02, LMP8358	13, 14
DAC	DAC101S101, DAC121S101	23
ADC	ADC121S625	22
Reference	LM4030, LM4132/40	54

Solutions	Example	Pages
Amplifier	LMP7701/02, LMP8358	13, 14
DAC	DAC101S101, DAC121S101	23
ADC	ADC121S625	22
Reference	LM4030, LM4132/40	54

Variable Current Source



Offset and Gain Calibration

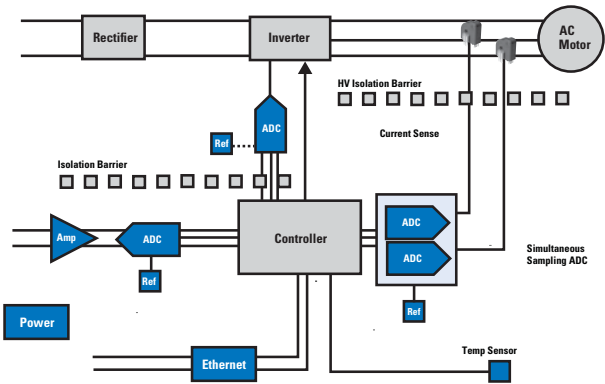


Solutions	Examples	Pages
Amplifier	LMP7711	14
DAC	DAC081S101, DAC101S101	23
Reference	LM4030, LM4132/40	54

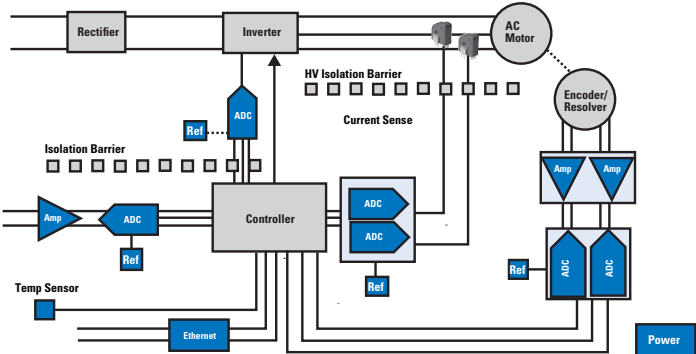
Solutions	Examples	Pages
Amplifier	LMP7701	14
ADC	ADC121S101	21
DAC	DAC122S085	23
Reference	LM4030, LM4132/40	54

Motor Control Sensing

AC Motor



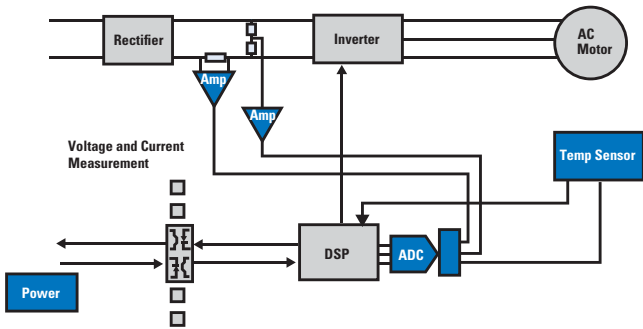
Servo Motor Control



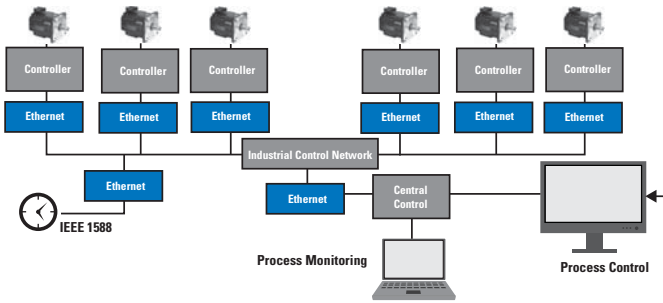
Solutions	Examples	Pages
Amplifier	LMP7712/31, LMP2015/16	14
ADC	ADC121S021/625, ADC161S626, ADC122Sxxx	21, 22
Reference	LM4030, LM4128/32	54
Ethernet	DP83640, DP83848/49	34, 35
Temp sensor	LM73	28
Power	LM2557X, LM557X, LM500x	46, 47

Solutions	Examples	Pages
Amplifier	LMP7702, LMP7731/32, LMP2015/16	14
ADC	ADC121S021, ADC121S625, ADC122Sxxx, ADC161S626	21, 22
Ethernet	DP83640, DP83848/49	34, 35
Reference	LM4030, LM4128/32	54
Power	LM2267x, LM557x, LM5009x	46, 47

Low-Side Motor Control



Multiple Motor Control Synchronization

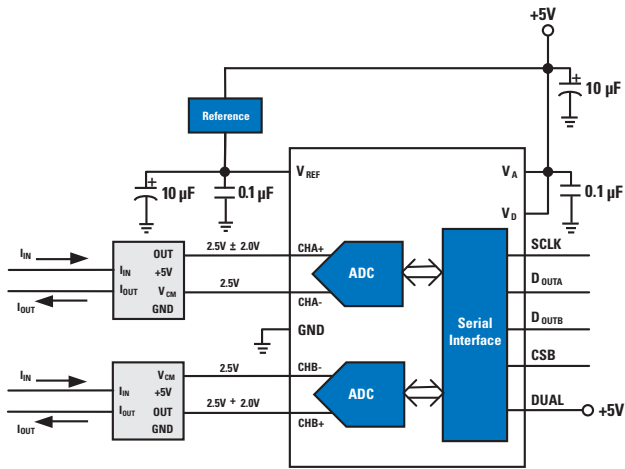


Solutions	Examples	Pages
Amplifier	LMP7707, LMP8601/02/03, LMP7711	17
ADC	ADC124Sxxx	21
Temp sensor	LM94022, LM73	28
Reference	LM4030, LM4132/40	54

Solutions	Examples	Pages
Ethernet	DP83640, DP83848/49I	34, 35

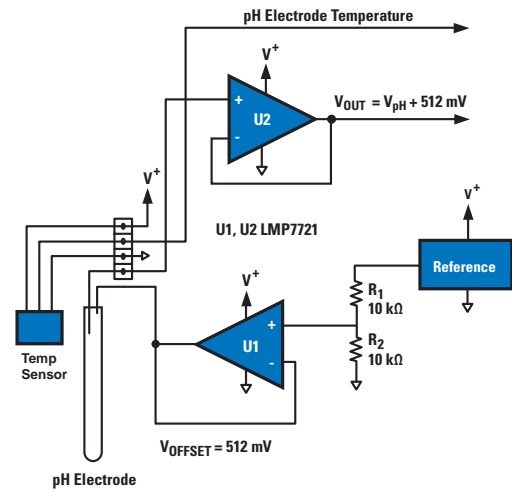
Sensing and System Health Monitoring

Current Sense



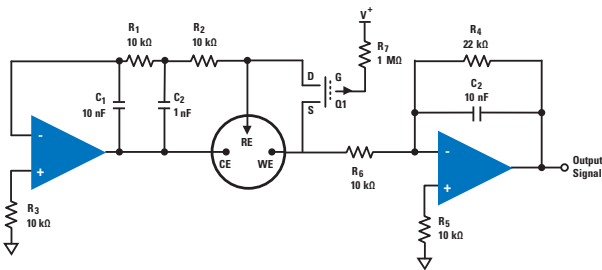
Solutions	Examples	Pages
ADC	ADC122S625, ADC122S655, ADC122S706	22
Reference	LM4030, LM4132/40	54

pH Sensor



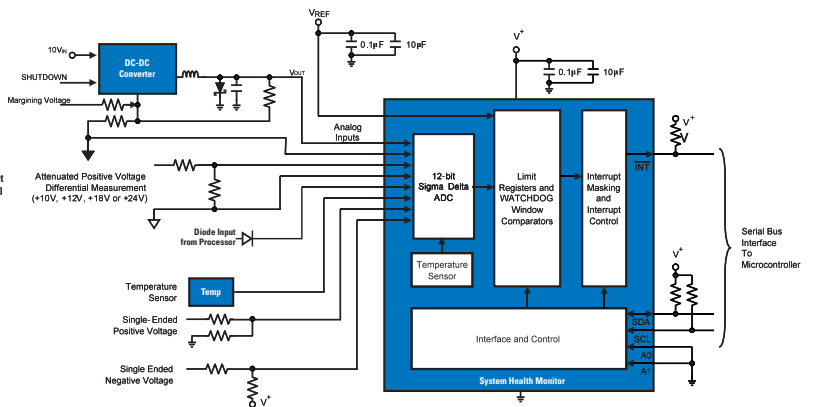
Solutions	Examples	Pages
ADC	ADC122S021	21
Amplifier	LMP7721	14
Reference	LM4030, LM4132/40	54
Temp Sensor	LM94022, LM57B/C	28, 29
Power	LP5990, LP38511-ADJ	52, 53

Chemical Sensor



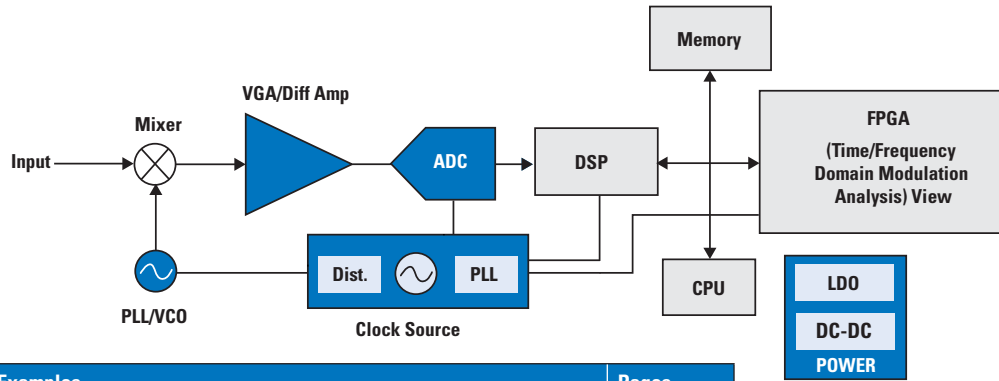
Solutions	Examples	Pages
ADC	ADC121S021	21
Amplifier	LMP7721	14
Power	LP5990, LP38511-ADJ	52, 53

System Health Monitor



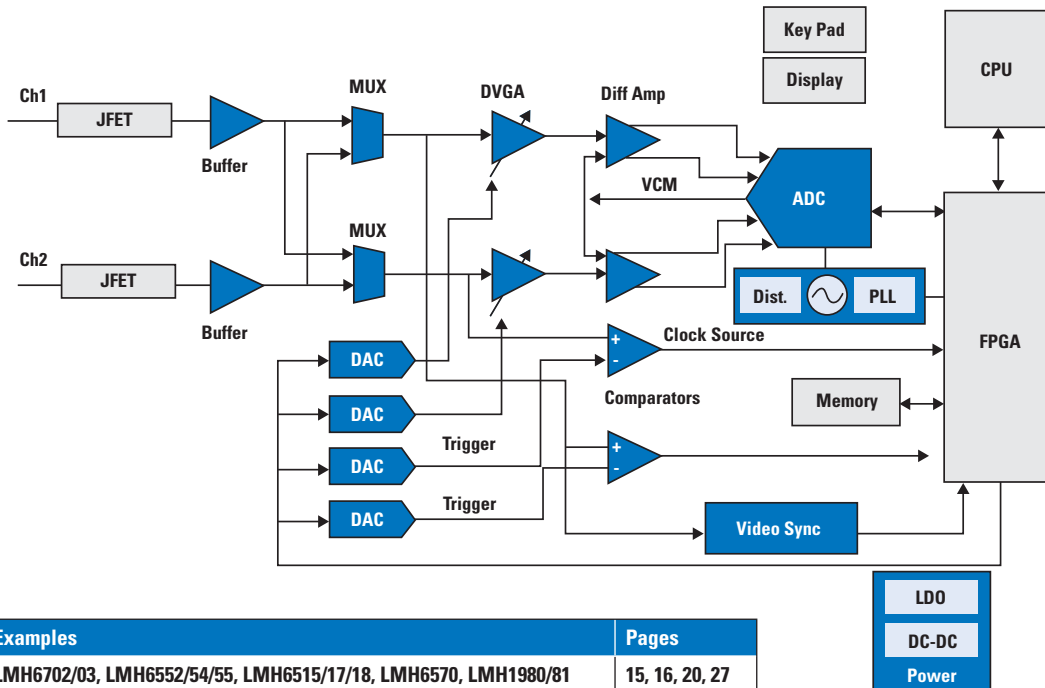
Solutions	Examples	Pages
ADC	ADC128D818	22
System Monitor	LM96080, LM96194, LM93	29

Spectrum Analyzer



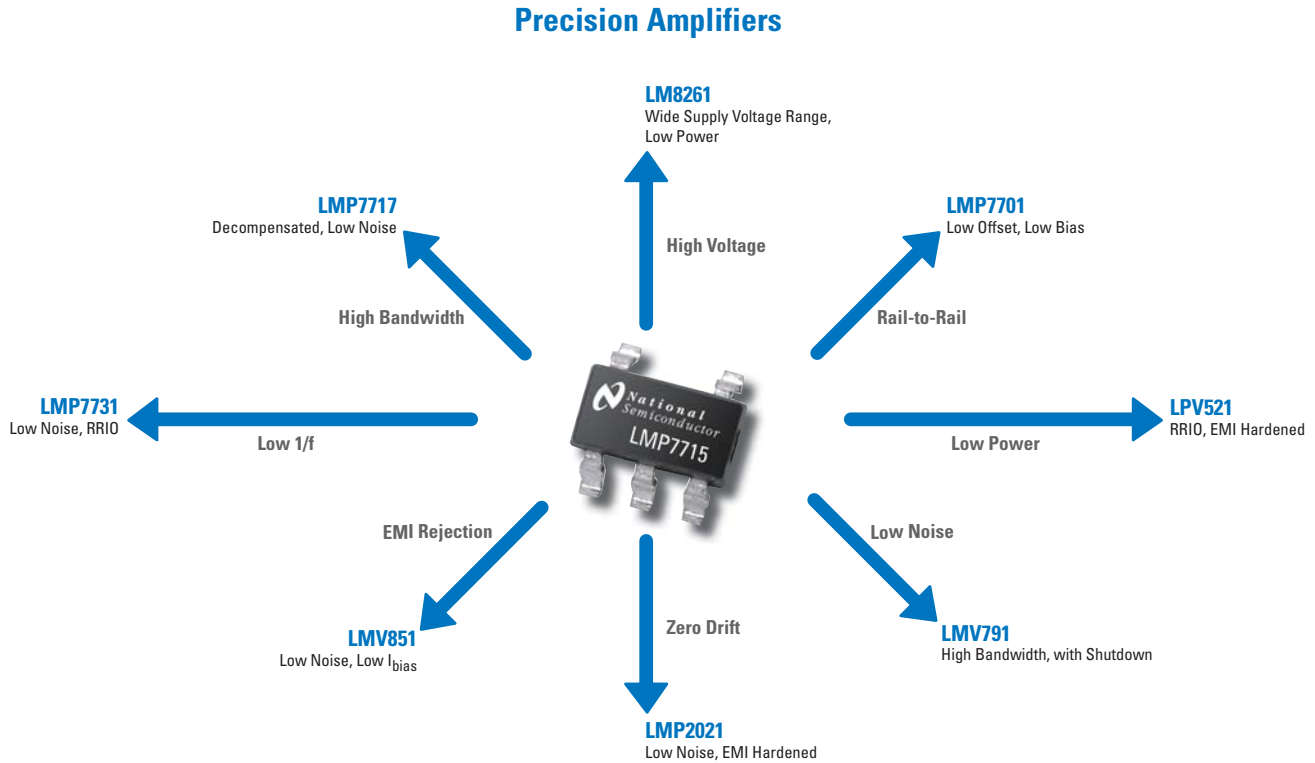
Solutions	Examples	Pages
Amplifier	LMH6505, LMH6515/17/18, LMH6552/54	15, 20
ADC	ADC10D1000/1500, ADC16V130, ADC16DV160, ADC12D1000/1600/1800	25, 26
Clock Source	LMX2531/41, LMK040xx, LMK010xx, LMK030xx	30, 32
Power	LMZ1200xEXT, LP3990, LP38511	45, 52, 53

Oscilloscope/Digitizer



Solutions	Examples	Pages
Amplifier	LMH6702/03, LMH6552/54/55, LMH6515/17/18, LMH6570, LMH1980/81	15, 16, 20, 27
Comparator	LMH7220, LMH7322/24	15
ADC	ADC12D1000/1600/1800, ADC10D1000/1500, ADC08D1000/A, ADC08D1500	25
DAC	DAC121S101	23
Power	LMZ1050xEXT, LM21305, LM2267x	45, 46, 48
Clock Source	LMX2531/41, LMK040xx, LMK010xx, LMK030xx	32

Operational Amplifiers



For many designs, National recommends the high-performance LMP7715 precision, CMOS-input amplifier for its balanced noise, bandwidth, and power performance. If a design requires a greater emphasis on other specifications such as low EMI, high voltage, or rail-to-rail, National offers a broad portfolio of precision amplifiers to meet your requirements.

Op Amps Optimization

Precision op amps address critical DC and AC parameters (e.g. low noise, low offset voltage, low input bias current, and other application dependent parameters). National optimizes these requirements for a wide variety of precision applications. The graphic above illustrates the various amplifier selections using the LMP7715 as a starting point. Many National op amps are tested at three temperatures to ensure consistent performance to specification.

Signal Path Solutions

National organizes its precision data converters into pin- and function-compatible families. Combined with pin-compatible amplifiers, customers may minimize the number of board layouts required to address application results in standardized PC board and testing.

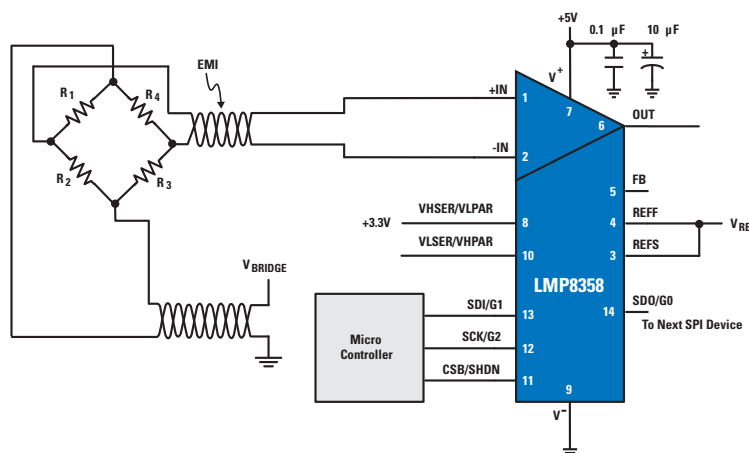
Operational Amplifiers

Instrumentation and Precision Level Shifter

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

Features

- $V_{OS} < 10 \mu\text{V}$, $\text{CMRR} > 125 \text{ dB}$
- 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 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 ($\mu\text{V}/^\circ\text{C}$)	CMRR (dB)	PSRR (dB)	Avol (dB)	Voltage Noise ($\text{nV}/\sqrt{\text{Hz}}$)	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

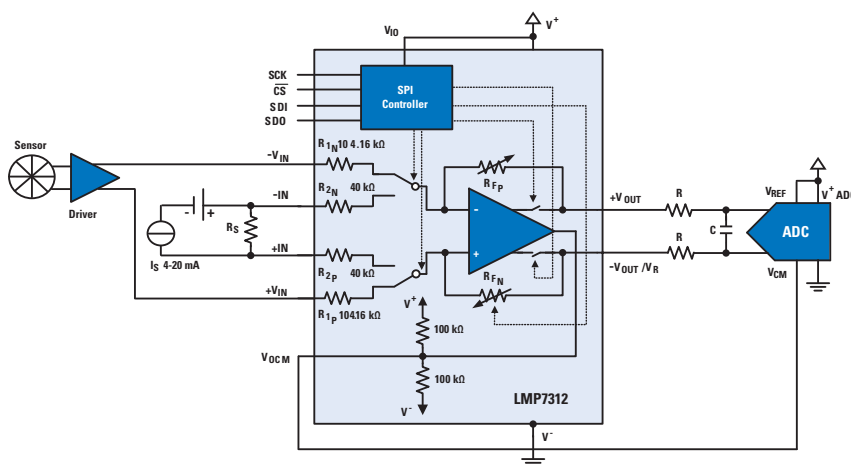
LMP7312 – Precision SPI-Programmable Analog Front End (AFE)

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

Application

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 ($\mu\text{V}/^\circ\text{C}$)	CMRR (dB)	PSRR (dB)	Avol (dB)	Voltage Noise ($\text{nV}/\sqrt{\text{Hz}}$)	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

Operational Amplifiers

Precision

Operational Amplifiers

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
LMP2015 ^W	0.005	0.015	130	120	130	35	1	0.003	0.93	2.7 to 5.0	SOT23-5, SOIC-8
LMP2016 ^W	0.005	0.015	130	120	130	35	2	0.003	0.93	2.7 to 5.0	SOIC-8 Narrow, mini SOIC-8
LMP2011 ^W	0.025	0.015	130	120	130	35	1	0.005	0.93	2.7 to 5.0	SOT23-5, SOIC-8 Narrow
LMP2021 ^W	0.005	0.02 (max)	139	130	160	11	1	0.1	1.1	2.2 to 5.5	SOIC-8, SOT23-5
LMP2022 ^W	0.005	0.02 (max)	139	130	160	11	2	0.1	1.1	2.2 to 5.5	SOIC-8 Narrow, mini SOIC-8
LMP2012 ^W	0.025	0.015	130	120	130	35	2	0.005	0.93	2.7 to 5.0	mini SOIC-8, SOIC-8
LMP2014 ^W	0.025	0.01	130	120	130	35	4	0.005	0.93	2.7 to 5.0	TSSOP-14
LMP7731/32 ^W	0.04	0.5	120	129	130	2.9	1/2	30	2.2	1.8 to 5.5	SOT-23, SOIC-8
LMP2231 ^{E, W}	0.15	0.3	97	120	120	60	1	0.001	0.016	1.6 to 5.5	SOIC-8, SOT23-5
LMP2232 ^{E, W}	0.15	0.3	97	120	120	60	2	0.003	0.014	1.6 to 5.5	SOIC-8, mini SOIC-8
LMP2234 ^{E, W}	0.15	0.3	97	120	120	60	4	0.001	0.009	1.8 to 5.0	TSSOP-14, SOIC-14
LMP7711 ^W	0.15	1.0	100	100	110	5.8	1	0.1	1.15	1.8 to 5.5	TSOT-6
LMP7712 ^W	0.15	1.75	100	100	95	5.8	2	0.1	1.3	1.8 to 5.5	mini SOIC-10
LMP7715 ^W	0.15	1.0	100	98	110	5.8	1	0.1	1.15	1.8 to 5.0	SOT23-5
LMP7716 ^W	0.15	1.8	100	98	110	5.8	2	0.1	1.3	1.8 to 5.0	mini SOIC-8
LMP7717 ^W	0.15	1.0	100	98	110	5.8	1	0.1	1.15	1.8 to 5.0	SOIC-8, SOT23-8
LMP7718 ^{E, W}	0.15	1.8	100	98	110	5.8	2	0.1	1.3	1.8 to 5.0	SOIC-8 Narrow, mini SOIC-8
LMP7721 ^{E, W}	0.15	1.5	100	96	120	6.5	1	0.00002	1.3	1.8 to 5.5	SOIC-8 Narrow, SOT23-5
LMP7701 ^W	0.2	1.0	130	100	119	9	1	0.05	0.715	2.7 to 12	SOIC-8 Narrow
LMP7707/08/09 ^W	0.2	1.0	138	98	119	9	1/2/4	0.05	0.715	2.7 to 12	SOT23-5, mini SOIC-8, TSSOP-14
LMP7702 ^W	0.22	1.0	130	100	119	9	2	0.4	0.75	2.7 to 12	SOIC-8 Narrow, mini SOIC-8
LMP7704 ^W	0.22	1.0	130	100	119	9	4	0.4	0.725	2.7 to 12	TSSOP-14
LMV771 ^{E, W}	0.85	0.35	90	90	100	12	1	0.1	0.6	2.7 to 5.0	SC70-5
LMC6062 ^W	0.8, 0.35	1.0	85	85	140	83	1	0.004, 0.1	0.016	4.5 to 15.5	SOIC-8 Narrow, MDIP-8

High-Speed Amplifiers (Offset Voltage ≤ 0.8 mV)

Product ID	Channels	Offset Voltage Max, 25°C (mV)	TcVos (µV/°C)	CMRR (dB)	PSRR (dB)	Voltage Noise (nV/√Hz)	-3 dB SSBW (MHz)	AVCL for -3 dB SSBW (V/V)	Slew Rate (V/µs)	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	5.0 to 12	SOIC-8, SOT23-5
LMH6626 ^{E, W}	2	0.5	0.2	95	88	1.0	160	10	360	5.0 to 12	SOIC-8
^{NEW} LMH6629 ^E	1	0.78	0.45	87	83	0.69	900	10	1600	2.7 to 5.5	LLP-8

^W PowerWise® product




^E Evaluation board

^W WEBENCH® enabled






Operational Amplifiers

High-Speed Variable Gain Amps and Comparators

High-Speed Variable Gain Amplifiers

Product ID	Gain Control	-3 dB 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	—	5.0 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	—	5.0 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	—	7.0 to 12	11	1	4.4	Single/single	HD2/HD3= -47/ -61 (2 V _{P-P} , 20 MHz)	SOIC-8 Narrow, mini-SOIC-8
LMH6514 ^E 	Digital	600	42	6.0	4.0 to 5.25	107	1	1.8	Diff/diff	OIP3= 40 dBm at 70 MHz	LLP-16
LMH6515	Digital	600	31	1.0	4.0 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	2.0/8.5m	4.75 to 5.25	210/150	1	0.98	Diff/diff	HD2/HD3=-50/-53 all gains, 100 MHz	LLP-16

High-Speed Comparators

Product ID	Channels	Response Time (μs)	Offset Voltage Max, 25°C (mV)	Supply Voltage Range (V)	Supply Current Per Channel (mA)	Input Bias Current (μA)	Output Compatibility	Temp Range (°C)	Packaging
LMV7219 	1	0.007	6.0	2.7 to 5.0	1.1	0.45	Push-pull	-40 to 85	SC70-5, SOT23-5
LMV7235/39 	1	0.045	6.0	2.7 to 5.0	0.065	0.03	Open drain/ Push-pull	-40 to 85	SC70-5, SOT23-5
LMH7220 	1	0.0029	2.7	2.7 to 12	7.5	1.5	LVDS	-40 to 125	TSOT-6
LMH7322 ^E 	2	0.0007	8.0	2.7 to 12	22.8	2.6	RS(P)ECL, LVDS	-40 to 125	LLP-24
LMH7324 ^E 	4	0.0007	9.5	5.0 to 12	17.2	2.6	RS(P)ECL, LVDS	-40 to 125	LLP-32

 PowerWise product

^E Evaluation board

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Operational Amplifiers

Low Noise

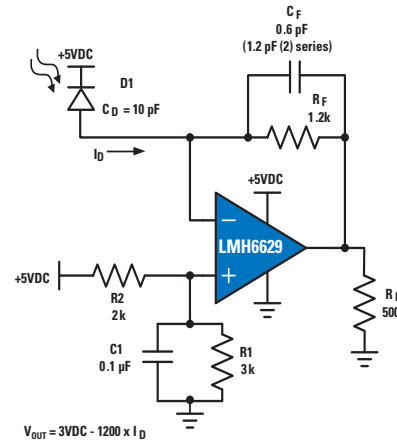
LMH6629 – 900 MHz, Gain Bandwidth, Ultra-Low Noise Amplifier

Features

- 0.69 nV $\sqrt{\text{Hz}}$ input noise voltage
- 780 μV offset voltage max at 25°C
- 1600 V/ μs slew rate
- -90/-94 dBc HD2/HD3 at 1.0 MHz
- ≥ 4 or ≥ 10 selectable minimum gain
- 15.5 mA typical supply current

Applications

Ideal for wideband applications with high gain and low noise such as test and measurement, optical, and ultrasound systems



High-Speed, Low-Noise Operational Amplifiers

Product ID	Voltage Noise (nV $\sqrt{\text{Hz}}$)	Offset Voltage Max, 25°C (mV)	Max Input Bias Current (nA)	Supply Current Per Channel (mA)	Channels	Gain Bandwidth (MHz)	Supply Range (V)	Temp Range (°C)	Packaging
LMH6629	0.69	0.78	23000	15.5	1	4000	2.7 to 5.5	-40 to 125	LLP-8
LMH6624 ^{E,W}	0.92	0.5	25000	12	1	1500	5.0 to 12	-40 to 125	SOIC-8, SOT23-5
LMH6626 ^{E,W}	1.0	0.5	25000	12	2	1300	5.0 to 12	-40 to 125	SOIC-8, mini SOIC-8
LMH6622 ^{E,W}	1.6	1.2	15000	4.3	2	160	5.0 to 12	-40 to 85	SOIC-8, mini SOIC-8
LMH6628 ^{E,W}	2.0	2.0	20000	9.0	2	300	5.0 to 12	-55 to 125	SOIC-8
LMH6702 ^{E,W}	1.83	4.5	34000	12.5	1	1700	10 to 12	-40 to 85	SOIC-8, SOT23-5
LMH6703	1.0	2.3	23000	7.0	11	1200	8.0 to 12	-40 to 85	SOIC-8, SOT23-5

PowerWise product

^E Evaluation board

^W WEBENCH[®] enabled

Low-Noise Operational Amplifiers

Product ID	Voltage Noise (nV $\sqrt{\text{Hz}}$)	Offset Voltage Max, 25°C (mV)	Max Input Bias Current (nA)	Supply Current Per Channel (mA)	Channels	Gain Bandwidth (MHz)	Supply Range (V)	Temp Range (°C)	Packaging
LMP7731/32 ^W	2.9	0.04	30	2.2	1/2	22	1.8 to 5.5	-40 to 125	SOT23-5, SOIC-8
LMP7717/18 ^{E,W}	5.8	0.15	0.05	1.15	1	88	1.8 to 5.5	-40 to 125	SOIC-8, SOT23-5
LMV793 ^W	5.8	1.35	0.025	1.15	1	88	1.8 to 5.5	-40 to 125	SOIC-8, SOT23-5
LMV794 ^E	5.8	1.35	0.025	1.3	2	88	1.8 to 5.5	-40 to 125	SOIC-8 Narrow, mini SOIC-8
LMP7711/12 ^W	5.8	0.15	0.05	1.15/1.3	1/2	17	1.8 to 5.5	-40 to 125	TSOT-6, mini SOIC-10
LMP7715/16 ^W	5.8	0.15	0.05	1.15/1.3	1	17	1.8 to 5.5	-40 to 125	SOT23-5, SOIC-8, mini SOIC-8
LMV791/92 ^W	5.8	1.35	0.025	1.15/1.3	1/2	17	1.8 to 5.5	-40 to 125	TSOT-6, mini SOIC-10
LMV796/97 ^W	5.8	1.35	0.025	1.15/1.3	1/2	17	1.8 to 5.5	-40 to 125	SOT23-5, mini SOIC-8
LM6211 ^W	6.0	2.5	0.01	0.96	1	17	5.0 to 24	-40 to 125	SOT23-5
LMV751 ^W	6.5	1.0	0.1	0.6	1	5	2.7 to 5.5	-40 to 85	SOT23-5
LMP7721 ^{E,W}	6.5	0.15	0.00002	1.3	1	15	1.8 to 5.5	-40 to 125	SOIC-8
LMP7701 ^W	9.0	0.2	0.05	0.715	1	2.5	2.7 to 12	-40 to 125	SOIC-8, SOT23-5
LMP7702/04 ^W	9.0	0.22	0.05	0.75/0.725	2/4	2.5	2.7 to 12	-40 to 125	SOIC-8, mini SOIC-8, TSSOP-14
LMP7707/08/09 ^W	9.0	0.2/0.22	0.05	0.715/0.75/0.725	1/2/4	14	2.7 to 12	-40 to 125	SOIC-8, SOT23-5, mini SOIC-8, TSSOP-14
LMV772 ^W	12	1.0	0.1	0.6	2	3.5	2.7 to 5.5	-40 to 125	SOIC-8, mini SOIC-8

Operational Amplifiers

Rail-to-Rail

Rail-to-Rail Operational Amplifiers

Product ID	Channels	Offset Voltage Max, 25°C (mV)	Max Input Bias Current (nA)	Supply Voltage Range (V)	Supply Current Per Channel (mA)	Gain Bandwidth (MHz)	Voltage Noise (nV/√Hz)	Output Swing High (mV)	Output Swing Low (mV)	Temp Range (°C)	Packaging
LMP7707 ^W	1	0.2	.05	2.7 to 12	0.715	14	9.0	110	80	-40 to 125	SOT-23
LMP7708 ^{E,W}	2	0.2	.05	2.7 to 12	0.715	14	9.0	120	120	-40 to 125	mini SOIC-8
LMP7709 ^W	4	0.2	.05	2.7 to 12	0.715	14	9.0	120	120	-40 to 125	TSSOP-14
LMH6618 ^{E,W}	1	0.6	2400	2.7 to 11	1.25	140	10	255	270	-40 to 125	TSOT-6
LMH6619 ^{E,W}	2	0.6	2400	2.7 to 11	1.25	140	10	255	275	-40 to 125	SOIC-8 Narrow
LM6152	2	5, 2	1500	2.7 to 24	1.4	75	9.0	-8.0	6.0	0 to 70	SOIC-8 Narrow
LM6154	4	5.0	1500	2.7 to 24	1.4	75	9.0	-8.0	6.0	0 to 70	SOIC-14 Narrow
LMH6645 ^E	1	3.0	4000	2.5 to 12	0.725	55	17	-30	20	-40 to 85	SOIC-8 Narrow, SOT23-5
LMH6646 ^E	2	3.0	4000	2.5 to 12	0.725	55	17	-30	20	-40 to 85	mini SOIC-8, SOIC-8 Narrow
LMH6647 ^{E,W}	1	3.0	4000	2.5 to 12	0.725	55	17	-30	20	-40 to 85	SOIC-8 Narrow, SOT23-6
LMP8601 ^E	1	1.0	7200	3.0 to 5.5	1.1	.060	890	4980	20	-40 to 125	SOIC-8 Narrow
LMP8602	1	1.0	7200	3.0 to 5.5	1.1	.060	890	4980	20	-40 to 125	SOIC-8, mini SOIC-8
LMP8603	1	1.0	7200	3.0 to 5.5	1.1	.060	890	4980	20	-40 to 125	SOIC-8, mini SOIC-8
LMP7731 ^W	1	0.04	30	1.8 to 5.5	2.2	22	2.9	50	50	-40 to 125	SOT23-5
LMP7732 ^W	2	0.04	30	1.8 to 5.5	2.2	22	2.9	50	50	-40 to 125	SOIC-8
LMP7701 ^W	1	0.2	0.001	2.7 to 12	0.715	2.5	9.0	110	80	-40 to 125	SOIC-8, SOT23-5
LMP7702 ^W	2	0.22	0.001	2.7 to 12	0.75	2.5	9.0	120	120	-40 to 125	SOIC-8, mini SOIC-8
LMP7704 ^W	4	0.22	0.001	2.7 to 12	0.725	2.5	9.0	120	120	-40 to 125	TSSOP-14
LMV841 ^E	1	0.5	0.01	2.7 to 12	1.02	4.5	20	100	120	-40 to 125	SC70-5
LMV842	2	0.5	0.01	2.7 to 12	1.02	4.5	20	100	120	-40 to 125	SOIC-8, mini SOIC-8
LMV844	4	0.5	0.01	2.7 to 12	1.02	4.5	20	100	120	-40 to 125	TSSOP-14
LMC6462	2	0.5	0.005	3.0 to 15.5	0.02	0.05	80	4980	20	-40 to 85	SOIC-8, MDIP-8
LMC6482	2	0.75	0.004	3.0 to 15.5	0.5	1.5	37	4700	240	-40 to 85	SOIC-8, MDIP-8
LPV511	1	3.0	1.9	2.7 to 12	0.00097	0.027	320	4890	200	-40 to 85	SC70-5
NEW LPV521 ^E	1	1.0	0.001	1.6 to 5.5	0.000351	0.0062	255	50	50	-40 to 125	SC-70
LMC7101 ^W	1	3.0	0.064	2.7 to 15.5	0.5	1.1	37	4700	200	-40 to 85	SOT23-5, SOIC-8
LMC6484	4	3.0	0.004	3.0 to 15	0.5	1.5	37	4980	20	-40 to 85	SOIC-14, MDIP-14
LMC6494	4	3.0	0.2	2.5 to 15.5	0.5	1.5	37	4980	20	-40 to 125	SOIC-14
LMC8101 ^W	1	5.0	0.064	2.7 to 10	0.7	1.0	36	4730	-4950	-40 to 85	mini SOIC-8, micro SMD-8
LM7301 ^E	1	6.0	250	2.2 to 30	0.6	4.0	36	4930	120	-40 to 85	SOIC-8, SOT23-5
LMC6492	2	6.0	0.2	2.5 to 15.5	0.5	1.5	37	4900	240	-40 to 125	SOIC-8

PowerWise product

^E Evaluation board

^W WEBENCH® enabled

Operational Amplifiers

Micropower and Low Voltage

Micropower/Low-Power Operational Amplifiers

Product ID	Channels	Supply Current Per Channel (mA)	Gain Bandwidth (MHz)	Offset Voltage Max, 25°C (mV)	Voltage Noise (nV/√Hz)	Output Current (mA)	Packaging
NEW LPV521 ^E	1	0.000351	0.0062	1.0	255	23	SC-70
LMC6442	2	0.00095	0.01	3.0	170	0.9	SOIC-8, MDIP-8
LPV511 ^W	1	0.00097	0.027	3.0	320	0.5	SC-70
LPV358	2	0.007	0.152	7.0	146	17	SOIC-8, mini SOIC-8
LPV324	4	0.0075	0.152	7.0	146	17	SOIC-14 Narrow, TSSOP-14
LMP2234 ^W	4	0.009	0.13	0.15	60	22	SOIC-14, TSSOP-14
LPV321 ^W	1	0.009	0.152	7.0	146	17	SOT-23
LM4250	1	0.01	0.25	6.0	40	12	SOIC-8, MDIP-8, TO99-8
LMC6042	2	0.01	0.1	3.0	83	21	SOIC-8, MDIP-8
LMC6044	4	0.01	0.1	6.0	83	21	SOIC-15, MDIP-14
LMC6041	1	0.014	0.075	6.0	83	21	SOIC-8, MDIP-8
LMP2232 ^W	2	0.014	0.13	0.15	60	22	SOIC-8, mini SOIC-8
LMP2231 ^W	1	0.016	0.13	0.15	60	22	SOIC-8, SOT23-5
LMC6062 ^W	2	0.019	0.1	0.8, .35	83	21	SOIC-8, MDIP-8
LMC6064 ^W	4	0.019	0.1	0.8, .35	83	21	SOIC-14, MDIP-14
LMC6061	1	0.024	0.1	0.8, .35	83	21	SOIC-8, MDIP-8
LMC7111	1	0.025	0.05	7.0	110	7	SOT23-5
LMV551/52/54 ^W	1/2/4	0.037	3.0	3.0	70	10	SC70-5, SOIC-8, TSSOP-14
LMV651 ^W	1	0.11	12	1.5	17	15	SC70-5
LMV641 ^E	1	0.158	10	0.5	14	26	SOIC-8, SC70-5
LMV851/52/54 ^{E,W}	1/2/4	0.41	8.0	1.0	0.5	30	SC70-5, SOIC-8, TSSOP-14
LPV531	1	0.425	4.6	4.5	25	15	TSOT-6
LMV771/72/74	1/2/4	0.6	3.5	1.0	12	66	SC70-5, SOIC-8, mini SOIC-8, TSSOP-14
LMC6061/62/64	1/2/4	0.02/.016	0.1	0.35	83	21	SOIC-8, MDIP-8/14, CERDIP-8

Low-Voltage Operational Amplifiers

Product ID	Channels	Supply Voltage Range (V)	Offset Voltage Max, 25°C (mV)	Supply Current Per Channel (mA)	Gain Bandwidth (MHz)	Voltage Noise (nV/√Hz)	Shutdown	Temp Range (°C)	Packaging
LM6142 ^W	2	1.8 to 24	1.0	0.65	17	16	—	-40 to 85	SOIC-8, MDIP-8
LM6144 ^W	4	1.8 to 24	2.5	0.65	17	16	—	-40 to 85	SOIC-14, MDIP-14
LMV951	1	0.9 to 3.0	2.8	0.57	2.8	25	✓	-40 to 125	TSOT-6
LMP7716 ^W	2	1.8 to 5.0	0.15	1.3	17	5.8	—	-40 to 125	mini SOIC-8
LMP7717 ^W	1	1.8 to 5.0	0.15	1.15	88	5.8	—	-40 to 125	SOIC-8, SOT23-5
LMV791 ^W	1	1.8 to 5.0	1.35	1.15	17	5.8	✓	-40 to 125	TSOT-6
LMV792 ^W	2	1.8 to 5.0	1.35	1.3	17	5.8	✓	-40 to 125	mini SOIC-10
LMV793 ^W	1	1.8 to 5.0	1.35	1.15	88	5.8	—	-40 to 125	SOIC-8, SOT23-5
LMV794 ^W	2	1.8 to 5.0	1.35	1.15	88	5.8	—	-40 to 125	SOIC-8, mini SOIC-8
LMV796 ^W	1	1.8 to 5.0	1.35	1.15	17	5.8	—	-40 to 125	SOT23-5
LMV797	2	1.8 to 5.0	1.35	1.3	17	5.8	—	-40 to 125	mini SOIC-8
LMP7711/12 ^W	1/2	1.8 to 5.5	0.15	1.15/1.3	17	5.8	✓	-40 to 125	TSOT-6
LM7301 ^{E,W}	1	2.2 to 30	6.0	0.6	4.0	36	—	-40 to 85	SOIC-8, SOT23-5
LMP2231 ^W	1	1.6 to 5.5	0.15	0.016	0.13	60	—	-40 to 125	SOIC-8, SOT23-5
LMP7721 ^{EW}	1	1.8 to 5.5	0.15	1.3	17	6.5	—	-40 to 125	SOIC-8 Narrow

PowerWise product

^E Evaluation board

^W WEBENCH® enabled

Operational Amplifiers

Low Power and Current Sense

Operational Amplifiers

Product ID	Channels	Supply Current Per Channel (mA)	Gain Bandwidth (MHz)	Offset Voltage Max, 25°C (mV)	Max Input Bias Current (nA)	Voltage Noise (nV/√Hz)	Supply Voltage Range (V)	Temp Range (°C)	Packaging
LM4250	1	0.01	0.25	6.0	20	40	2.0 to 36	0 to 70	SOIC-8, MDIP-8, T099-8
LM346	4	0.035	1.2	6.0	250	28	3.0 to 36	0 to 70	SOIC-16, MDIP-16
LMC6572/74	2/4	0.038	0.22	3.0/7.0	0.01	45	2.7 to 10	-40 to 85	SOIC-8, SOIC-14
LPC660	4	0.04	0.35	3.0	0.004	42	5.0 to 15	-40 to 85	SOIC-14
LMV651 ^E	1	0.11	12	1.5	100	17	2.7 to 5.5	-40 to 125	SC70-5
LMV652 ^E	2	0.11	12	1.5	100	17	2.7 to 5.5	-40 to 125	SOIC-8
LMV981 ^E	1	0.116	1.5	4.0	50	50	1.8 to 5	-40 to 125	micro SMD-6, SC70-5, SOT23-5
LMV654 ^E	4	0.119	12	1.8	300	17	2.7 to 5.5	-40 to 125	TSSOP-14
LMV641 ^E	1	0.158	10	0.5	105	14	2.7 to 12	-40 to 125	SOIC-8, SC70-5
LF442	2	0.2	1.0	5.0	3	35	6.0 to 36	0 to 70	T099-8, MDIP-8
LM10	1	0.3	0.09	4.0	40	50	1.1 to 45	0 to 70	SOIC-14, MDIP-8, T05-8
LM6132/34 ^{E, W}	2/4	0.36	10	6.0/2.0	350/300	27	2.7 to 24	-40 to 85	SOIC-8, MDIP-8, SOIC-14, MDIP-14
LMV851 ^E	1	0.41	8.0	1.0	0.5	11	2.7 to 5.0	-40 to 125	SC70-5
LMV852 ^E	2	0.41	8.0	1.0	0.5	11	2.7 to 5.0	-40 to 125	SOIC-8
LMV854 ^E	4	0.41	8.0	1.0	0.5	11	2.7 to 5.0	-40 to 125	TSSOP-14
LPV531	1	0.425	4.6	4.5	0.01	25	2.7 to 5.0	-40 to 85	TSOT-6
LMC6001 ^W	1	0.45	1.3	0.35	0.002	22	4.5 to 15.5	-40 to 85	MDIP-8
LMV951	1	0.57	2.8	2.8	85	25	0.9 to 3.0	-40 to 125	TSOT-6
LM7301	1	0.6	4.0	6.0	250	36	2.2 to 30	-40 to 85	SOIC-8, SOT23-5
LMV771 ^E	1	0.6	3.5	0.85	0.1	12	2.7 to 5.0	-40 to 125	SC70-5
LMV772	2	0.6	3.5	1.0	0.1	12	2.7 to 5.0	-40 to 125	SOIC-8, mini SOIC-8
LMV774	4	0.6	3.5	1.0	0.1	12	2.7 to 5.0	-40 to 125	TSSOP-14
LM6142 ^{E, W}	2	0.65	17	1.0	526	16	1.8 to 24	-55 to 125	SOIC-8, MDIP-8
LM6144 ^{E, W}	4	0.65	17	2.5	526	16	1.8 to 24	-40 to 85	SOIC-14, MDIP-14
LMP7704	4	0.725	2.5	0.22	0.001	9.0	2.7 to 12	-40 to 125	TSSOP-14
LMP7702	2	0.75	2.5	0.22	0.001	9.0	2.7 to 12	-40 to 125	SOIC-8, MSOP-8
LM6152	2	1.4	75	5.0, 2.0	1500	9.0	2.7 to 24	0 to 70	SOIC-8 Narrow
LM6154	4	1.4	75	5.0	1500	9.0	2.7 to 24	0 to 70	SOIC-14 Narrow
LMH6645 ^E	1	0.725	55	3.0	4000	17	2.5 to 12	-40 to 85	SOIC-8 Narrow, SOT23-5
LMH6646 ^E	2	0.725	55	3.0	4000	17	2.5 to 12	-40 to 85	SOIC-8 Narrow, mini SOIC-8
LMH6647 ^E	1	0.725	55	3.0	4000	17	2.5 to 12	-40 to 85	SOIC-8 Narrow, SOT23-6
LM8261 ^E	1	0.97	21	5.0	2700	15	2.5 to 30	-40 to 85	SOT23-5
LM6588	4	0.8	15.4	4.0	7000	23	5.0 to 16	-40 to 85	SOIC-14 Narrow, TSSOP-14
LM6584	4	0.78	15.4	4.0	7000	23	5.0 to 13	-40 to 85	SOIC-14 Narrow, TSSOP-14

PowerWise product

^EEvaluation board

^WWEBENCH[®] Enabled


Current-Sense Amplifiers

Product ID	Description	V _{cm} Range (V)	V _{os} (mV) (max)	Max TcV _{os} (μV/°C)	Gain Output (V/V)	Supply Voltage Range (V)	Supply Current (mA)	PSRR (dB)	Packaging
LMP8601	High common-mode, AV = 20, bidirectional	-22 to 60 (5V supply)	1.0	10	20	3.0 to 5.5	1.1	90	SOIC-8 Narrow
LMP8602	High common-mode, AV = 50, bidirectional	-22 to 60 (5V supply)	1.0	10	50	3.0 to 5.5	1.1	90	SOIC-8, mini SOIC-8
LMP8603	High common-mode, AV = 100, bidirectional	-22 to 60 (5V supply)	1.0	10	100	3.0 to 5.5	1.1	90	SOIC-8, mini SOIC-8
LMP8645	Variable gain	-2 to 76	1.0	7.0	1 to 100	2.7 to 12	0.61	90	TSOT-6







Operational Amplifiers


High Speed and High Voltage

High-Voltage Operational Amplifiers

Product ID	Channels	Supply Voltage Range (V)	Supply Current Per Channel (mA)	Gain Bandwidth (MHz)	Slew Rate (V/ μ s)	Offset Voltage Max, 25°C (mV)	Voltage Noise (nV/ \sqrt Hz)	Output Current (mA)	Temp Range (°C)	Packaging
LM6144 ^W	4	1.8 to 24	0.65	17	25	1.0	16	8.0	-40 to 85	SOIC-14
LM6142 ^W	2	1.8 to 24	0.65	17	25	2.5	16	8.0	-40 to 85	SOIC-8, MDIP-8, MDIP-14
LM833	2	10 to 36	2.5	15	7.0	5.0	4.5	40	-40 to 85	SOIC-8, MDIP-8, MSOP-8
LM4250	1	2.0 to 36	0.01	0.25	0.2	6.0	40	12	0 to 70	TO99-8, SOIC-8, MDIP-8
LM7301 ^{E, W}	1	2.2 to 30	0.6	4.0	1.25	6.0	36	9.5	-40 to 85	SOIC-8, SOT23-5
LM8272 ^{E, W}	2	2.5 to 24	0.9	13	12	5.0	15	100	-40 to 85	mini SOIC-8
LM8262 ^{E, W}	2	2.5 to 30	1.05	21	12	7.0	15	60	-40 to 85	mini SOIC-8
LM8261 ^{E, W}	1	2.5 to 30	0.97	21	12	5.0	15	53	-40 to 85	SOT23-5
LMC7101 ^W	1	2.7 to 15.5	0.5	1.1	1.1	7.0	37	24	-40 to 85	SOT23-5, SOIC-8
LM6154 ^W	4	2.7 to 24	1.4	75	30	5.0	9.0	6.2	0 to 70	SOIC-14
LM6152 ^W	2	2.7 to 24	1.4	75	30	2.0	9.0	6.2	0 to 70	SOIC-8
LM6134 ^W	4	2.7 to 24	0.36	10	14	2.0	27	4.3	-40 to 85	SOIC-14, MDIP-14
LM6132 ^W	2	2.7 to 24	0.36	10	14	6.0	27	4.3	-40 to 85	SOIC-8, MDIP-8
LM7121 ^{E, W}	1	4.5 to 33	4.8	175	1300	8.0	17	52	-40 to 85	SOIC-8, SOT23-5
LM6211 ^W 	1	5.0 to 24	0.96	17	5.5	2.5	6.0	16	-40 to 125	SOT23-5
LM6171 ^E	1	5.5 to 34	2.5	100	3600	3.0	12	135	-40 to 85	SOIC-8, MDIP-8
LM6172 ^E	2	5.5 to 36	2.3	100	3000	3.0	12	85	-40 to 85	SOIC-8, MDIP-8
LF444	4	6.0 to 36	0.15	1.0	1.0	1.0	35	8.0	0 to 70	SOIC-14, MDIP-14
LF442	2	6.0 to 44	0.15	1.0	1.0	1.0	35	6.8	-55 to 125	TO99-8, MDIP-8
LM6181 ^E	1	7.0 to 32	7.5	100	1400	5.0	4.0	130	-40 to 85	SOIC-8, SOIC-16, MDIP-8
LMC6462 ^W	2	3.0 to 15.5	0.02	0.05	0.015	0.5, 3.0	80	27	-55 to 125	SOIC-8, MDIP-8
LMC6464 ^W	4	3.0 to 15.5	0.02	0.05	0.015/0.028	0.5, 3.0	80	27	-55 to 125	SOIC-14, MDIP-14
LMC6482 ^W	2	3.0 to 15.5	0.5	1.5	1.3	0.75, 3.0	37	30	-55 to 125	SOIC-8, MDIP-8, mini SOIC-8
LMC6484 ^W	4	3.0 to 15.5	0.5	1.5	1.3	3.0	37	30	-55 to 125	SOIC-14, MDIP-14, mini SOIC-14
LMC6061 ^W	1	4.5 to 15.5	0.0016, .02	0.1	0.035	0.8, 0.35	83	21	40 to 85	SOIC-8, MDIP-8
LMC6062 ^W	2	4.5 to 15.5	0.0016, .02	0.1	0.035	0.8, 0.35	83	21	40 to 85	SOIC-8, MDIP-8
LMC6064 ^W	4	4.5 to 15.5	0.0016, .02	0.1	0.035	0.8, 0.35	83	21	40 to 85	SOIC-14, MDIP-14
LMC660	4	4.75 to 15.5	0.38	1.4	1.1	6.0, 3.0	22	21	-40 to 85	SOIC-14 Narrow, MDIP-14
LMC662	2	4.75 to 15.5	0.38	1.4	1.1	6.0, 3.0	22	21	-40 to 85	SOIC-14 Narrow, MDIP-14

High-Speed Fully Differential 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 Hz)	2nd/3rd HD (dBc)	Packaging
LMH6550 ^E 	400 at 1	3000	5.0 to 12	20	1	6.0	-92/-103 at $V_0 = 2 V_{PP}$, $f = 5$ MHz, $R_L = 800\Omega$	SOIC-8, mini SOIC-8
LMH6551 ^E 	370 at 1	2400	3.0 to 12	12.5	1	6.0	-94/-96 at $V_0 = 2 V_{PP}$, $f = 5$ MHz, $R_L = 800\Omega$	SOIC-8, mini SOIC-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, $R_L = 800\Omega$	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, $R_L = 800\Omega$	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, $R_L = 200\Omega$	FCOL-14
LMH6555 ^E 	1200 at 13.6 dB	1300	3.0 to 3.6	120	1	19	-60/-67 at $V_{OUT} = 0.8 V_{PP}$, $f = 250$ MHz, $R_L = 100\Omega$	LLP-16

 PowerWise product

^E Evaluation board

^W WEBENCH® Enabled

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
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
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
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 105	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

^W PowerWise product

^E Evaluation board

^W WEBENCH® enabled

A/D Converters

SPI and I²C Interface

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

Product ID	Res (bits)	Inputs	Pin and Function Compatible	Speed Range (kSPS)	Supply Voltage Range (V)	Typ Power (mW)		INL (LSB)	Temp Range (°C)	Multi Address	Alarm	Packaging
						3V	5V					
ADC081C021 ^{EW}	8	1	↕	5.5 to 189	2.7 to 5.5	0.26	0.78	±0.2	-40 to 105	✓	✓	TSOT-6, mini SOIC-8
ADC101C021 ^{EW}	10	1		5.5 to 189	2.7 to 5.5	0.26	0.78	±0.5	-40 to 105	✓	✓	TSOT-6, mini SOIC-8
ADC121C021 ^{EW}	12	1		5.56 to 189	2.7 to 5.5	0.26	0.78	±0.5	-40 to 105	✓	✓	TSOT-6, mini SOIC-8
ADC081C027 ^{EW}	8	1		5.5 to 189	2.7 to 5.5	0.26	0.78	±0.5	-40 to 105	✓	—	TSOT-6
ADC101C027 ^{EW}	10	1		5.5 to 189	2.7 to 5.5	0.26	0.78	±0.5	-40 to 105	✓	—	TSOT-6
ADC121C027 ^{EW}	12	1		5.56 to 189	2.7 to 5.5	0.26	0.78	±0.5	-40 to 105	✓	—	TSOT-6
NEW ADC128D818	12	8	—	100 sps*	2.7 to 5.5	0.9	2.0	±1.0	-40 to 125	✓	✓	TSSOP-16

*Note: All channels active

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)		ENOB (bits) typ	Temp Range (°C)	Packaging
						3V	5V	INL (LSB)	DNL (LSB)			
ADC121S625 ^{EW}	12	1	↕	50 to 200	4.5 to 5.5	—	2.25	-0.5 / -0.3	±0.4	11.8	-40 to 85	mini SOIC-8
ADC121S655 ^{EW}	12	1		200 to 500	4.5 to 5.5	—	9	±0.6	±0.4	11.7	-40 to 105	mini SOIC-8
ADC121S705 ^{EW}	12	1		500 to 1000	4.5 to 5.5	—	11.5	±0.6	±0.4	11.7	-40 to 105	mini SOIC-8
ADC122S625 ^{EW}	12	2	↕	50 to 200	4.5 to 5.5	—	—	±1.0	±0.95	11.25	-40 to 105	mini SOIC-10
ADC122S655 ^{EW}	12	2		200 to 500	4.5 to 5.5	—	25	±1.0	±0.95	11.25	-40 to 105	mini SOIC-10
ADC122S706 ^{EW}	12	2	—	500 to 1000	4.5 to 5.5	20	25	±1	±0.95	11.25	-40 to 105	TSSOP-14
ADC141S626 ^{EW}	14	1	↕	50 to 250	2.7 to 5.5	2	4.8	±0.5	±0.5	13.7	-40 to 85	mini SOIC-10
ADC161S626 ^{EW}	16	1		50 to 250	4.5 to 5.5	—	5.8	±0.8	±0.5 / ±0.8	14.3	-40 to 85	mini SOIC-10

^P PowerWise® product

^E Evaluation board

^W WEBENCH® enabled

D/A Converters

SPI and I²C Interface

8-/10-/12-Bit DACs Provide Seamless Upgradeability

Features

- Pin- and function-compatible across resolutions
- 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	↕	3.0	2.7 to 5.5	175	260	+0.16, -0.12	+0.04, -0.02	From supply	MSOP-8, TSOT-6
DAC101S101 ^E	10	1		5.0	2.7 to 5.5	175	260	±0.6	+0.15, -0.05	From supply	MSOP-8, TSOT-6
DAC121S101 ^E	12	1		8.0	2.7 to 5.5	175	260	±2.6	+0.25, -0.15	From supply	MSOP-8, TSOT-6
DAC082S085 ^E	8	2	↕	3.0	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		6.0	2.7 to 5.5	210	320	±2.4	+0.2, -0.1	External	MSOP-10, LLP-10
DAC084S085 ^E	8	4	↕	3.0	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		6.0	2.7 to 5.5	360	480	±2.4	+0.2, -0.1	External	MSOP-10, LLP-10
DAC088S085 ^E	8	8	↕	3.0	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		6.0	2.7 to 5.5	650	970	±2.0	+0.15, -0.09	Dual external	TSSOP-16, LLP-16
Single-Ended Input I²C Digital-to-Analog Converters											
DAC081C081 ^E	8	1	↕	6.0	2.7 to 5.5	0.38	0.73	±0.1	±0.08	Supply	TSOT-6, LLP-6
DAC101C081 ^E	10	1		6.0	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		6.0	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	↕	6.0	2.7 to 5.5	0.38	0.73	±0.1	±0.08	External	MSOP-8
DAC101C085 ^E	10	1		6.0	2.7 to 5.5	0.38	0.73	+0.21, -0.16	+0.25, -0.16	External	MSOP-8
DAC121C085 ^E	12	1		6.0	2.7 to 5.5	0.38	0.73	+2.2, -1.5	+0.18, -0.12	External	MSOP-8

 PowerWise[®] product

^E Evaluation board

A/D Converters

GSPS Ultra-High-Speed

Ultra-High Speed ADC Family

National's ultra-high-speed ADC family delivers unparalleled performance in a small package at the industry's lowest power. This ADC family maintains excellent dynamic performance at gigasample-per-second (GSPS) sampling rates and over large input bandwidths to support and enable applications such as wideband

communications, data acquisition, optical infrastructure, set-top boxes, microwave backhaul, gaming systems, and more. In addition, National works with industry-leading FPGA vendors to offer design-in support for next-generation development and provides easy-to-use reference boards for faster time to market.

Features

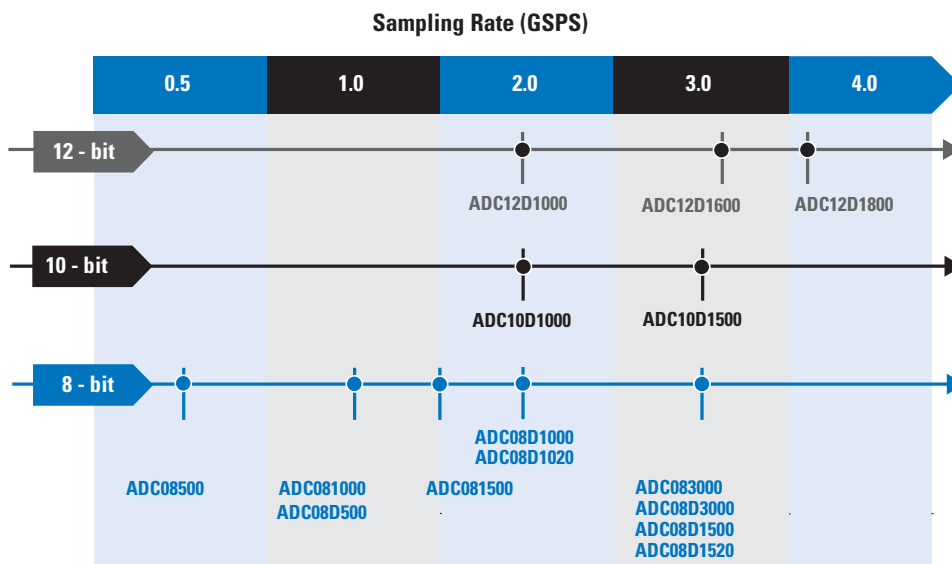
- GSPS Sampling Rate - Accurately receives modulated, bandwidth-limited signals within large bandwidth to support a variety of applications
- Wide Bandwidth - Flexibly supports everything from time domain applications to IQ sampling communications to high-IF applications in interleaved mode
- Power Efficient - Reduces power consumption for energy-efficient solutions
- Smaller Solution Size - Reduces board area and footprint providing for low-cost upgrades and weight reduction

Applications

Ideal for applications such as software-defined radio, wideband communications, data acquisition, optical infrastructure, set-top boxes, microwave backhaul, gaming systems, and more

National's ultra-high-speed ADCs are well matched to work with the National's high-speed operational amplifiers such as the LMH6554 ultra-linear fully differential amplifier and integrated PLL+VCO ICs, such as the LMX2541, to provide a complete signal-path system solution. More companion products can be found at the following pages:

- LMH655x Fully Differential Amplifiers pg. 20
- LMH651x Variable Gain Amplifiers pg. 15
- LMK & LMX Timing & Clocking Products pg. 30



ADC12D1x00 – 12-Bit, 2.0/3.2/3.6 GSPS Ultra-High-Speed ADC Enables Software-Defined Radio Applications

National's new ADC12D1x00 family features up to 3.6 GSPS sampling rate to enable a new generation of software-defined radio architectures and applications through its ability to receive modulated, bandwidth-limited signals within large bandwidth.

Features

- Wide input bandwidth
- Configurable to 2.0/3.2/3.6 GSPS interleaved or 1.0/1.6/1.8 dual channel mode
- Pin-compatible with ADC10D1000/1500
- 1:1 non-demuxed or 1:2 demuxed LVDS outputs
- Auto sync feature for multi-chip systems
- Single 1.9V ± 0.1V power supply

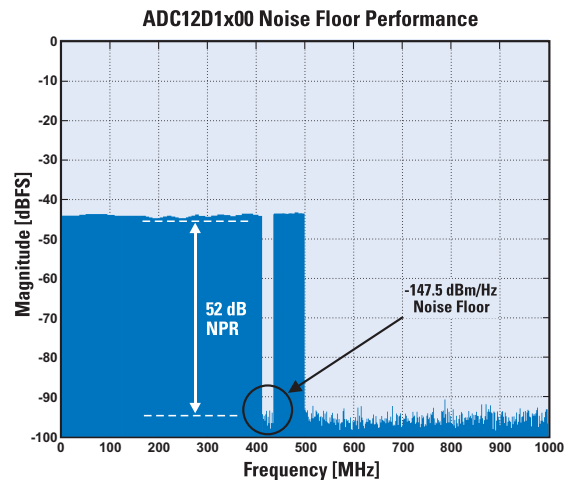
Key Specifications (typ)

Interleaved 2.0/3.2/3.6 GSPS ADC

- Noise floor -147.5/-147.5/-147 dBm/Hz
- IMD3 -66/-63/-61 dBFS
- Noise power ratio 52 dB
- Power 3.4/3.8/4.1W
- Full power bandwidth 2.15 GHz

Dual 1.0/1.6/1.8 GSPS ADC, Fin = 125 MHz

- ENOB 9.5/9.3/9.2 bits
- SNR 59.1/58.6/57.8 dB
- SFDR 70.5/68/67 dBc
- Power 3.4/3.8/4.1W
- Full power bandwidth 2.8 GHz



GSPS Ultra-High-Speed ADCs

Product ID	Sampling Rate (MSPS)	Power (W)	NPR (dB)	IMD (dBFS)	Noise Floor (dBm/Hz)	ENOB (bits)	SNR (dB)	SFDR (dBc)	Full Power Bandwidth (GHz)	Packaging
NEW ADC12D1800	1800/3600	4.1	52	-61	-147	9.2	57.8	67	2.8	TEPBGA-292
NEW ADC12D1600	1600/3200	3.8	52	-63	-147.5	9.3	58.6	68	2.8	TEPBGA-292
NEW ADC12D1000	1000/2000	3.4	52	-66	-147.5	9.5	59.1	70.5	2.8	TEPBGA-292
ADC10D1500	1500/3000	3.59	48	-67.6	-144.7	8.9	57	66	3.1	TEPBGA-292
ADC10D1000	1000/2000	2.77	48	-67.6	-144.7	9.1	57	66	2.8	TEPBGA-292
ADC08B3000	3000	1.6	—	—	—	7.2	45.3	55.4	3.0	eLQFP-128
ADC083000	3000	1.9	—	—	—	7.2	45.3	57	3.0	eLQFP-128
ADC08D1520	1500/3000	2.0	—	—	—	7.4	46.8	58	2.0	eLQFP-128
ADC08D1500	1500/3000	2.0	—	—	—	7.4	47	56	1.7	eLQFP-128
ADC081500	1500	1.2	—	—	—	7.4	47	56	1.7	eLQFP-128
ADC08D1020	1000/2000	1.6	—	—	—	7.4	46.8	58	2.0	eLQFP-128
ADC08D1000	1000/2000	1.6	—	—	—	7.4	47/1	55	1.7	eLQFP-128
ADC081000	1000	1.43	—	—	—	7.5	48	58.5	1.7	eLQFP-128
ADC08D500	500	1.4	—	—	—	7.5	47	55	1.7	eLQFP-128
ADC08500	500	0.8	—	—	—	7.5	47	56	1.7	eLQFP-128






























PowerWise® product

national.com/industrial

A/D Converters

MSPS High-Speed

High-Speed MSPS A/D Converters

Product ID	Channels	Speed (MSPS)	Power (mW)	SNR (dB)	SFDR (dB)	Outputs	Packaging
16-Bit							
ADC16V130 ^E 	1	130	755	78.5	95.5	LVDS	LLP-64
NEW ADC16DV160 ^E 	2	160	1300	78	95	LVDS	LLP-68
14-Bit							
ADC14I155 ^E 	1	155	967	71.3	87	CMOS	LLP-48
ADC14V155 ^E 	1	155	951	71.7	86.9	Parallel LVDS	LLP-48
ADC14DS080/105 ^E 	2	80/105	800/1000	74.2/73	90	Serial LVDS	LLP-60
ADC14DC080/105 ^E 	2	80/105	600/800	73/74	90	CMOS	LLP-60
ADC14C080/105 ^E 	1	80/105	300/400	74.2/74	90	CMOS	LLP-32
ADC14L040/20 ^E 	1	40/20	235/150	73/74	90/93	CMOS	LQFP-32
12-Bit							
ADC12C170 ^E 	1	170	715	67.2	85.4	CMOS	LLP-48
ADC12V170 ^E 	1	170	781	67.2	85.8	Parallel LVDS	LLP-48
ADC12C105 ^E 	1	105	400	71	90	CMOS	LLP-32
ADC12DS080/105 ^E 	2	80/105	800/1000	71	88	Serial LVDS	LLP-60
ADC12DC080/105 ^E 	2	80/105	600/800	71.5/71	90	CMOS	LLP-60
ADC12C080 ^E 	1	80	300	71.2	90	CMOS	LLP-32
ADC12DL080 ^E 	2	80	447	69	82	CMOS	TQFP-64
ADC12L080 ^E 	1	80	425	66	80	CMOS	LQFP-32
ADC12L066	1	66	357	66	80	CMOS	LQFP-32
ADC12DL066 ^E 	2	66	686	66	81	CMOS	TQFP-64
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 	1	65	68.4	59.6	80	CMOS	TSSOP-28
ADC10D040	2	40	267	60	72	CMOS	TQFP-48
ADC10040 	1	40	55.5	59.6	80	CMOS	TSSOP-28
ADC10D020	2	20	150	59	75	CMOS	TQFP-48

Analog Front Ends (AFE) and Analog Video Products

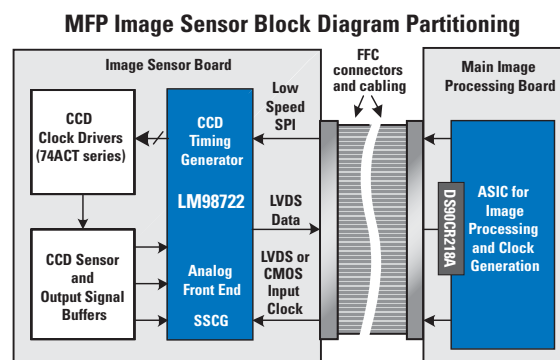
LM98722/25 – 3-Channel, 16-Bit, 81/45 MSPS Fully Integrated Analog Front End

Features

- LVDS/CMOS outputs
- Flexible spread-spectrum clock generator
- CCD/CIS sensor timing generator
- Automatic per-channel gain and offset calibration

Applications

Ideal for use in multi-function peripherals, copiers, and bill/check/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)
LM98722/25	3	45/81	16	✓	LVDS, CMOS	-4.2	18.4	9.0	307	0.63/0.755

LMH6586 – 32 x 16 Analog Video Crosspoint Switch

Features

- Video and sync detection; expandable
- -3 dB bandwidth = 66 MHz
- -58 dB at 6 MHz crosstalk rejection

Applications

Ideal for use in security/surveillance systems and analog video routing

Analog Video Crosspoint Switches

Product ID	Channels	Key Features	SSBW (MHz)	Crosstalk Rejection (dB)	Diff. G/P %/deg. into $R_L=150\Omega$	Temp. Range (°C)	Supply Voltage Range (V)	Packaging
LMH6586 ^E	32 x 16	Video/sync det., video clamps	66	-58 db at 6 MHz	0.05/0.05 at 3.58 MHz	-40 to 85	5.0	TQFP-80
LMH6585 ^E	32 x 16	Gain+1, +2, serial prog.	400	-52/-43 (10 MHz/100 MHz)	0.04/0.03 at 3.58 MHz/4.43 MHz	-40 to 85	±3.0 to ±5.0	TQFP-144
LMH6583 ^E	16 x 8	Gain +1, +2, serial prog.	550	-70/-45 (10 MHz/100 MHz)	0.04/0.04 at 3.58 MHz/4.43 MHz	-40 to 85	±3.0 to ±5.0	eTQFP-64
LMH6580	8 x 4	Gain +1, +2, serial prog.	500	-55/-45 (10 MHz/100 MHz)	0.05/0.05 at 3.58 MHz/4.43 MHz	-40 to 85	±3.0 to ±5.0	TQFP-48

^E Evaluation board

Sync Separators

Product ID	Type	Key Features	Inputs (V_{p-p})	Outputs	Supply Voltage Range (V)	Packaging
LMH1981	50% slicing	Auto-video format detection, 50% sync slicing, low H sync jitter	0.5 to 2.0	H/V/C sync, odd/even, burst/clamp, video format	3.3 to 5.0	TSSOP-14
LMH1980	70 mV fixed	Auto-video format detection	0.5 to 2.0	H/V/C sync, odd/even, burst/clamp, HD detect flag	3.3 to 5.0	MSOP-10

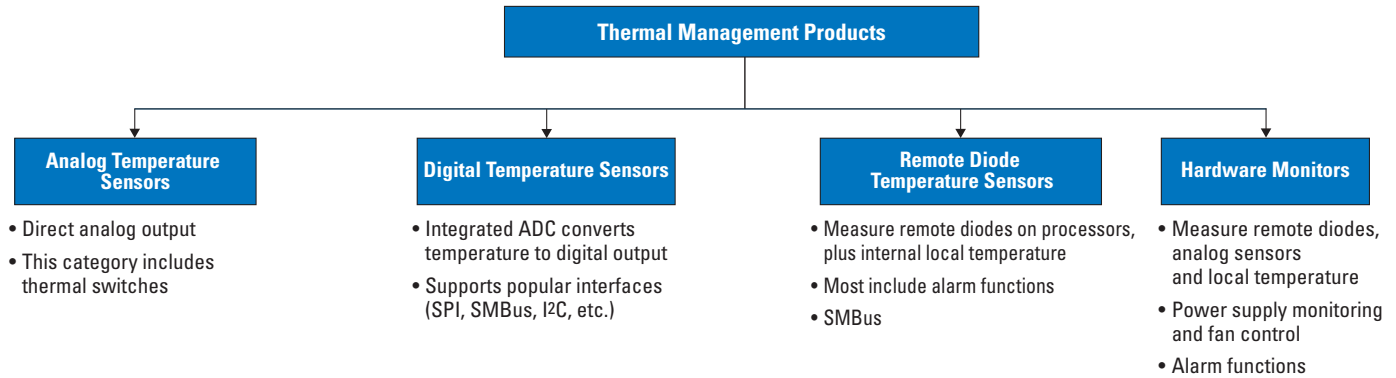
* Supported video formats: NTSC, PAL, SECAM, 480i/p, 576i/p, 720p, 1080i/p

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)	Temp. Range (°C)	Packaging
LMH6570/74	500	3:1/4:1	1	8	70/85	17	to 0.05%	-68/-84	±3.3 to ±6.0	-40 to 85	SOIC-8/SOIC-14
LMH6572	350	3:1	3	10	90	17	to 0.05%	-78/-75	±3.3 to ±6.0	-40 to 85	SSOP-16

Temperature Sensors

Analog and Digital



Analog Temperature Sensors

Product ID	Key Features	Temp Range (°C)	Accuracy (°C)	Operating Supply Voltage Range (V)	Temp Coefficient (mV/°C)	Supply Current (µA)	Packaging
LM19/20 [‡]	Low power consumption	-55 to 130	±1.5, ±2.5	2.4 to 5.5	-11.7	4.0	SC-70, TO-92
LM45	No trim or external calibration required	-40 to 125	±3, ±4.0	4 to 10	10	120	SOT23-3
LM50	Negative temperature support	-40 to 150	±3, ±4.0	4.5 to 10	10	130	SOT23-3
LM60	Low voltage support	-40 to 125	±3, ±4.0	2.7 to 10	6.25	82	SOT23-3, TO92-3
LM61	Low voltage support	-30 to 100	±3, ±4.0	2.7 to 10	10	82	SOT23-3, TO92-3
LM62	Low voltage support	0 to 90	±3, ±4.0	2.7 to 10	15.6	155	SOT23-3
LM94022	Low 1.5V operation	-50 to 150	±2.4	1.5 to 5.5	-5.5/-8.2/10.9/-13.6	5.4	SC70-5

Digital Temperature Sensors

Product ID	Key Features	Temp Range (°C)	Temp Accuracy	Interface	Operating Supply Voltage (V)	Temp Resolutions (°C/LSB)	No. of Interrupts	No. of Available Addresses	Packaging
LM71C [‡]	Low precision version of LM74	-10 to 85	-1.5, -2.0	Microwire/SPI	2.85 to 5.5	0.125	—	—	mini SOIC-8, LLP-8
LM74	Industrial	-10 to 85/100	±1.25, 2.1	Microwire/SPI	3.0 to 5.5	0.0625	—	—	SOP-8
LM95071	High-precision version of LM74	0 to 70	±1.0	Microwire/SPI	2.4 to 5.5	0.03125	—	—	SOT23-5
LM73 [Ⓜ]	Precision	-10 to 110	±1.0, 1.5	I ² C/SMBus2.0	2.7 to 5.5	0.03125	1	6	SOT23-6
LM75A	Industry standard	25 to 100	±2.0	I ² C Bus	3.0 to 5.5	0.5	1	8	SOP-8, mini SOIC-8
LM76	Precision	-10 to 100	±.5, 1.0, 2.5	I ² C Bus	3.0 to 5.5	0.0625	2	4	SOP-8
LM77	Separate open-drain outputs	-10 to 100	±1.5, 2.0	I ² C Bus	3.0 to 5.5	0.25	2	4	SOP-8, mini SOIC-8
LM92	Centralized thermal control system precision	-25 to 150	±.33 to 1.5	I ² C Bus	2.7 to 5.5	0.0625	2	4	SOP-8

[Ⓜ] PowerWise® product

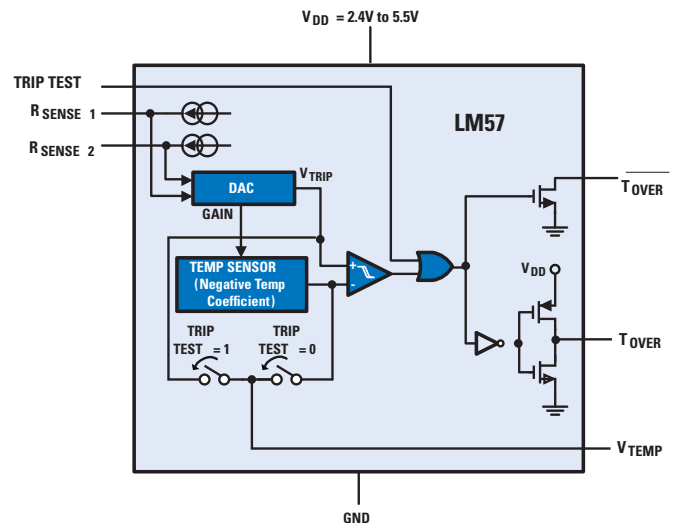
[‡] Evaluation board

Temperature Sensors Switches and Remote Diode

LM26/27 and LM56/57 – Low-Power Temperature Switches 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)
- Low supply current: 20 μ A to 230 μ A (typ)
- Operating supply voltage range: +2.7V to +5.5V
- Detection temperature accuracy:
 - LM26 $\pm 3^\circ\text{C}$ (max) (-55 $^\circ\text{C}$ to 110 $^\circ\text{C}$), $\pm 4^\circ\text{C}$ (max) (+120 $^\circ\text{C}$)
 - LM27 $\pm 3^\circ\text{C}$ (max) (-120 $^\circ\text{C}$ to 150 $^\circ\text{C}$)
 - LM56BIM $\pm 2^\circ\text{C}$ (max) (-25 $^\circ\text{C}$ to 85 $^\circ\text{C}$)
 - LM57B $\pm 1.5^\circ\text{C}$ (max) (-50 $^\circ\text{C}$ to 150 $^\circ\text{C}$)



Temperature Switches

Product ID	Temp Range ($^\circ\text{C}$)	Accuracy ($^\circ\text{C}$)	Supply Range (V)	No. of Interrupt Outputs	Interrupt Temp Setting	Packaging
LM26 ^E	-55 to 125	+3	2.7 to 5.5	1	Factory set	SOT23-5
LM27	+120 to 150	+3	2.7 to 5.5	1	Factory set	SOT23-5
LM56	-40 to 125	$\pm 2, 3, 4$	2.7 to 10	2	User specified	SOP-8, mini SOIC-8
LM26LV	0 to 150	± 2.2	1.6 to 5.5	2	Factory set	LLP-6
LM57	-50 to 150	$\pm 1.5, 2.3$	2.4 to 5.5	2	User specified	LLP-8

Remote Diode Temperature Sensors and Hardware Monitors

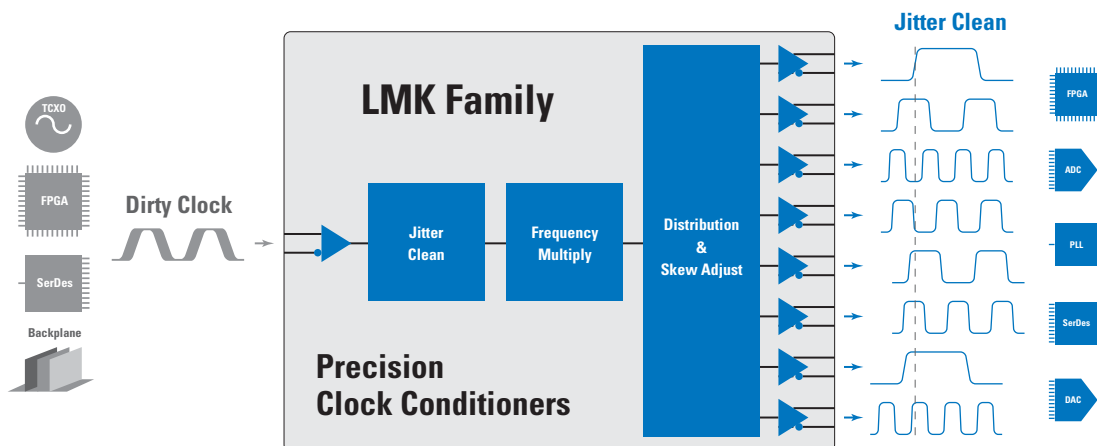
Product ID	Description	Pin-Compatible	Processor Supported	Measurement Method	No. of Remote Channels	System Interrupt	Selectable Addresses
LM86/89/99 ^E	$\pm 0.75^\circ\text{C}$, MSOP-8	↕	P4 and AMD	Traditional	1	1	Factory set
LM95235 ^E	$\pm 0.75^\circ\text{C}$, MSOP-8	↕	65 nm	TruTherm [®]	1	1	✓
LM95245	$\pm 0.75^\circ\text{C}$, MSOP-8	↕	45 nm	TruTherm	1	1	✓
LM95231	$\pm 1.25^\circ\text{C}$, MSOP-8	↕	90 nm	TruTherm	2	—	Factory set
LM95241	$\pm 1.25^\circ\text{C}$, MSOP-8	↕	65 nm	TruTherm	2	—	Factory set
LM95213 ^E	$\pm 1.1^\circ\text{C}$, LLP-14	↕	—	Traditional	0 to 2	3	✓
LM95233 ^E	$\pm 0.875^\circ\text{C}$, LLP-14	↕	65 nm	TruTherm	0 to 2	3	✓
LM95214 ^E	$\pm 1.1^\circ\text{C}$, LLP-14	↕	—	Traditional	0 to 4	3	✓
LM95234 ^E	$\pm 0.875^\circ\text{C}$, LLP-14	↕	65 nm	TruTherm	0 to 4	3	✓
LM96194	$\pm 2.5^\circ\text{C}$, LLP-48	—	65 nm	TruTherm	2 to 4	—	Full PI hardware monitor
NEW LM96080 ^E	$\pm 3^\circ\text{C}$, TSSOP-24	—	—	Traditional	0	1	Fan plus voltage monitor
LM87	$\pm 4^\circ\text{C}$, TSSOP-24	—	—	Traditional	2	1	DAC hardware monitor
LM93	$\pm 3^\circ\text{C}$, TSSOP-56	↕	—	Traditional	2	—	Full LUT hardware monitor
LM94	$\pm 2.5^\circ\text{C}$, TSSOP-56	↕	65 nm	TruTherm	2 to 4	—	Full PI and LUT hardware monitor
LM96163 ^E	$\pm 0.75^\circ\text{C}$, LLP-10	—	45 nm	TruTherm	1	1	LUT fan control

PowerWise[®] product

^E Evaluation board

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	—	0.03 (additive)
LMK01010 ^E	0	8	0		1 to 1600	—	0.03 (additive)
LMK01020 ^E	8	0	0		1 to 1600	—	0.03 (additive)
LMK02000 ^E	5	3	0	PLL + Clock Distribution (needs external VCXO)	1 to 800	—	0.02 (+VCXO)
LMK02002 ^E	4	0	0		1 to 860	—	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
LMK03033 ^E	4	4	0		1 to 1080	1843 to 2160	0.5
LMK03033C	4	4	0		1 to 1080	1843 to 2160	0.8
LMK03200 ^E	5	3	0	1 to 1080	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)
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	1600 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

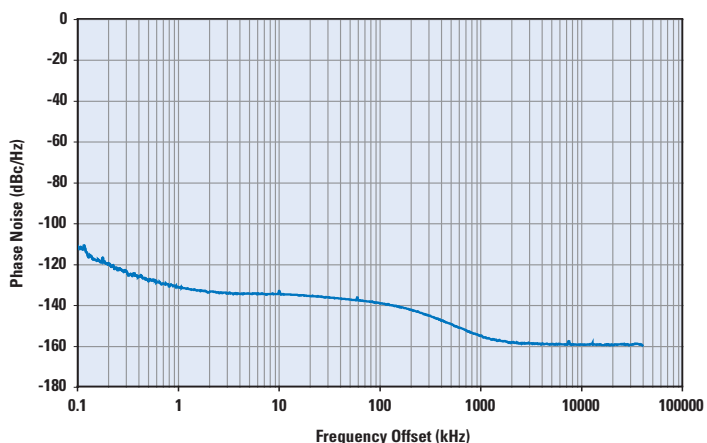
PowerWise product

^E Evaluation board

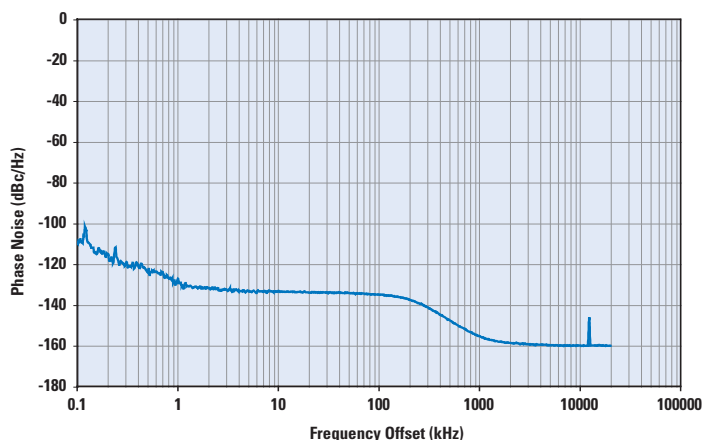
^W WEBENCH[®] enabled

LMK Clock Conditioner Family Performance

Superior Phase Noise Performance



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



LMK04031B LVC MOS Output Phase Noise at 122.88 MHz using a low-cost Vectron Crystal

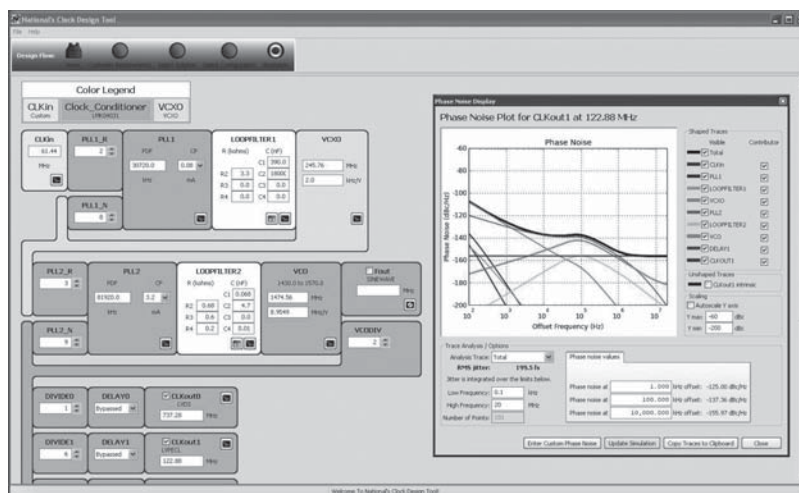
National's Clock Design Tool

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

Features

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

Updated to support LMX2531 and LMX2541 part selection and design.



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

High-Performance Frequency Synthesizer Solutions

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

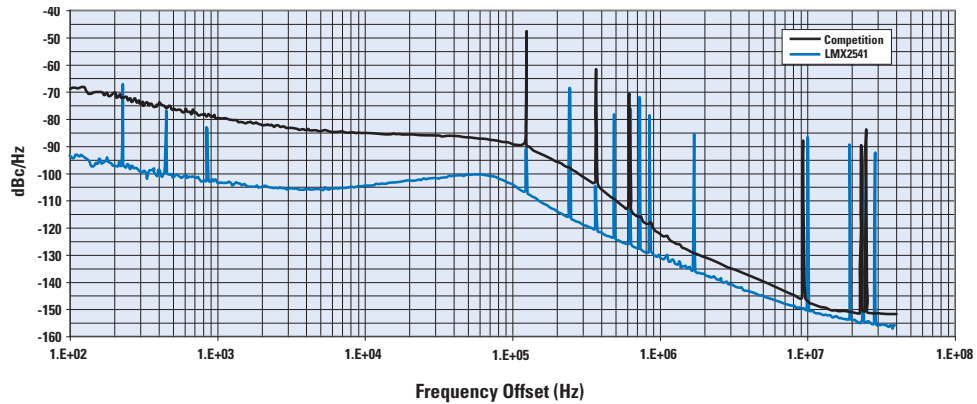
Features

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

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

PowerWise product ^E Evaluation board ^W WEBENCH® enabled

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



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

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	Package
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	Input Max Voltage (V)	Input Min Voltage (V)	Hot Swap FET RDS _{ON} Typ (Ω)	Integrated DC-DC Controller	Output Power (W)	Auxiliary Support	Reference Accuracy (+/-)	Current Draw with AUX Winding (typ)	Packaging
LM5070 ^E 	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

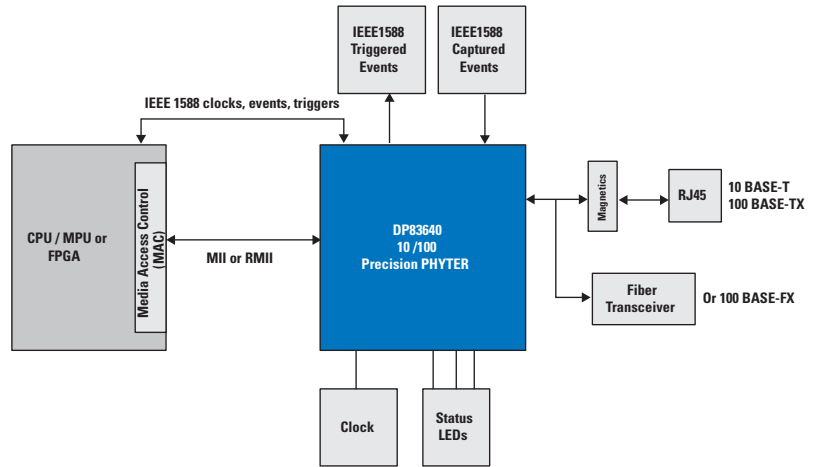
- Supports IEEE 1588 PTP v1 and v2
- 8 ns hardware timestamp
- Internal IEEE 1588 clock
- 12 1588 GPIOs
- Packet-based 1588 management
- Copper or fiber support
- ESD 8kV HBM / 2kV CDE
- Low power consumption
 - < 23 mW (energy detect mode)
 - < 250 mW (normal operation)

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

Typical Application Circuit



Precision PHYTER 10/100 IEEE 1588 PHY

Product ID	DP83640T ^E
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

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

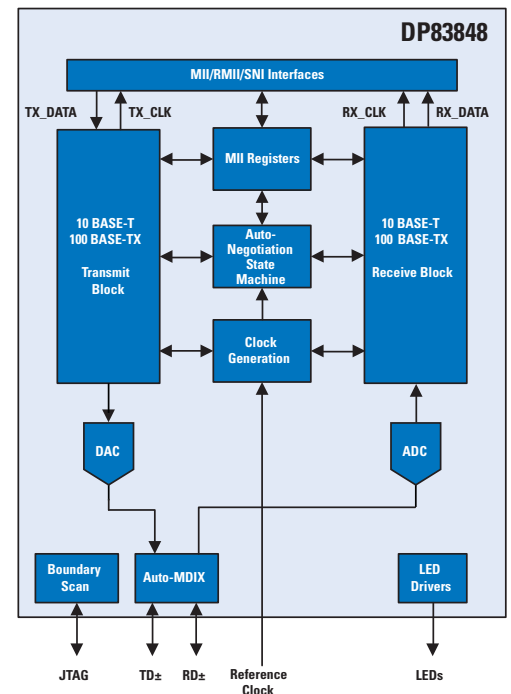
Features

- 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

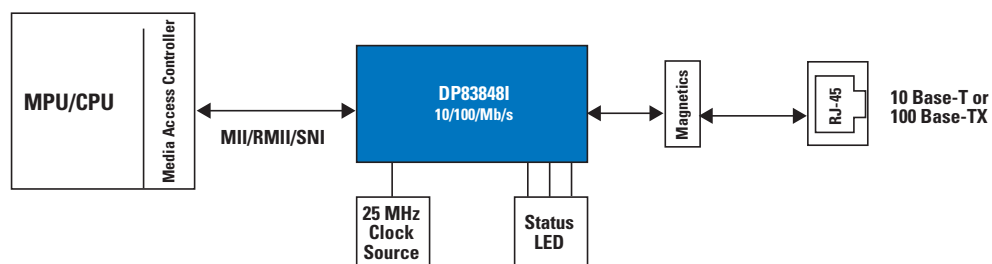
Ideal for use with industrial controls, factory automation, FPGAs, and embedded applications

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

NEW

Renesas 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

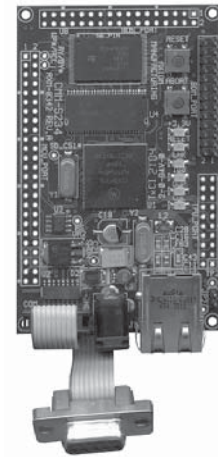
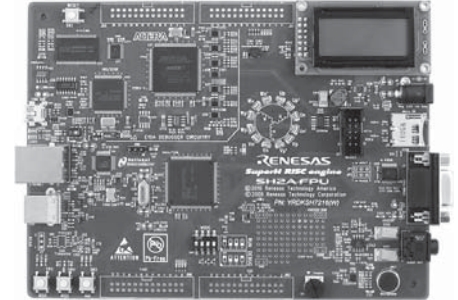
Freescal Reference Design

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

Applications

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

For PHYTER Ethernet Utility, visit: national.com/analog/interface/ethernet_utility

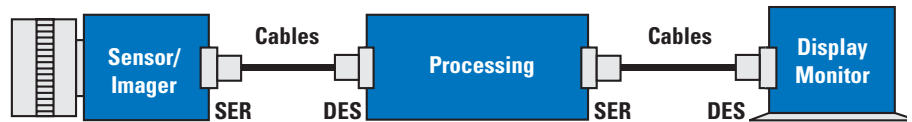


Serializers/Deserializers

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

Features

- Broad portfolio
- Wide operating frequency range
- Low EMI, high ESD protection
- Easy to use



Serializers and Deserializers

Product ID	Serializer	Deserializer	Parallel I/O	Parallel Width	Freq Range (MHz)	Mux Ratio	Chipset Compatibility	Features	Temp Range	Packaging
FPGA - Link Family										
DS32EL0421	DS32EL0124	DS32EL0124	LVDS	5	125 to 312.5	ANY: 1	↑	EQ on RX, de-emphasis on TX, narrow bandwidth PLL on TX, 8 kV HBM ESD	I	LLP-48
DS32ELX0421	DS32ELX0124	DS32ELX0124	LVDS	5	125 to 312.5	ANY: 1		EQ on RX, de-emphasis on TX, narrow bandwidth PLL on TX, redundant serial output on TX, retimed loop through driver on Rx, serial input on Mux on RX, 8 kV HBM ESD	I	LLP-48
Channel Link III with Embedded Clock and Control Channel										
DS92LX2121	DS92LX2122	DS92LX2122	LVC MOS	21	10 to 50	21 : 1	—	EQ on RX,SSCG on RX, 4 GPO on TX/4 GPI on RX, 8 kV HBM ESD	I	LLP-40 (SER)/LLP-48 (DES)
DS92LX1621	DS92LX1622	DS92LX1622	LVC MOS	16	10 to 50	16 : 1	—	Up to 6 GPIOs on RX/TX, EQ on RX, SSCG on RX, CRC, 8 kV HBM ESD	I	LLP-32 (SER) / LLP-40 (DES)
Channel Link II with Embedded Clock										
DS92LV2421	DS92LV2422	DS92LV2422	LVC MOS	24	10 to 75	24 : 1	↑	De-emphasis on TX, SSC on TX, EQ on RX, SSCG on RX, 8 kV HBM ESD	I	LLP-48 (SER) / LLP-60 (DES)
DS92LV2411	DS92LV2412	DS92LV2412	LVC MOS	24	5 to 50	24 : 1		De-emphasis on TX, SSC on TX, EQ on RX, SSCG on RX, 8 kV HBM ESD	I	LLP-48(SER) / LLP-60 (DES)
DS92LV0421	DS92LV0422	DS92LV0422	LVDS	4	10 to 75	4 : 1	↓	De-emphasis on TX, SSC on TX, EQ on RX, SSCG on RX, 8 kV HBM ESD	I	LLP-36 (SER) / LLP-48 (DES)
DS92LV0411	DS92LV0412	DS92LV0412	LVDS	4	5 to 50	4 : 1		De-emphasis on TX, SSC on TX, EQ on RX, SSCG on RX, 8 kV HBM ESD	I	LLP-36 (SER) / LLP-48 (DES)
DS92LV3241	DS92LV3242	DS92LV3242	LVC MOS	32	20 to 85	32 : 4	↑	Pre-emphasis on TX, built-in channel De-skew , 4 kV HBM ESD	I	TQFP-64
DS92LV3221	DS92LV3222	DS92LV3222	LVC MOS	32	20 to 50	32 : 2		Pre-emphasis on TX, built-in channel De-skew , 4 kV HBM ESD	I	TQFP-64
Channel Link										
DS90CR217	DS90CR218A	DS90CR218A	LVC MOS	21	20/12 to 85	21 : 3	—	7 kV HBM ESD	C	TSSOP-48
DS90CR287	DS90CR288A	DS90CR288A	LVC MOS	28	20 to 85	28 : 4	—	7 kV HBM ESD	C	TSSOP-56
DS92CR483A	DS92CR484A	DS92CR484A	LVC MOS	48	33 to 112	48 : 8	↑	6 kV HBM ESD on Tx, 2kV HBM ESD on Rx	C	TQFP-100
DS92CR485	DS92CR486	DS92CR486	LVC MOS	48	66 to 133	48 : 8		2 kV HBM ESD	C	TQFP-100
Embedded Clock Start/Stop Bit										
DS92LV16	DS92LV16	DS92LV16	LVC MOS	16	25 to 80	16 : 1	—	Transceiver, 2.5 kV HBM ESD	I	LQFP- 80
DS92LV18	DS92LV18	DS92LV18	LVC MOS	18	15 to 66	18 : 1	—	Transceiver , 2 kV HBM ESD	I	LQFP-80

* I - Temp Range = -40°C to +85°C

** C - Temp Range = -10°C to +70°C

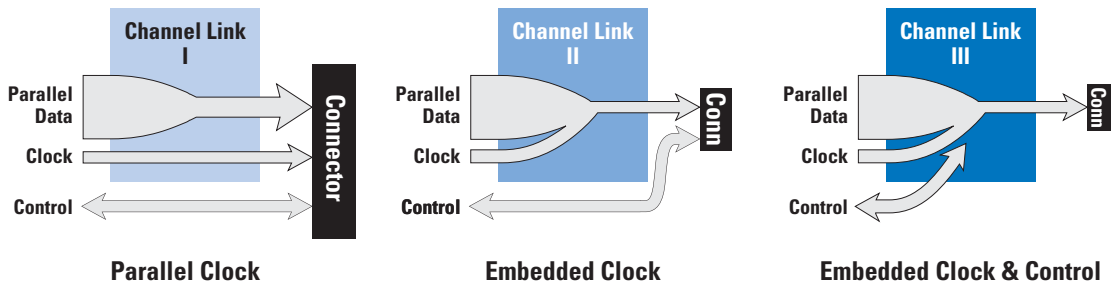
Serializers/Deserializers

Channel Link

Evolution of Channel Link Families of Serializers and Deserializers

Through three generations of Channel Link Serializers and Deserializers (SerDes), National Semiconductor has enabled robust high-speed data serialization in a wide array of industrial video and imaging applications.

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



Channel Link

- Reduced parallel data bus
- 21-/28-/48-bit parallel data bus

Channel Link

- Clock and data bus over one wire pair
- Up to 32-bit parallel data bus
- Integrated signal conditioning, low EMI

Channel Link

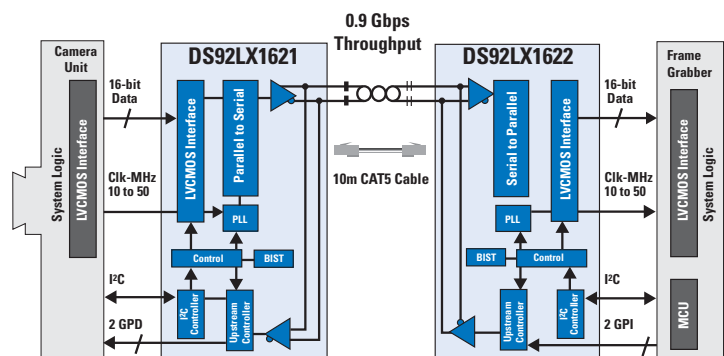
- Clock, data, and bi-directional control bus over one wire pair
- Up to 21-bit parallel data bus
- Integrated signal conditioning, low EMI

DS92LX1621/22 – 16-Bit, 10 MHz to 50 MHz Channel Link III Embedded Clock SerDes with Integrated Zero-Latency, Bi-Directional Control Channel

Features

- Supports up to 900 Mbps application data payload
- Wide operating range — 16-bit parallel data (LVCMOS), 10 MHz to 50 MHz parallel clock
- Zero-latency, bi-directional, I²C compatible control channel eliminates additional control wires
- Up to 6 general-purpose upstream control signals for increased design flexibility
- Embedded clock architecture eliminates external clock channel or reference clock
- Integrated signal conditioning (EQ) enables use of inexpensive, long cables or FR-4 backplane
- Automatic validation of data integrity
- Spread-spectrum clocking, staggered output control, and slew rate control for lower EMI
- Available in LLP-32 (SER) and LLP-40 (DES) packaging

Typical Application Circuit



Serializers/Deserializers

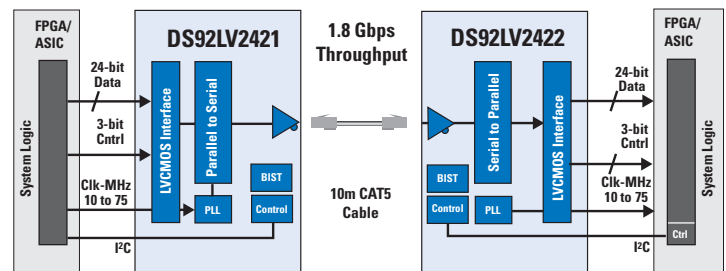
Channel Link

DS92LV2421/2422 – 24-Bit, 10 MHz to 75 MHz Channel Link II Embedded Clock SerDes

Features

- Supports up to 1.8 Gbps application data payload
- Wide operating range - up to 24-bit parallel data (LVCMOS), 10 MHz to 75 MHz parallel clock
- Supports up to HD resolution, 8-bit RGB video applications
- Embedded clock architecture eliminates external clock channel or reference clock
- Integrated signal conditioning (Selectable VoD, De-Emphasis, EQ) for long interconnects
- High ESD tolerance (ISO10605, > 8 kV HBM), -40°C to +85°C
- On-chip data scrambler, DC-balance encoder – receiver locks to random data, AC-coupling
- Spread-spectrum clocking, data scrambling, and slew control reduce EMI
- Compatible with DS92LV0421/22 Channel Link II SerDes with LVDS parallel bus
- Available in LLP-48 (SER) and LLP-60 (DES) packaging

Typical Application Circuit

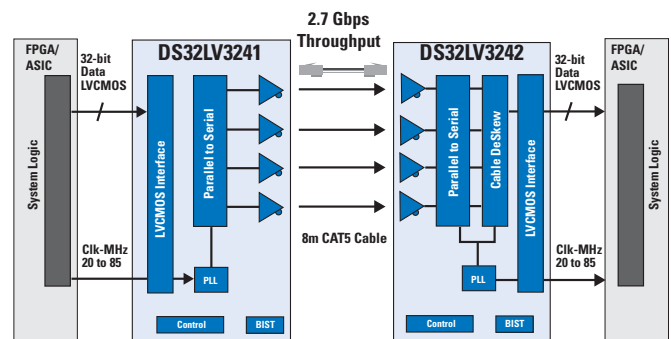


DS92LV3241/42 – 32-Bit, 20 MHz to 85 MHz Channel Link II Embedded Clock SerDes

Features:

- Supports up to 2.72 Gbps application data payload
- Wide operating range - Up to 32-bit parallel data (LVCMOS), 20 MHz to 85 MHz parallel clock
- Supports up to HD resolution, 10-bit RGB video applications
- Selectable serial LVDS bus width - dual lane (20 MHz to 50 MHz), quad lane (40 MHz to 85 MHz)
- Embedded clock architecture eliminates external clock channel or reference clock
- Integrated signal conditioning (Pre-Emphasis, EQ) enables inexpensive, long interconnects
- Built-in AT-SPEED BIST simplifies end-to-end system testing
- Compatible with DS92LV3221/22 32-bit Channel Link II SerDes for 20 MHz to 50 MHz operation
- Available in TQFP-64 packaging (10 x 10 mm)

Typical Application Circuit



Serializers/Deserializers

Evaluation Kits for SerDes Families

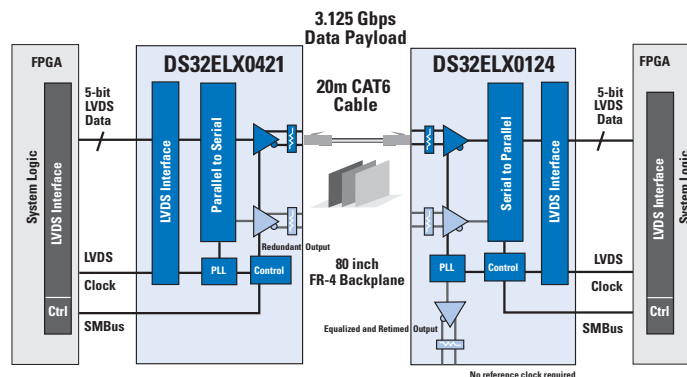
SerDes Chipset	Evaluation Kit Ordering Number
Channel Link II	
DS92LV2421 and DS92LV2422	LV24EVK01
DS92LV2411 and DS92LV2412	
DS92LV0421 and DS92LV0422	LV04EVK01
DS92LV0411 and DS92LV0412	
DS92LV3241 and DS92LV3242	LV32EVK01
DS92LV3221 and DS92LV3222	
Channel Link III	
DS92LX1621 and DS92LX1622	LX16EVK01
DS92LX2121 and DS92LX2122	LX21EVK01



DS32ELX0421/0124 – 5-Bit LVDS, 125 MHz to 312.5 MHz FPGA-Link Embedded Clock SerDes

Features

- Supports up to 3.125 Gbps application data payload
- Wide operating range with superior jitter performance – FPGA-friendly, 5-bit LVDS parallel data, 125 MHz to 312.5 MHz parallel clock
- Redundant Serial I/O, retimed serial loop-through enables daisy chaining, fail-over links
- Advanced signal conditioning (De-Emphasis, EQ, VoD) for long CAT5e/6/7, FR-4, coax support
- No external reference clock or training sequence required
- On-chip data scrambler, DC-balance encoder – receiver locks to random data, AC-coupling
- Advanced link management with cable and signal detect indicators plus automatic link
- Compatible with DS32EL0421/0124 FPGA-Link SerDes (No redundant I/O, retimed loop-through)
- Available in LLP-48 packaging (7 x 7 mm)



LVDS and CML PHYs

Signal Conditioning—Extend Your Reach

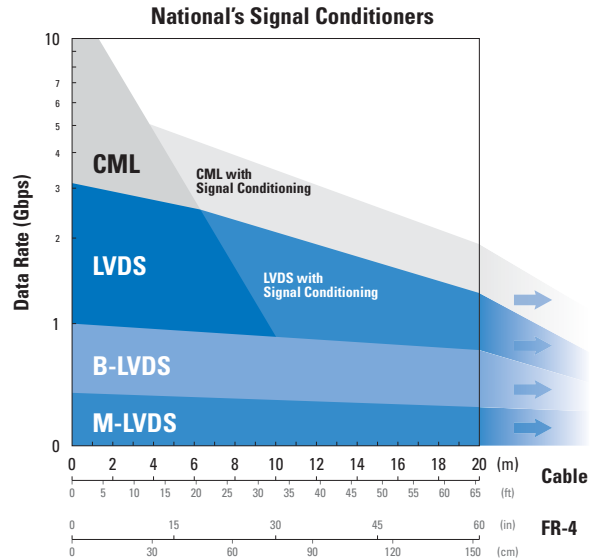
National offers an array of signal conditioning solutions, covering data rates from DC to 10 Gbps and topologies ranging from point-to-point to 32 multidrop loads.

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 multi-drop or multi-point configurations.



Select Signal Conditioning Products

Product ID	Function	Transmit Equalization (dB)	Receive Equalization (dB)	Max Speed/Ch (Mbps)	Packaging	Eval Kit
Buffers						
DS15BA101	Adjustable output buffer	—	—	1500	LLP-8	DriveCable02EVK
DS10BR150	Single LVDS buffer	—	—	1000	LLP-8	DS10BR150EVK
NEW DS50PCI402	Quad PCIe transceiver	0/3/6/9/12	0/9/15/21/26	5000	LLP-54	DS50PCI402EVK
DS91D176	Single M-LVDS transceiver	—	—	200	SOIC-8	DS91D176EVK
DS91M047	Quad M-LVDS driver	—	—	250	SOIC-16	DS91M047EVK
DS92001	Single B-LVDS buffer	—	—	400	SOIC/LLP-8	—
DS92LV040A	Quad B-LVDS buffer	—	—	155	LLP-44	—
Equalizers						
DS15EA101	Adaptive cable equalizer	—	Adaptive	1500	LLP-16	DriveCable02EVK
DS25BR110	Single LVDS equalizer	—	0/3/6/9	3125	LLP-8	DS25BR100EVK
DS38EP100	Power-saver equalizer	—	7	5000	LLP-6	DS38EP100-EVK
Multiplexers and Mux-Buffers						
DS25MB100	2:1/1:2 mux/buffer	0/-3/-6/-9	0/5	2500	LLP-36	DS25MB100-EVK
DS15MB200	Dual 2:1/1:2 mux/buffer	0/6	—	1500	LLP-48	SCAN15MB200EVK
DS42MB200	Dual 2:1/1:2 mux/buffer	0/-3/-6/-9	0/5	4250	LLP-48	—
Crosspoint Switches						
DS25CP102	2 x 2 crosspoint	0/3/6/9	0/3/6/9	3125	LLP-16	DS25CP102EVK
DS10CP154A	4 X 4 crosspoint	—	—	1500	LLP-40	DS10CP154EVK
DS25CP104A	4 X 4 crosspoint	0/3/6/9	0/3/6/9	3125	LLP-40	DS25CP104EVK
1:n Repeaters						
DS90LV110A	1:10 LVDS repeater	—	—	400	TSSOP-28	—
DS10BR254	1:4 LVDS repeater	—	—	1500	LLP-40	—
DS25BR204	1:4 LVDS repeater	0/6	0/6	3125	LLP-40	DS25BR204EVK

PowerWise® product

Cable Extenders

For HDMI/DVI/DisplayPort Applications

Cable Extending Equalizer Family

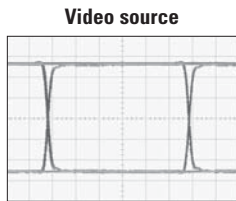
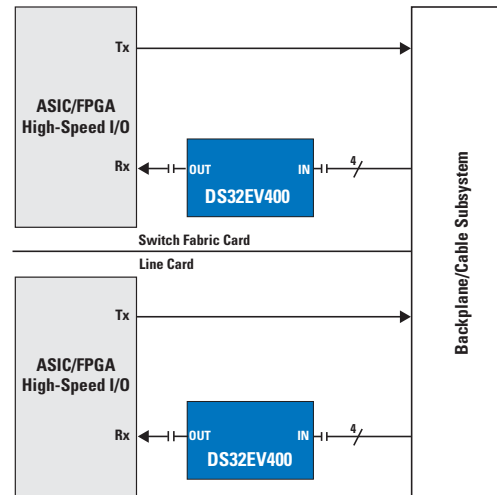
Features

- Significantly extends the reach of DVI, HDMI, and CAT5 cables
- Pin-selectable boost for equalization optimization
- Low output jitter
- Pin-selectable de-emphasis for signal conditioning optimization

Applications

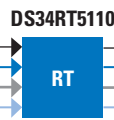
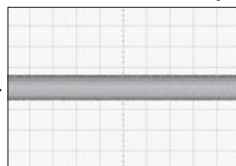
Ideal for use in HDTVs, projectors, extenders, dongles, and video capture cards/editing equipment

Typical DisplayPort Application

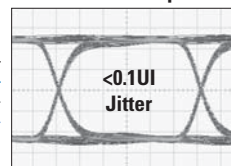


HDMI/DVI Extender Application

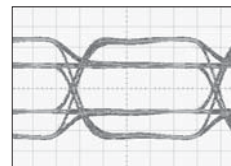
Input signal after 35m 28 AWG DVI cable, 1.65 Gbps



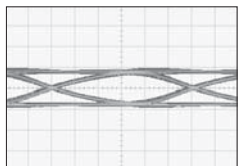
After DS34RT5110/DS22EV5110 without de-emphasis



After DS34RT5110/DS22EV5110 with de-emphasis



At sink device after 10m 28 AWG



Product ID	Function	Input Equalization	Output	Clock Rate (MHz)	Application	Comment	Packaging
HDMI							
DS16EV5110 ^E	Equalizer	8 levels, pin-selectable	HDMI	165/225	Sink	Supports 1080p applications	LLP-48
DS22EV5110 ^E	Equalizer	8 levels, pin-selectable	HDMI with de-emphasis	165/225	Source, sink	Longer reach for 1080p applications	LLP-48
DS34RT5110 ^E	Reclocking equalizer	8 levels, pin-selectable	HDMI with de-emphasis	165/225/340	Source, multi-hop, sink	Supports deeper color, higher resolutions, higher frame rate up to 1440p, multi-hop applications	LLP-48
Display Port							
NEW DS32EV400 ^E	Equalizer	8 levels, pin-selectable	CML with de-emphasis	270	Sink	Supports DisplayPort v1.1	LLP-48

Constant Voltage Supply Optimization

Create a constant supply voltage from a variable DC supply. The chosen option depends on system requirements such as the load current level, the anticipated changes in load current and input voltage, noise tolerance, and the physical size of the solution.

Linear Regulators:

- Power transfers continuously from V_{IN} to V_{OUT}
- Low noise but may have low efficiency since the regulator is similar to a variable resistor consuming power from the source and is equal to the output load current times the difference between the input and output voltages. Since this power does not reach the load, it is wasted and the resulting heat must be dissipated.

Switching Regulators (switchers):

- Power transfers from V_{IN} to V_{OUT} in bursts
- Inductor-based (inductive): Integrate high-efficiency MOSFETs to support low- to medium- load current levels
- Charge pump (capacitive or inductorless): Used for higher load current levels; due to heat dissipation, the MOSFETs are not integrated. Such switchers are called controllers.

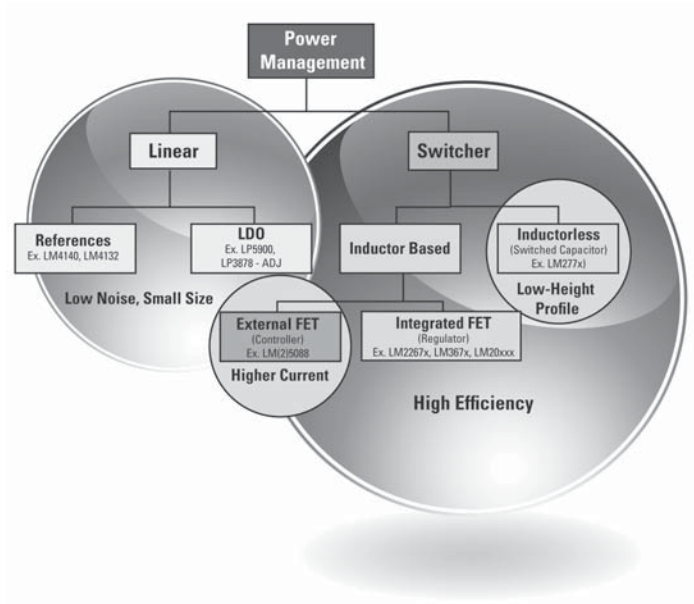
Selection Criteria:

Signal path designs usually do not require switching regulators as their supply currents are in the range of a few mA.

Switching regulators (with adequate LC filtering at the output) are advantageous in the following situations:

- Special low quiescent and PFM-mode regulators for portable solutions to increase efficiency, thus extending battery life time.
- Linear regulators with high power dissipation which would reach the maximum datasheet specifications of the junction temperature.
- Linear regulators with high power dissipation which reduces reliability due to constant high junction temperature.

Please use National Semiconductor's WEBENCH® design simulation software on national.com/webench for assistance in regulator selection, efficiency optimization, and circuit design and analysis.



Power Management

National Provides Highly Reliable Power Management Solutions for Your Industrial Applications

Hot Swap Control

Limits in-rush current with both power AND current limiting to increase system robustness in high-power industrial applications where reliability is critical.

High-Voltage DC-DC Converters

Proprietary high-voltage process technologies employed by National enable conversion from voltages as high as 95V down to 2.5V with excellent efficiency, ideal to withstand a rugged industrial environment.

Point-of-Load (PoL) Regulators

National offers a wide selection of PoL regulators to drive a variety of digital industrial loads such as microprocessors, FPGAs, logic, memory, or I/O.

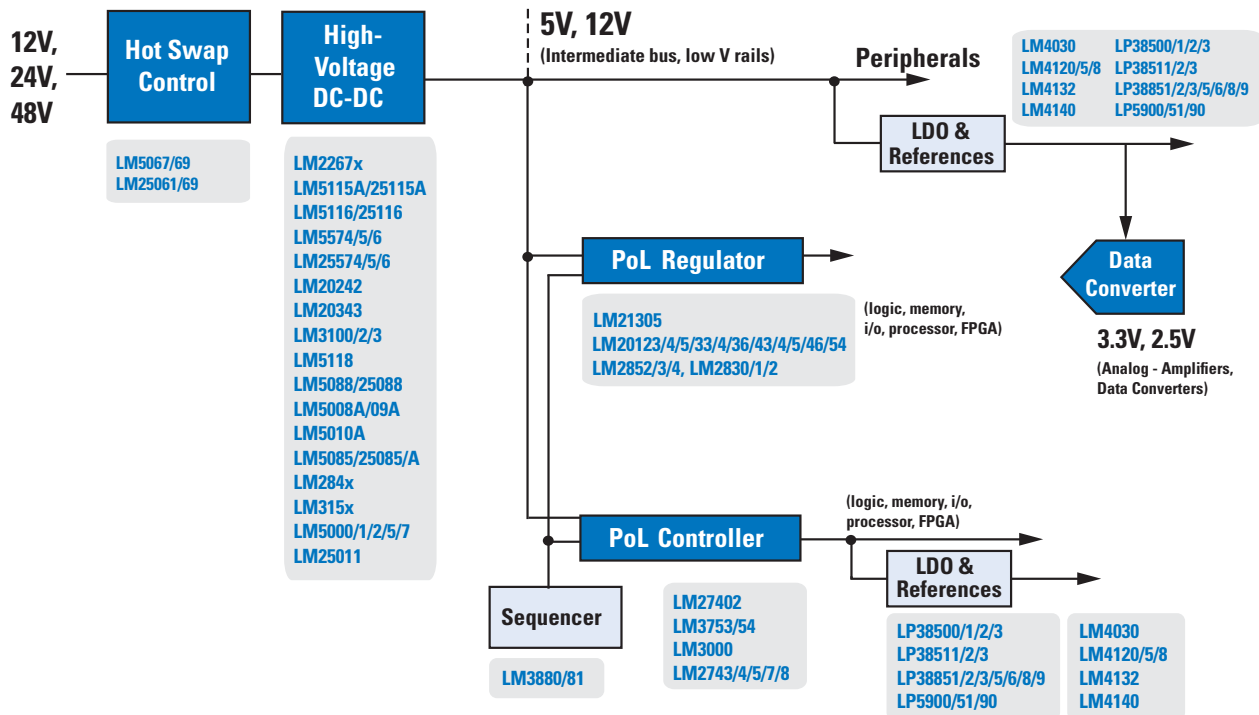
LDOs and References

National offers a wide portfolio of low-noise and precision LDOs and references to drive sensitive analog and digital loads for industrial applications.

Online Design Tools

National's WEBENCH® tools allow for a simple design process which can be optimized for cost, efficiency, or size. The new WEBENCH Power Architect is the industry's first design tool that allows engineers to rapidly create, model, and implement multiple-output, high-performance DC-DC power supplies for an entire system. With WEBENCH Power Architect, system designers can instantly optimize multiple power supplies across several performance parameters including topology, intermediate voltage rails, footprint, efficiency, component count, and bill of materials (BOM) cost.

Power Architecture for Industrial Applications



SIMPLE SWITCHER® Power Modules

Highly Integrated Solution in Easy-to-Use Package

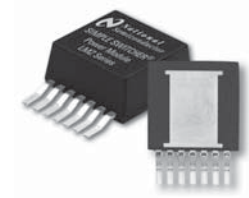
The SIMPLE SWITCHER power modules deliver excellent system performance, low EMI, and high reliability, enabling today's state-of-the-art production facilities and factory floor machinery. The energy-efficient power modules, combined with easy-to-use online design tools, make designing a high-performance power supply easy.

Features

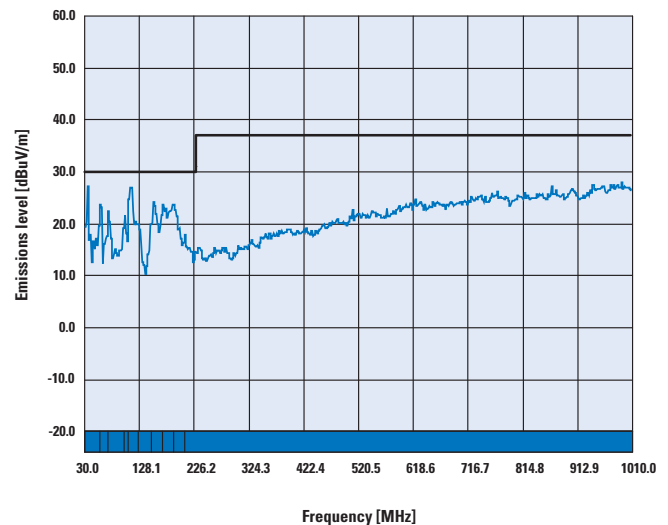
- Innovative packaging makes modules as easy to use as a Low-Dropout (LDO) linear regulator
- Highly integrated solution simplifies board layout and design
- Pin-to-pin compatibility and identical footprint for different load currents
- Up to 96% peak efficiency
- Semiconductor integrated circuit-level reliability and performance for rugged environments
- Excellent thermal performance eliminates the need for external heat sinks and fans
- Passes 10 V/m radiated immunity EMI test standard EN61000 4-3
- EXT versions offer extended temperature range (-55°C to 125°C) and meet military vibration/drop standards

Applications

Ideal for use in distributed control systems, motor and motion control, machine vision, embedded computer board, and I/O modules



LMZ10504 Radiated EMI Performance



Complies with EN55022 (CISPR22) Class B Radiated EMI Standard

NEW!

Product ID	Output Current	Input Min Voltage (V)	Input Max Voltage (V)	Output Min (V)	Output Max (V)	Temp 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

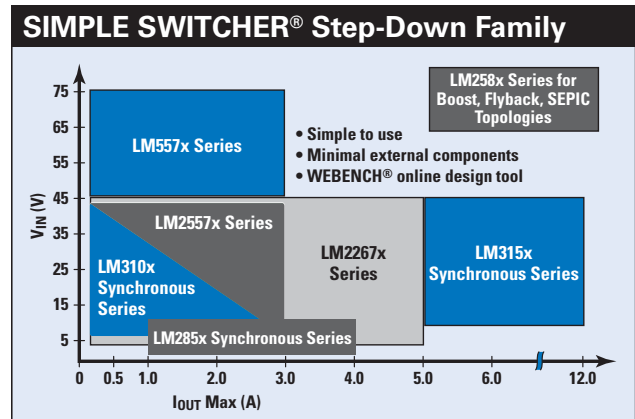
^E Evaluation board

^W WEBENCH® enabled

SIMPLE SWITCHER® Regulators

SIMPLE SWITCHER® regulators with WEBENCH® online support for maximum ease of use

- LM310x – Synchronous buck converters regulate outputs down to 0.6V and require no loop compensation
- LM557x – Emulated Current-Mode buck converters support up to 75V input and offers high performance and design flexibility
- LM2267x – Non-synchronous regulators with adjustable switching frequency and frequency synchronization for reducing EMI



National's SIMPLE SWITCHER families of integrated regulators feature a full suite of online design tools including the WEBENCH software that allows designers to select, customize, simulate, and order an evaluation board that meets the needs of his or her specific application.

SIMPLE SWITCHER Non-Synchronous Buck Regulators

Product ID	Output Current (mA)	Input Max Voltage (V)	Input Min Voltage (V)	Output Min (V)	Output Max (V)	Frequency Range (kHz)	Sync	PWM Mode	Packaging
LM25574 ^{E,W}	500	42	6.0	1.23	40	50 to 1000	✓	Current	TSSOP-16
LM5574 ^{E,W}	500	75	6.0	1.23	70	50	✓	Current	TSSOP-16
LM25575 ^{E,W}	1500	42	6.0	1.23	40	50 to 1000	✓	Current	eTSSOP-16
LM5575 ^{E,W}	1500	75	6.0	1.23	70	50	✓	Current	eTSSOP-16
LM25576 ^{E,W}	3000	42	6.0	1.23	40	50 to 1000	✓	Current	eTSSOP-20
LM5576 ^{E,W}	3000	75	6.0	1.23	70	50	✓	Current	eTSSOP-20
LM22671/74 ^{E,W}	500	42	4.5	1.285	40	200 to 1000 Adj	✓/–	Voltage	PSOP-8
LM22672/75 ^{E,W}	1000	42	4.5	1.285	40	200 to 1000 Adj	✓/–	Voltage	PSOP-8
LM22680 ^{E,W}	2000	42	4.5	1.285	40	200 to 1000 Adj	✓	Voltage	PSOP-8
LM22670/73/76 ^{E,W}	3000	42	4.5	1.285	40	200 to 1000 Adj	✓/–/–	Voltage	TO263-7 Thin, PSOP-8
LM22677/78/79 ^{E,W}	5000	42	4.5	1.285	40	200 to 1000 Adj	✓/–/–	Voltage	TO263-7 Thin

SIMPLE SWITCHER Synchronous Regulators

Product ID	Output Current (mA)	Input Max Voltage (V)	Input Min Voltage (V)	Output Min (V)	Output Max (V)	Frequency Range (kHz) and Sync (computed field)	PWM Mode	Packaging
LM3103 ^{E,W}	750	42	4.5	0.6	7.0	1000	COT	eTSSOP-16
LM3100 ^{E,W}	1500	36	4.5	0.8	7.0	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	7.0	1000	COT	eTSSOP-20
LM2853 ^{E,W}	3000	5.5	3.0	0.8	3.3	550	Voltage	eTSSOP-14
LM2854 ^{E,W}	4000	5.5	2.95	0.8	5.0	500, 1000	Voltage	eTSSOP-16

^E PowerWise® product

^E Evaluation board

^W WEBENCH® enabled

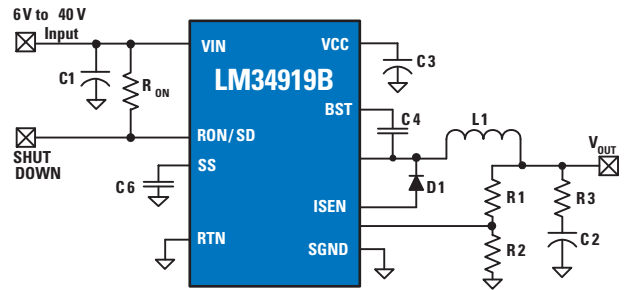
Integrated FET Switching Regulators

Integrated FET switching regulators are ideal for applications where design time is limited and a low Bill of Materials (BOM) count is critical.

National has several families of switching regulators:

- LM20xxx PowerWise® family of high-efficiency, synchronous step-down regulators for Point-of-Load (PoL) applications.
- LM500x wide input voltage regulators support input rails up to 75V with transients up to 100V
- LM3491x and LM248x – Small form factor non-synchronous bucks in ultra-small packages. Internal compensation allows for smaller board space by reducing the number of external components

Typical Application Circuit



LM5000 Series Wide-Input-Range Regulators

Product ID	Switch Current (mA)	Input Min Voltage (V)	Input Max Voltage (V)	Frequency Range (kHz) and Sync	Output Min (V)	Output Max (V)	Topology	Packaging
LM5000/01/02 ^{E, W}	500/1000/2000	3.1	40/75	50 to 1500, Sync	1.26	Set by external feedback network	Boost	LLP-8/16, TSSOP-16, SOIC-8 Narrow
LM(2)5005 ^{E, W}	2500	7.0	(42) 75	50 to 1000, Sync	1.23	(40) 70	Buck	TSSOP-20
LM5009/9A/08/8A ^{E, W}	150/350	9.5, 6.0	95	50 to 600	2.5	85/75	Buck	LLP-8, mini SOIC-8
LM(2)5007 ^{E, W}	500	9.0	42/75	50 to 800	2.5	(37) 73	Buck	mini SOIC-8
LM25010/5010(A) ^{E, W}	1000	6.0	42/75	50 to 1000	2.5	37/70	Buck	LLP-10, eTSSOP-14
LM25011 ^E	Up to 2000	6.0	42	Up to 2000	2.5	37	Buck	mini SOIC-10

LM284X and LM3491X Small Form Factor Non-Synchronous Buck Regulators

Product ID	Current (mA)	Input Max Voltage (V)	Input Min Voltage (V)	Output Min (V)	Output Max (V)	Frequency Range	PWM Mode	Package
LM2841 ^E	300	42	4.5	0.765	37	550 or 1250	Voltage	TSOT-6
LM2842 ^E	600	42	4.5	0.765	37	550 or 1250	Voltage	TSOT-6
NEW LM34919B ^E	600	40	6.0	2.5	35	Up to 2600	Constant on-time	micro SMD-10
LM34930 ^E	1000	33	8.0	2.5	30	Up to 2000	Constant on-time	micro SMD-12
LM34917A ^E	1250	33	8.0	2.5	30	Up to 2000	Constant on-time	micro SMD-12
LM34910/C ^{E, W}	1250	36/50	8.0	2.5	33/45	Up to 1000	Constant on-time	LLP-10
LM34914 ^E	1250	40	8.0	2.5	37	Up to 1300	Constant on-time	LLP-10

PowerWise® product

^E Evaluation board

^W WEBENCH® enabled

Switching Regulators

LM21305 – 5A, Adjustable-Frequency Synchronous Buck Regulator

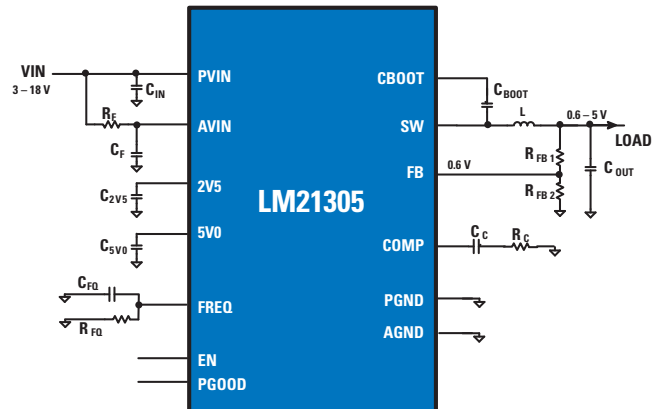
Features

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

Applications

Ideal for use in point-of-load regulation from 3.3V, 5V, and 12V rails and broadband and networking solutions.

Typical Application Circuit



PowerWise® Step-Down Synchronous Buck Regulators

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

^W PowerWise® product

^E Evaluation board

^W WEBENCH® enabled

Switching Controllers

LM27402 – Full-Featured 20 V_{IN} Synchronous Buck Controller with DCR Current Sensing

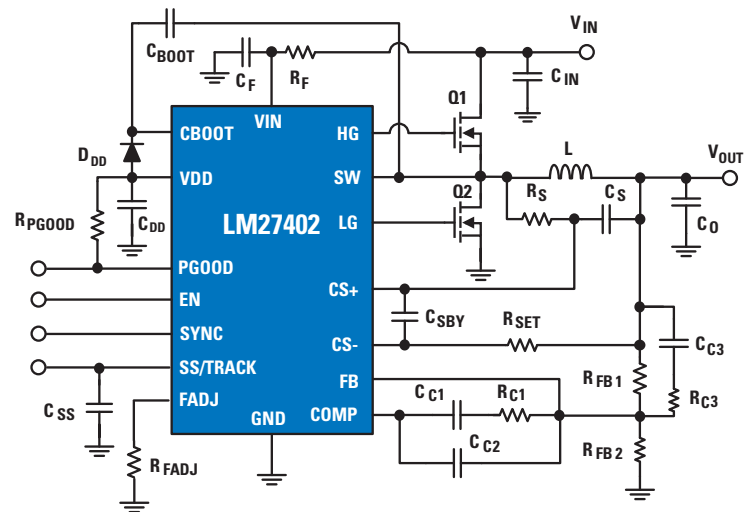
Features

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

Applications

Ideal for use in networking, battery-powered instruments, and Point-of-Load (PoL) modules

Typical Application Circuit



LM3753/54 – Scalable 2-Phase Synchronous Buck Controllers

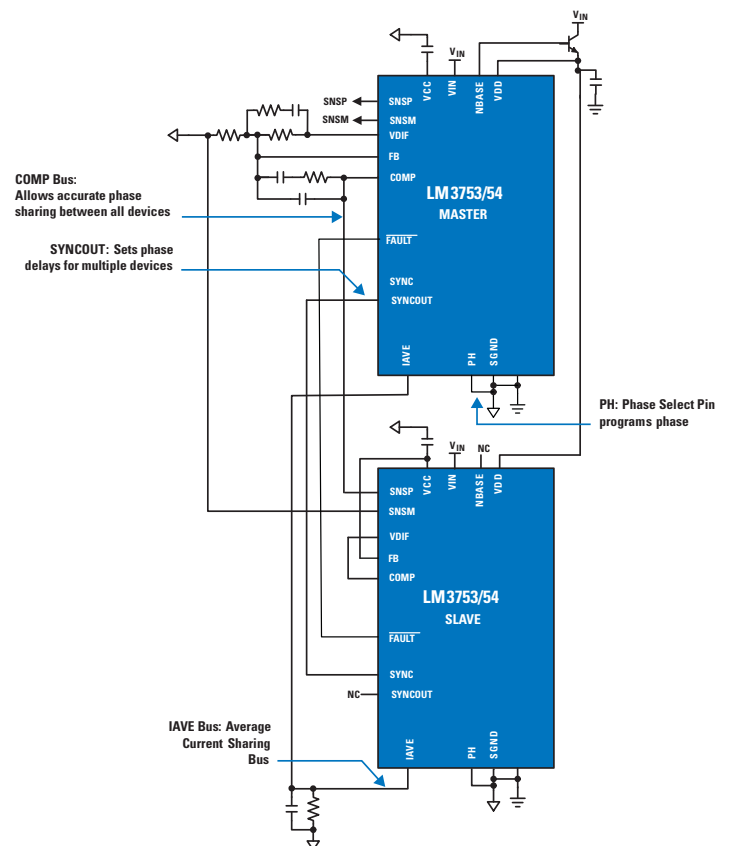
Features

- 2 to 12 phase capability
- Supports loads up to 300A
- Better than 1% system accuracy
- Accurate phase sharing over temperature
- I_{AVE} bus allows real-time current measurements

Applications

Ideal for use in high-current PoL converters and power distribution systems as well as with CPUs, GPUs, ASICs, FPGAs, DDR, and large memory arrays

Typical Application Circuit



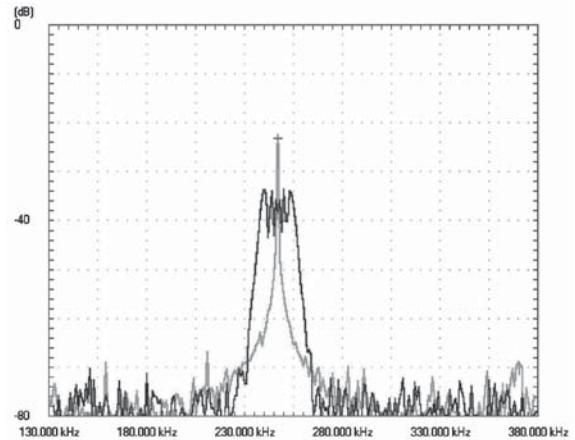
Switching Controllers

Switching controllers with external MOSFETs are ideal for applications where higher currents are needed and design flexibility is important.

National has several families of switching controllers:

- LM(2)5xxx Emulated Current Mode (ECM) family of high-efficiency step-down controllers supports input rails to 100V
- LM5118 3V to 75V buck-boost controller supports applications with an input voltage that varies both above and below the output voltage
- LM3000 dual output synchronous controller converts 12V rails to Point of Load (PoL) using separate error amp ground pins for accurate differential sensing of output voltage
- LM315x synchronous SIMPLE SWITCHER® controllers feature WEBENCH® support for a quick and easy design process

LM5088 Uses Spread-Spectrum Technique to Reduce EMI



National's LM5088 ECM step-down controller features:

- Frequency dithering (+ 5%) to improve EMI
- Synchronizable frequency, settable to 750 kHz
- Robust 2A gate drivers for high current capability

Controllers: Single and Dual Channel

Product ID	Input Max Voltage (V)	Input Min Voltage (V)	Output Min (V)	Feedback Tolerance (%)	Freq Range (kHz) and Sync	Error Flag	Channels	PWM Mode	Packaging	Comments
LM2642 ^E	30	4.5	1.238	2.0	300	✓	2	Current	TSSOP-28	Paralleled single output
LM2647 ^E	28	5.5	0.6	1.5	200 to 500	✓	2	Voltage with V _{IN} FF	LLP-28, TSSOP-28	Lossless current limiting
LM(2)5085/A ^E	(42) 75	4.5	1.25 / 0.9	2.0	1000	—	1	COT	mini SOIC-8, LLP-8	No loop comp required
LM(2)5088 ^{E, W}	(42) 75	4.5	1.2	1.5	50 to 1000, Sync	—	1	ECM	eTSSOP-16	Spread-spectrum EMI reduction
LM(2)5116 ^E	(42) 100	6	1.2	1.5	50 to 1000	—	1	ECM	eTSSOP-20	Low I _q SHDN
LM2742	16	1.0	0.6	1.5	50 to 2000	✓	1	Voltage	TSSOP-14	Adj soft start
LM2743 ^{E, W}	16	1.0	0.6	2.0	50 to 2000	✓	1	Voltage	TSSOP-14	Adj soft start, tracking
LM2744 ^E	16	1.0	0.5	Ext	50 to 2000	✓	1	Voltage	TSSOP-14	Adj external ref, soft start
LM2745/47/48 ^E	16	1.0	0.6	1.5/1/1.5	50 to 1000, Sync	✓	1	Voltage	TSSOP-14	Pre-bias operation, track
LM3000 ^E	18.5	3.3	0.6	1.0	200 to 1000, Sync	✓	2	ECM	LLP-32	Clock out, diff remote sense, dual
LM3150 ^{E, W}	42	6.0	0.6	1.5	Adj to 1000	—	1	COT	eTSSOP	No loop comp required
LM3151/52/53 ^{E, W}	42/33/18	6.0	3.3	1.5	250/500/700	—	1	COT	eTSSOP	No loop comp required
NEW LM3753/54	18	4.5	0.6	1.0	200 to 1000	✓	1	Voltage	LLP-32	Stackable to 12 phases
LM5118 ^{E, W}	75	13	1.23	1.5	50 to 500, Sync	✓	1	ECM	TSSOP-20	Buck-boost operation
LM5642 ^{E, W}	36	4.5	1.3	1.5	200 to 500, Sync	—	2	Current	TSSOP-28	Paralleled single output
LM(2)5115/A	(42) 75	4.5	0.75	1.7	50 to 1000, Sync	—	1	Voltage	TSSOP-16, LLP-16	Synchronous operation
NEW LM27402	20	3.0	0.6	1.0	200 to 1200	✓	1	Voltage with V _{IN} FF	LLP-16	DCR current sensing

PowerWise® product

^E Evaluation board

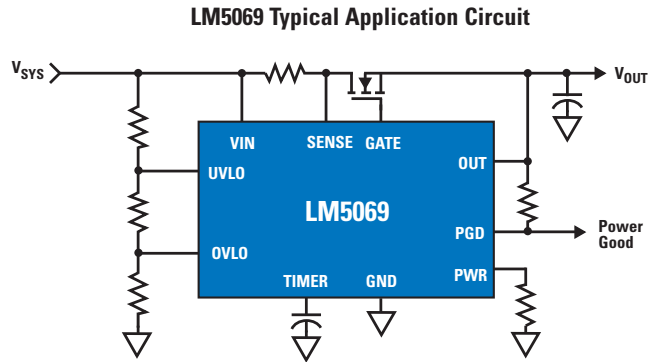
^W WEBENCH® enabled

Hot Swap/In-Rush Current Controllers

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

Features

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

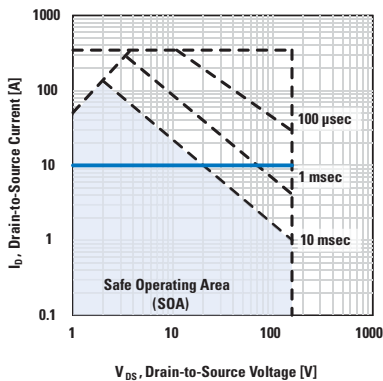


Power Limiting Protects External Pass Device for Improved System Reliability

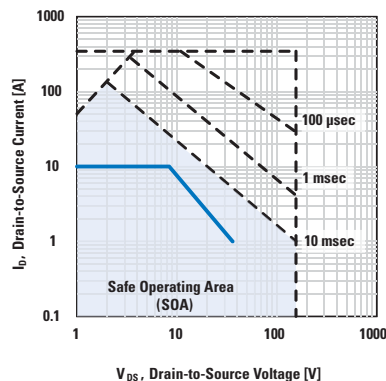
To ensure system reliability, any MOSFET must operate within its SOA in order to avoid FET failure. National's LM(2)506x hot swap controllers provide both current and power limiting to

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

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



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



Hot Swap/In-Rush Current Controllers

Product ID	V_{IN} Range (V)	Power GOOD	Adjustable UVLO	Adjustable OVLO	Active In-Rush Current Limit	Active Current Limiting	Active Power Limiting	Fault Latch-Off/Auto Retry	Packaging
LM5067 ^E	+9 to -80	V_{DS}	✓	✓	✓	✓	✓	Both	mini SOIC-10, SOIC-10 wide
LM5069 ^E	+9 to +80	V_{DS}	✓	✓	✓	✓	✓	Both	mini SOIC-10
LM25061 ^E	+2.9 to +17	V_{OUT} (Adj)	✓	—	✓	✓	✓	Both	mini SOIC-10
LM25069 ^E	+2.9 to +17	V_{DS}	✓	✓	✓	✓	✓	Both	mini SOIC-10

^E Evaluation board

Low-Dropout (LDO) Linear Regulators

LP38xxx Family of High-Performance CMOS LDOs Power Digital ICs

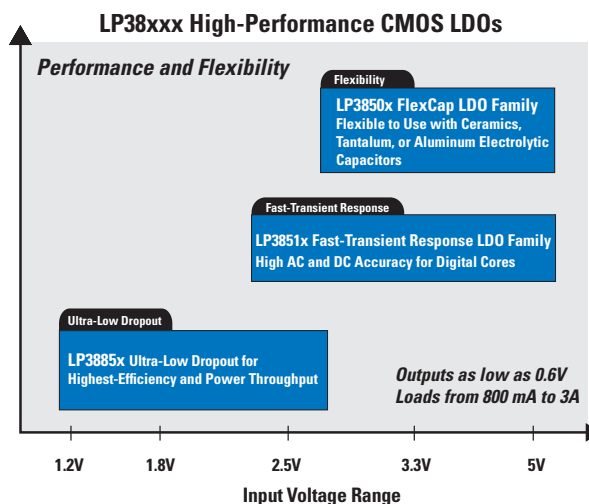
Performance and Flexibility

The LP38xxx family offers performance:

- Ultra-low dropout as low as 115 mV
- Fast-transient response with high AC and DC accuracy for powering digital cores
- High efficiency of 80% for 1.5V to 1.2V conversions

The LP38xxx family offers flexibility:

- Flexible to use with ceramics, tantalum, and aluminum electrolytic capacitors
- Supports input voltages from 1.2V, 1.5V, 1.8V, 2.5V, 3.3V, and 5V rails
- Load currents from 800 mA to 3A with the same pin-out



Fast Transient Response LDOs

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	✓	✓	T0263-5
LP38512 ^E	1.5	2.25	5.5	1.8, Adj down to 0.8V	✓	✓	T0263-5, LLP-8
LP38513 ^E	3.0	2.25	5.5	1.8, Adj down to 0.8V	✓	✓	T0263-5

Low Input Voltage and High-Efficiency LDOs

Product ID	Load Current (A)	V _{OUT} Options (V)	Adj. Output	Enable Pin	Soft-Start Pin	Typical Dropout (mV)	Packaging
LP38851	0.8	Adj 0.8 to 1.8	✓	✓	✓	115	PSOP-8, T0263-7
LP38852 ^E	1.5	Adj 0.8 to 1.8	✓	✓	✓	180	PSOP-8, T0263-7
LP38855	1.5	0.8V, 1.2	—	✓	—	180	T0263-5, T0220-5
LP38858	1.5	0.8V, 1.2	—	—	✓	180	T0263-5, T0220-5
LP38853 ^E	3.0	Adj 0.8 to 1.8	✓	✓	✓	450	PSOP-8, T0263-7
LP38856 ^E	3.0	0.8V, 1.2	—	✓	—	450	T0263-5, T0220-5
LP38859 ^E	3.0	0.8V, 1.2	—	—	✓	450	T0263-5, T0220-5

FlexCap LDOs





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	—	T0263-5, LLP-8
LP38502 ^E	1.5	2.7	5.5	Adj down to 0.6	220	✓	T0263-5, LLP-8
LP38501 ^E	3.0	2.7	5.5	Adj down to 0.6	450	✓	T0263-5
LP38503	3.0	2.7	5.5	Adj down to 0.6	450	—	T0263-5

PowerWise® product





^EEvaluation board

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






Low-Dropout CMOS Linear Regulator Family

Product ID	V _{IN}		V _{OUT}	Maximum Dropout (mV)	Load (mA)	Enable Pin	Packaging
	Min	Max					
LP38690 	2.7	10	ADJ (1.25 - 9) or 1.8, 2.5, 3.3, 5	1600	1000	—	T0252-3, SOT223-5, LLP-6
LP38691 	2.7	10	ADJ (1.25 - 9) or 1.8, 2.5, 3.3, 5	725	500	—	T0252-3, LLP-6
LP38692 ^E 	2.7	10	ADJ (1.25 - 9) or 1.8, 2.5, 3.3, 5	1600	1000	✓	SOT223-5, LLP-6
LP38693 ^E 	2.7	10	ADJ (1.25 - 9) or 1.8, 2.5, 3.3, 5	725	500	✓	SOT223-5, LLP-6

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

Product ID	Input Max Voltage (V)	Input Min Voltage (V)	Output Current (mA)	Dropout Voltage (V)	Output Voltage (V)	Adjustable Output	On/Off Pin	Quiescent Current (mA)	PSRR (dB)	Voltage Noise (RMS)	Packaging
LP3990 	6.0	2.0	150	0.06	1.5, 3.8, 1.8, 2.5, 0.8, 1.35, 2.8, 1.2, 3.3	—	✓	0.043	55	125	SOT23-5, micro SMD-4, LLP-6
LP3991 ^E 	3.6	1.65	300	0.075	1.5, 1.3, 2.8, 1.2	—	✓	0.05	65	280	micro SMD-4
LP5951 ^E 	5.5	1.8	150	0.2	2.0, 1.5, 3.0, 1.8, 1.3, 2.5, 2.8, 3.3	—	✓	0.029	60	125	SOT23-5, SC70-5
LP5952 ^E 	4.5	0.9	350	0.088, 0.128	2.0, 1.6, 1.5, 0.7, 1.8, 1.3, 1.0, 1.2, 1.2, 1.4	—	✓	0.011	95	100	micro SMD-5

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

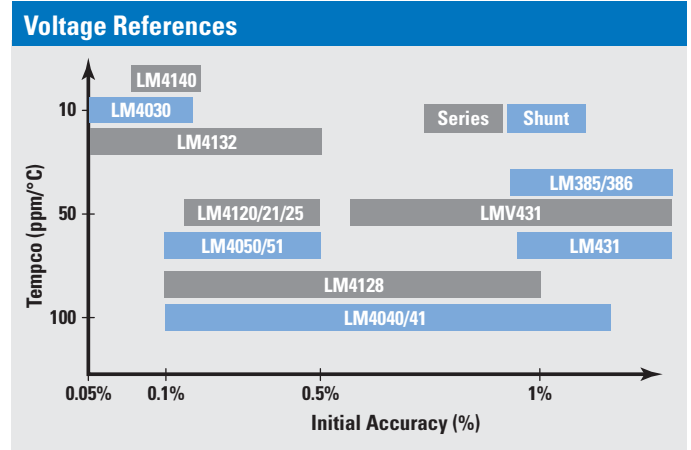
Product ID	Input Max Voltage (V)	Input Min Voltage (V)	Output Current (mA)	Dropout Voltage (V)	Output Voltage (V)	Adjustable Output	On/Off Pin	Quiescent Current (mA)	PSRR (dB)	Voltage Noise (RMS)	Packaging
LP3995 	6.0	2.5	150	0.06	3, 2.8, 1.9	—	✓	0.085	60	25	micro SMD-5, LLP-6
LP3997 	6.0	2.0	250	0.14	3.3	—	✓	0.055	61	100	MSOP-8
LP3999 	6.0	2.5	150	0.06	1.5, 2.4, 1.8, 2.5, 2.8, 3.3	—	✓	0.085	60	30	micro SMD-5
LP5900 ^E 	5.5	2.5	150	0.08	1.5, 2.8, 3.3	—	✓	0.025	75	6.5	micro SMD-4
LP5990 ^E 	5.5	2.2	200	0.15	0.8 to 3.6	—	✓	0.03	55	60	micro SMD-4

 PowerWise® product

^E Evaluation board

High-Precision Voltage References

National's reference portfolio features low temperature coefficients and precise initial accuracy voltage references. Both series references and shunt references are available for a wide variety of industrial applications including instrumentation, test equipment, data acquisition, servo systems, battery chargers, and portable battery-powered equipment.



Voltage References

Product ID	Type	Input Max (V)	Input Min (V)	Reference (V)	Initial Accuracy (+/-) Max	Tempco, max (ppm/C)	Output Current (mA)	Quiescent Current (mA)	Long Term Stability (ppm/1000hr)	Voltage Noise (μV_{p-p})	Packaging
LM4120	Series	14	3.3	3, 3.3, 4.096, 2.048, 5, 1.8, 2.5	0.2, 0.5	50	5.0	0.16	100	20	SOT23-5
LM4125	Series	6.0	3.3	4.096, 2.048, 2.5	0.2, 0.5	50	5.0	0.16	100	20	SOT23-5
LM4128	Series	5.5	2.2	3, 3.3, 4.096, 2.048, 1.8, 2.5	0.1, 0.2, 0.5, 1	75, 100	20	0.06	50	170	SOT23-5
LM4132	Series	5.5	2.2	4.096, 2.048, 2.5	0.05, 0.1, 0.2, 0.4, 0.5	10 to 30	20	0.06	50	170	SOT23-5
LM4140	Series	5.5	1.8	1.25, 4.096, 2.048, 1.024, 2.5	0.1	3.0	8.0	0.23	60	2.2	SOIC-8 Narrow
LM4030	Shunt	—	—	2.5, 4.096, 5.0	0.05, 0.10, 0.15	10, 20, 30	30	0.12	50	100	SOT23-5
LM4050	Shunt	—	—	2.048, 2.5, 4.096, 5, 8.192, 10	0.1, 0.2, 0.5	50	15	0.06	120	34	SOT23-3
LM4040/41	Shunt	—	—	2.048, 2.5, 3, 4.096, 5, 8.192, 10	0.1, 0.2, 0.5, 1, 0, 2.0	100,150	15	0.06	120	35	SOT23-3, SC70-5
LM431	Shunt	—	—	Adj	1.0	50	100	1.0	—	—	micro SMD-4, SOT23-3, SO-8
LMV431	Shunt	—	—	Adj	0.5,1.0, 1.5	39	30	0.055	—	—	SOT23-5, TO92-3
LM385/86	Shunt	—	—	Adj, 1.2, 2.5	2, 3	150	20	0.01	—	—	SOIC Narrow-8, SOT23-3, TO92-3

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