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VOICE OF THE ENGINEER

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Issue 9/2008
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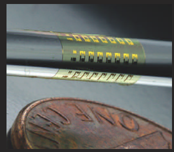

10 GbE IN THE MAINSTREAM

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EDN'S 2007 INNOVATOR AND INNOVATIONS OF THE YEAR

Page 27

BUCK-BOOST CONVERTERS CHANGE WITH THE TIMES

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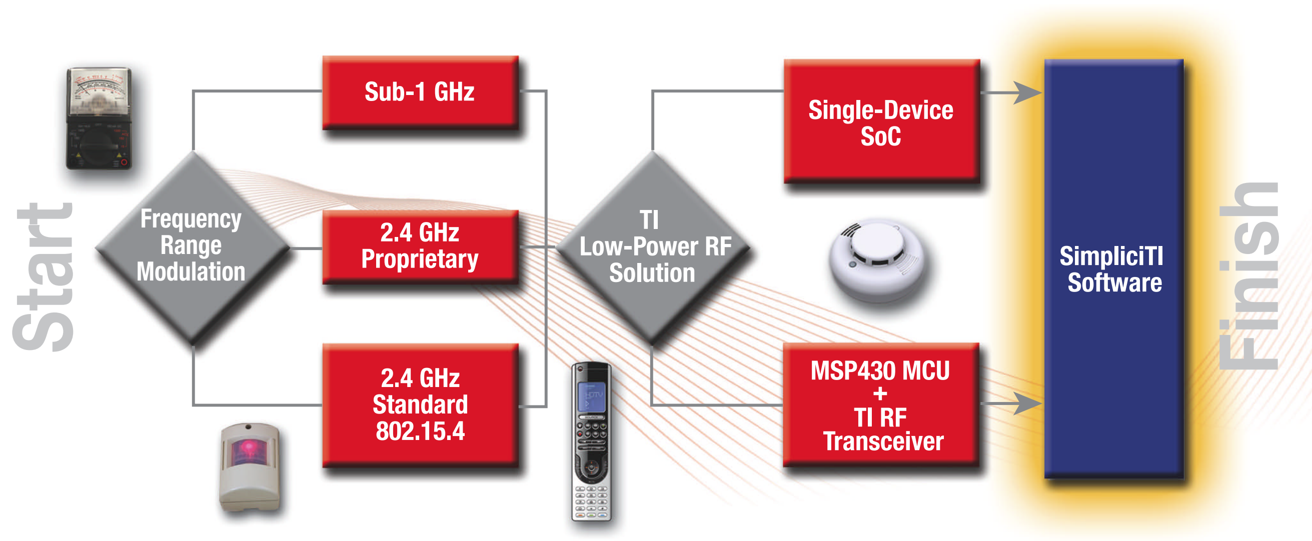
WHAT YOU WANT,
WHEN YOU NEED IT.
Digi-Key®
CORPORATION

SimpliciTI™ — RF Made Easy

Network Protocol for Sub-1 GHz, 2.4 GHz and IEEE/802.15.4 RF ICs

High-Performance Analog>>Your Way™



SimpliciTI is a low-power RF protocol aimed at simple, small RF networks. This open-source software is an excellent start for building a network with battery-operated devices using one of TI's low-power RF SoCs or the MSP430 ultra-low-power MCU and a TI RF transceiver. SimpliciTI network protocol supports alarm and security systems, automatic meter reading, smoke detectors, home automation and active RFID applications.

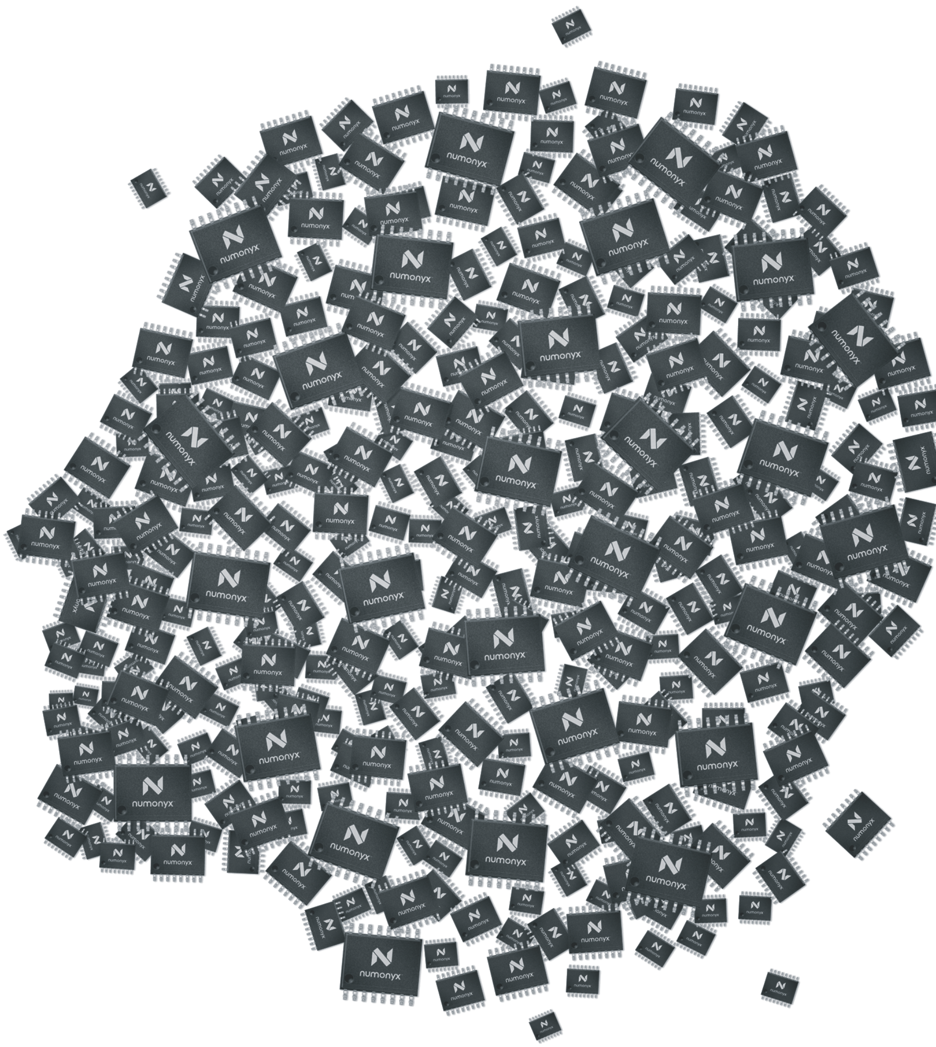
SimpliciTI works with the following low-power RF devices and tools:

Product	Description
CC1101	Sub-1 GHz, highly integrated, multi-channel RF transceiver designed for low-power wireless applications
CC111x	Sub-1 GHz System-on-Chip with enhanced 8051 MCU, up to 32 kB programmable Flash memory and optional USB
CC2520	Second-generation 2.4 GHz RF transceiver for proprietary and ZigBee®/IEEE 802.15.4 RF ICs with state-of-the-art selectivity/co-existence, excellent link budget, extended temperature range (–40°C to +125°C) and low-voltage operation
CC2430	2.4 GHz System-on-Chip specifically tailored for IEEE 802.15.4 and ZigBee applications. CC2430 comes in three different flash versions, 8F, 16F and 32F, with 32/64/128 kB of Flash memory, respectively
CC2500	2.4 GHz RF transceiver designed for low-power wireless applications in the 2.4 GHz ISM band
CC251x	2.4 GHz, low-power System-on-Chip with integrated MCU, up to 32 kB Flash memory and optional full-speed integrated USB
eZ430-RF2500	USB stick-based development tool combining the ability of the ultra-low-power MSP430 with low-power RF transceiver in a single device

Development kits are available for all products.

www.ti.com/simpliciti 1.800.477.8924 ext. 4354
Download Software Today!

Texas Instruments



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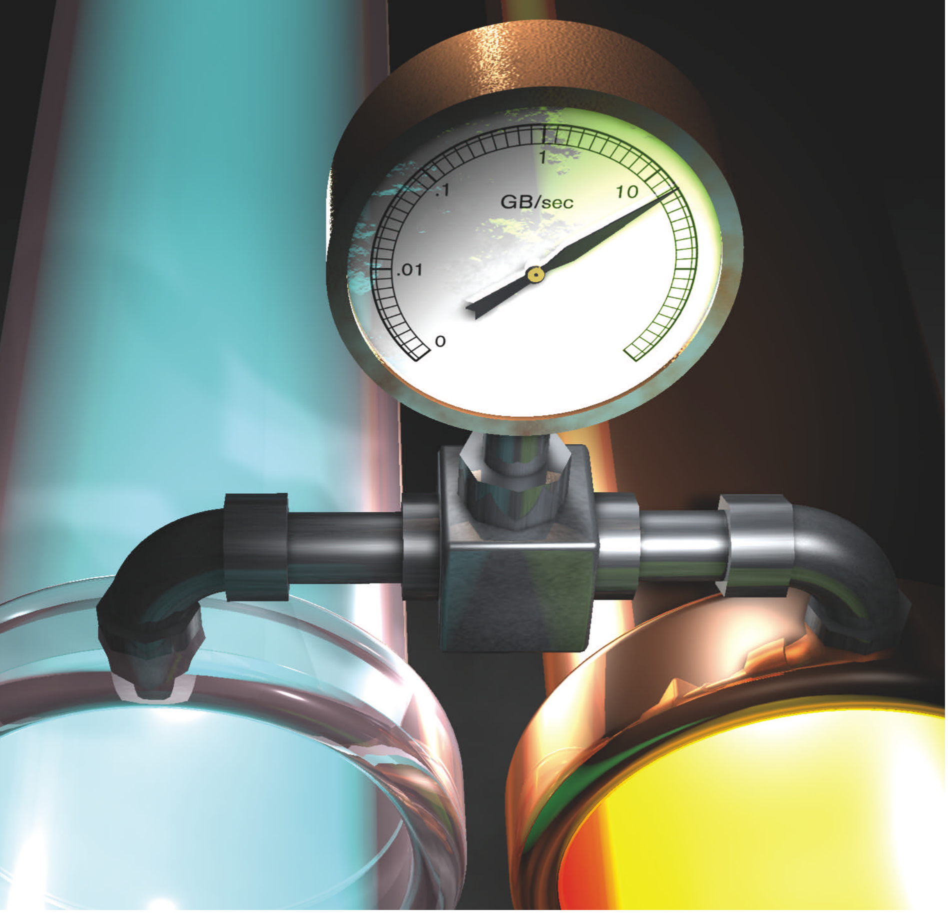
numonyx™



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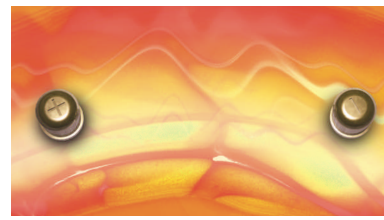
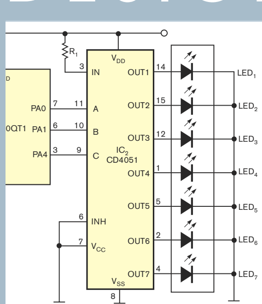


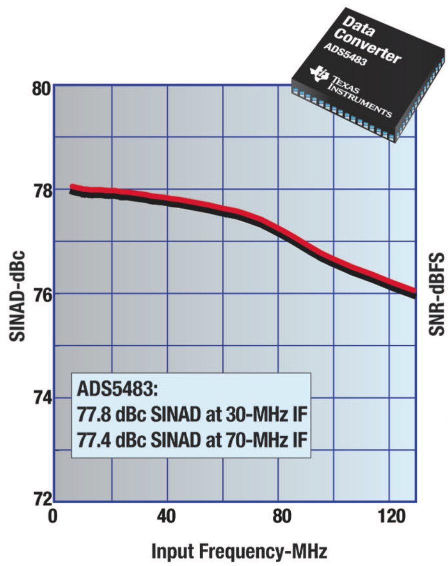
DESIGNIDEAS

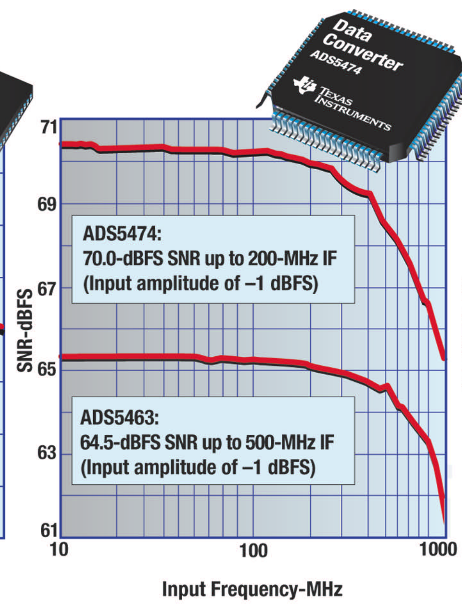


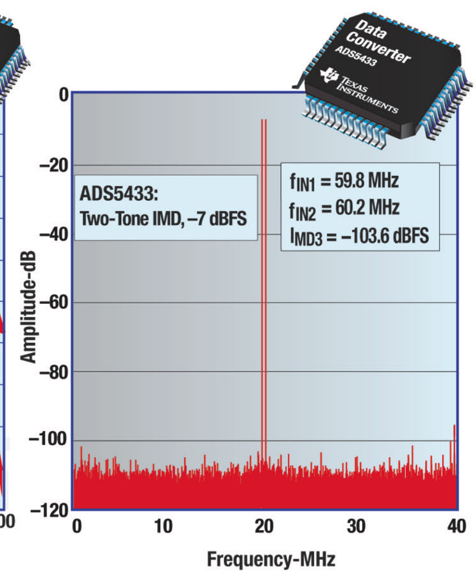
Ultimate Performance ADCs

High Speed and Resolution with Buffered Inputs

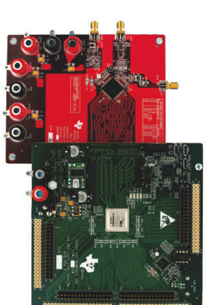
High-Performance Analog>>Your Way™







TI's portfolio of small-form factor, high impedance input, bipolar junction transistor ADCs deliver the highest speed, resolution, dynamic performance and widest operational envelope in the industry. Whether you're designing for wideband communications, advanced avionics or test & measurement, TI provides your design with the performance characteristics required to win in the marketplace. **That's High-Performance Analog>> Your Way™.**



Device	Description
ADS5483	**16-bit, 135-MSPS ADC** with high SNR, SFDR and SINAD up to 130-MHz input frequency, with 77.8 SINAD at 30 MHz and 77.4 SINAD at 70 MHz IF. Available in a 9 mm x 9 mm QFN package. Pin-compatible with ADS5482 and ADS5481.
ADS5474	**14-bit, 400-MSPS ADC** provides typical SNR above 70 dBFS and SFDR greater than 80 dBc for input frequencies from DC to 200 MHz. Available in a 14 mm x 14 mm HTQFP package. Pin-compatible with ADS5463, ADS5444 and ADS5440.
ADS5433	**14-bit, 80-MSPS ADC** optimized for spurious-free dynamic range with 91-dBc SFDR guaranteed for a 30-MHz input across the I-temp range (–40°C to 85°C). Available in a 12 mm x 12 mm QFP package. Pin-compatible with ADS5423, ADS5424 and AD6644/45.
ADS5463	**12-bit, 500-MSPS ADC** offers high SNR and linearity with 10 ENOB through second Nyquist. Ideal for wide bandwidth, under sampling applications. Available in a 14 mm x 14 mm HTQFP package. Pin-compatible with ADS5474, ADS5444 and ADS5440.

www.ti.com/ads5474 1.800.477.8924 ext. 14453
Get samples and evaluation modules

Texas Instruments

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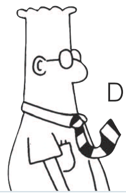

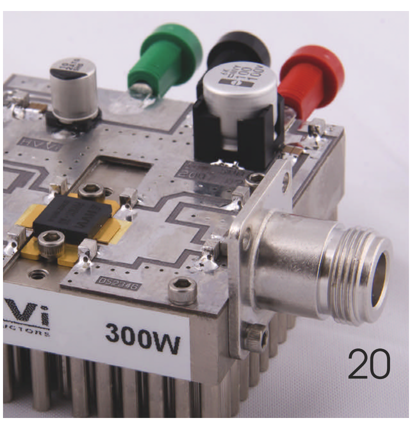

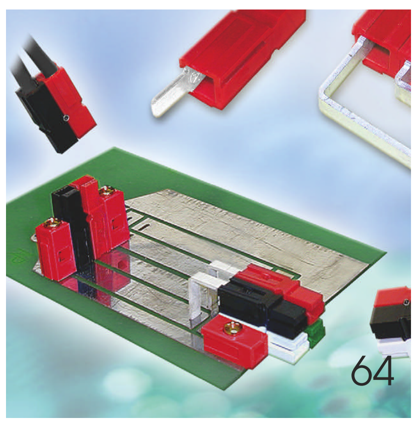

DEPARTMENTS & COLUMNS

PRODUCT ROUNDUP

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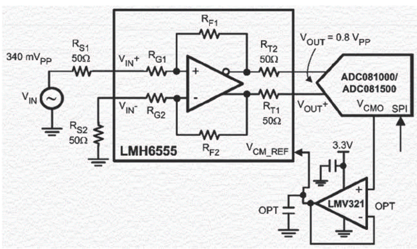

ONLINE ONLY

Check out these Web-exclusive articles:

Interfacing high-speed data converters
There are many ways to present a signal to a high-speed ADC. This article explains the tradeoffs between baluns, transformers, and op amps.
→www.edn.com/article/CA6550773

Synplicity introduces secure IP flow for FPGAs, signs ARM, Tensilica as partners
ReadyIP initiative aims to provide simple “try-before-you buy” access to IP for evaluation and FPGA implementation.
→www.edn.com/article/CA6551580

Group announces nonvolatile-memory host-controller spec
The specification aims to speed adoption of NAND flash in PC applications including hard-disk caching and solid-state drives.
→www.edn.com/article/CA6551696

IBM alliance touts early success for 32-nm high-k/metal gate technology
Circuits built using the technology perform up to 35% better and consume 45% less power than 45-nm process counterparts.
→www.edn.com/article/CA6551281

NXP, ST combine wireless operations for handset-focused joint venture
As part of the agreement, ST will take an 80% stake in the joint venture for which it will pay NXP $1.55 billion.
→www.edn.com/article/CA6550321

AMD: Time keeps on slippin,’ slippin’, slippin’
The root of my concern is that AMD has had to go the one-bad-core route at all, and that the triple-core launch was so obviously a last-minute reactive move versus a long-planned proactive part of Phenom program.
→www.edn.com/080501toc1

READERS’ CHOICE

A selection of recent articles receiving high traffic on www.edn.com.

Heads and tails: Design RF amplifiers for linearity and efficiency
Base stations and handsets need RF amplifiers with high linearity and efficiency. With some clever techniques, designers can align these mutually exclusive goals.
→www.edn.com/article/CA6544734

Current source makes novel Class A buffer
A pair of classic current sources in totem-pole configuration enables a novel Class A buffer.
→www.edn.com/article/CA6544738

Honest energy: The danger low-power-factor loads pose for the energy grid
As typical household products become more sophisticated, the power factor of the load they represent decays.
→www.edn.com/article/CA6544740

Designing a split termination
If no suitable voltage source exists for a relatively simple end-terminating structure, then you have no choice: You must synthesize the Thevenin equivalent.
→www.edn.com/article/CA6544741

Intel aims Atom at Internet ‘in your pocket’
Intel rolls out its Atom, the company’s smallest and lowest power processor, which contains 47 million transistors packed into an area of less than 25-mm^2 and targets pocket-sized mobile Internet devices.
→www.edn.com/article/CA6547147

Red LEDs function as light sensors
You can build simple LED illuminators using the red LED to sense ambient-light level.
→www.edn.com/article/CA6541376

DESIGN DRAMA

ENGINEER’S TRUE STORIES
Tales From The Cube, which appears on the back page of every issue, has become one of *EDN*’s most popular sections because it features true engineering stories as told by EEs. To catch up on any Tales you might have missed—and learn how to submit your own— please check out our new Tales archive page.
→www.edn.com/tales

FROM *EDN*’S BLOGS

Xilinx’s Gavrielov looks into the future of FPGAs

From Practical Chip Design, by Ron Wilson
You can almost detect between the lines that, as in the advanced microprocessor world, scaling is slowing down for FPGAs, and other issues are becoming more important than just getting to the next process node quickly.
→www.edn.com/080501toc3

Greenpeace pressure on the electronic supply chain: helpful or hurtful?

Supply Chain Reaction, by Suzanne Deffree,
What’s to stop governments from adopting stricter regulations brought about by electronics companies or from groups like Greenpeace pressuring the industry to be ever more green? It’s not like the powers that be bother to do life-cycle assessments before implementing these directives.
→www.edn.com/080501toc4

BY RICK NELSON, EDITOR-IN-CHIEF

Be careful what you promise

In the current cartoon series on my *Dilbert* calendar, Dilbert is trying to mount a marketing campaign with limited resources. He had hoped to exploit the laziness of hapless engineer Wally, which would seem to be counterproductive, and the attractiveness of a female colleague, Yvonne, which would seem to be illegal.

In any event, things don't work out for Dilbert. Yvonne convinces him to do her work for her, Wally goes on leave, and Dilbert's left with just his wits and a pencil. (The pointy-haired boss has appropriated Dilbert's computer.)

I would have recommended that Dilbert simply write a press release about his company's "out-of-the-box integrated end-to-end solution that increases ... effectiveness." But it turns out that this claim could be problematic. As reported in the April 8 *Wall Street Journal*, "SAP AG is being sued for failing to deliver an 'out-of-the-box integrated end-to-end solution. ...'" Ben Worthen, the story's author, states "Amazingly, the meaning of these buzzwords [is] at the heart of a claim seeking more than $100 million."

Now, marketing campaigns in which it's unclear whether the "solution" on offer is hardware, software, both, or neither have often baffled and annoyed me. And I wonder whether an end-to-end solution would be preferable to a beginning-to-end solution and whether an out-of-the-box solution can truly push the envelope. I also find paradigms perplexing, especially when they shift.

But buzzwords in our industry are unavoidable, and it behooves the target of marketing messages—or the trade-press editor through which marketers often convey these messages—to try to determine exactly what a marketer means. For my part, I would expect any software solution—whether it's part of a paradigm shift or not and whether it's located in the box or out of the box or at the beginning, middle, or end—to have "issues." I'd be hesitant to buy a solution or write about one in the pages of *EDN*, without further investigation.

It's notable that the vagueness of a phrase like "out-of-the-box solution" could lead to litigation.

I have no opinion about the merits of the suit against SAP, in which the plaintiff, Waste Management Inc, argues that SAP delivered an "undeveloped, untested, and defective" product instead of "a mature 'out-of-the-box' solution with the functionality and scalability necessary to meet Waste Management's specific business requirements and transaction volumes." But it's notable that the vagueness of a phrase like "out-of-the-box solution" could lead to litigation.

Being too specific can also get business people in trouble. In an opinion piece titled "Making Business a Crime" in the April 9 *Wall Street Journal*, criminal-defense lawyer Harvey Silverglate cites statements issued by Bear Sterns, including one to the effect that "balance sheet, liquidity, and capital remain strong."

I'm not a banker, but that statement seems clear enough to me. It also turned out to be too optimistic, and, writes Silverglate, "The Department of Justice has reportedly launched a criminal investigation into these public statements, just as they have done in recent years to other professionals who have engaged in seemingly routine requirements of their job." Perhaps Bear should have announced an "out-of-the-box integrated end-to-end solution that increases ... liquidity."

If there's a lesson in all these proceedings, it's: Be clear, but be accurate. And, as Worthen at the *WSJ* points out, we might end up with a legal definition of "integrated end-to-end out-of-the-box solution." **EDN**

Contact me at rnelson@reedbusiness.com.

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The Impact System features:
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PRESIDENT, BOSTON DIVISION, REED BUSINESS INFORMATION
Mark Finkelstein, mark.finkelstein@reedbusiness.com
1-781-734-8431

PUBLISHER, *EDN* WORLDWIDE
Russell E Pratt, 1-781-734-8417;
rpratt@reedbusiness.com

ASSOCIATE PUBLISHER, *EDN* WORLDWIDE
Judy Hayes, 1-408-345-4437;
judy.hayes@reedbusiness.com

VICE PRESIDENT, EDITORIAL DIRECTOR
Karen Field, 1-781-734-8188;
kfield@reedbusiness.com

EDITOR-IN-CHIEF, *EDN* WORLDWIDE
Rick Nelson, 1-781-734-8418;
rnelson@reedbusiness.com

EXECUTIVE EDITOR
Ron Wilson, 1-408-345-4427;
ronald.wilson@reedbusiness.com

EDITOR-IN-CHIEF, EDN.COM
Matthew Miller
1-781-734-8446; fax: 1-303-265-3017;
mdmiller@reedbusiness.com

SENIOR ART DIRECTOR
Mike O'Leary
1-781-734-8307; fax: 1-303-265-3021;
moleary@reedbusiness.com

ANALOG
Paul Rako, Technical Editor
1-408-745-1994; paul.rako@reedbusiness.com

EMBEDDED SYSTEMS
Warren Webb, Technical Editor
1-858-513-3713; fax: 1-858-486-3646;
wwebb@edn.com

MASS STORAGE, MULTIMEDIA, PCs, AND PERIPHERALS
Brian Dipert, Senior Technical Editor
1-916-760-0159; fax: 1-303-265-3187;
bdipert@edn.com

MICROPROCESSORS, DSPs, AND TOOLS
Robert Cravotta, Technical Editor
1-661-296-5096; fax: 1-303-265-3116;
rcravotta@edn.com

NEWS
Suzanne Deffree, Managing Editor
1-631-266-3433; sdeffree@reedbusiness.com

POWER SOURCES, ONLINE INITIATIVES
Margery Conner, Technical Editor
1-805-461-8242; fax: 1-805-461-9640;
mconner@reedbusiness.com

SEMICONDUCTOR MANUFACTURING AND DESIGN
Ann Steffora Mutschler, Senior Technical Editor
1-408-345-4436; ann.mutschler@reedbusiness.com

DESIGN IDEAS EDITOR
Charles H Small
edndesignideas@reedbusiness.com

SENIOR ASSOCIATE EDITOR
Frances T Granville, 1-781-734-8439;
fax: 1-303-265-3131;
f.granville@reedbusiness.com

ASSOCIATE EDITOR
Maura Hadro Butler, 1-617-276-6523;
mbutler@reedbusiness.com

EDITORIAL/WEB PRODUCTION MANAGER
Diane Malone, Manager
1-781-734-8445; fax: 1-303-265-3024
Steve Mahoney, Production/Editorial Coordinator
1-781-734-8442; fax: 1-303-265-3198
Melissa Annand, Newsletter/Editorial Coordinator
Contact for contributed technical articles
1-781-734-8443; fax: 1-303-265-3279
Adam Odoardi, Prepress Manager
1-781-734-8325; fax: 1-303-265-3042

CONTRIBUTING TECHNICAL EDITORS
Dan Strassberg, strassbergedn@att.net
Nicholas Cravotta, editor@nicholascravotta.com

COLUMNISTS
Howard Johnson, PhD; Bonnie Baker;
Joshua Israelsohn; Pallab Chatterjee

PRODUCTION
Dorothy Buchholz, Group Production Director
1-781-734-8329
Kelly Jones, Production Manager
1-781-734-8328; fax: 1-303-265-3164
Linda Lepordo, Production Manager
1-781-734-8332; fax: 1-303-265-3015

EDN EUROPE
Graham Prophet, Editor, Reed Publishing
The Quadrant, Sutton, Surrey SM2 5AS
+44 118 935 1650; fax: +44 118 935 1670;
gprophet@reedbusiness.com

EDN ASIA
Raymond Wong, Managing Director/
Publishing Director
raymond.wong@rbi-asia.com
Kirtimaya Varma, Editor in Chief
kirti.varma@rbi-asia.com

EDN CHINA
William Zhang, Publisher and Editorial Director
wmzhang@idg-rbi.com.cn
John Mu, Executive Editor
johnmu@idg-rbi.com.cn

EDN JAPAN
Katsuya Watanabe, Publisher
k.watanabe@reedbusiness.jp
Ken Amemoto, Editor-in-Chief
amemoto@reedbusiness.jp

EDN. 225 Wyman St, Waltham, MA 02451. **www.edn.com**. Phone 1-781-734-8000. **Address changes or subscription inquiries:** phone 1-800-446-6551; fax 1-303-470-4280; subsmail@reedbusiness.com. For a free subscription, go to **www.getfreemag.com/edn**. Reed Business Information, 8878 S Barrons Blvd, Highlands Ranch, CO 80129-2345. Include your mailing label.

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EDN’s 18th Annual
INNOVATION
AWARDS
We’ve announced the
WINNERS!
EDN’s 18th Annual Innovation Award
winners were honored on April 14th
in San Jose, California
For a complete list of the 2007 Innovations
and Innovator of the Year, go to
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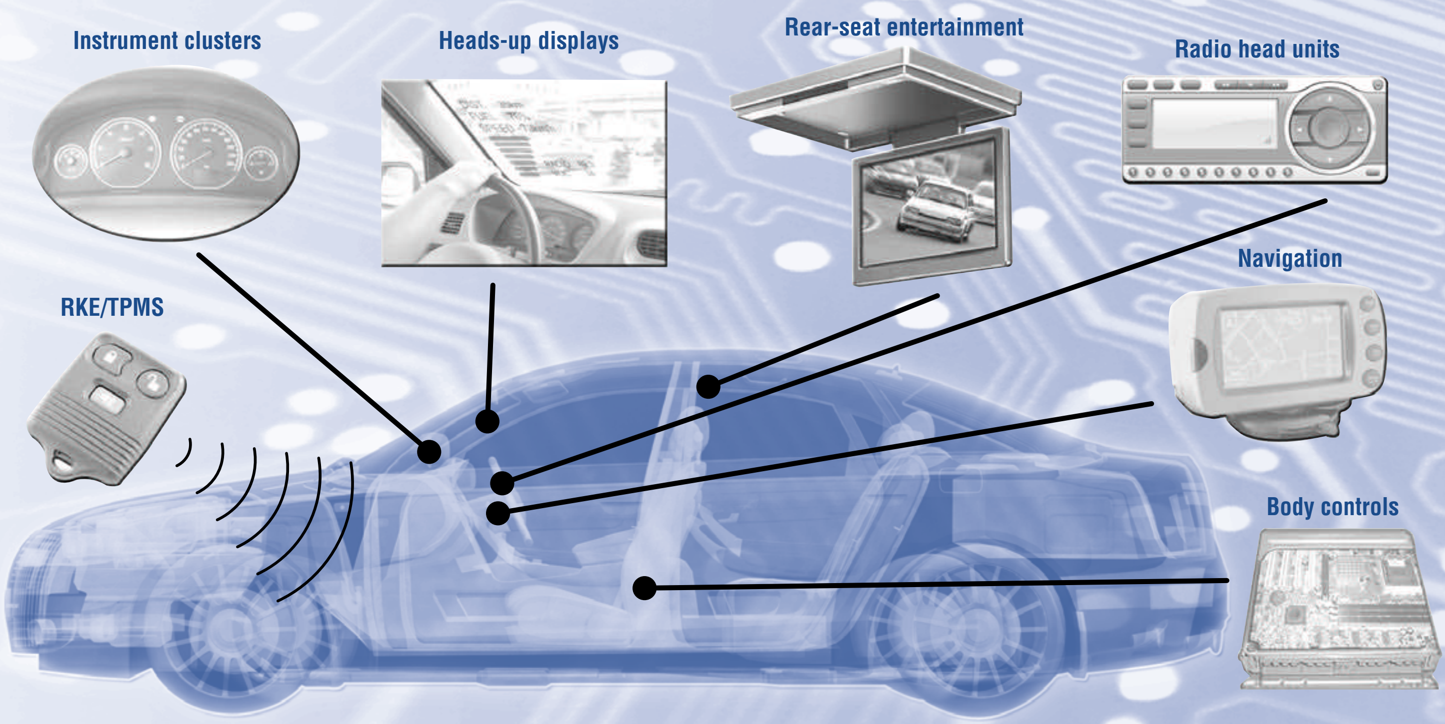
AUTOMOTIVE Design Guide

4th Edition April 2008

Comprehensive product portfolio fits all analog/mixed-signal automotive needs

Maxim provides a wide array of solutions for automotive applications specific to infotainment, driver assistance, body electronics, comfort, safety, lighting, and hybrid battery measurement.

Our high-performance, analog/mixed-signal ICs include multiple output switching regulators with load-dump protection; rugged drivers for vacuum-fluorescent displays (VFDs), active-matrix thin-film transistor (TFT) displays, and LCD/high-brightness (HB) LED displays; hall-effect sensor interfaces; contact monitors; and also a complete lineup of wireless ICs from high-range RKE transceivers to complete digital broadcast tuners.



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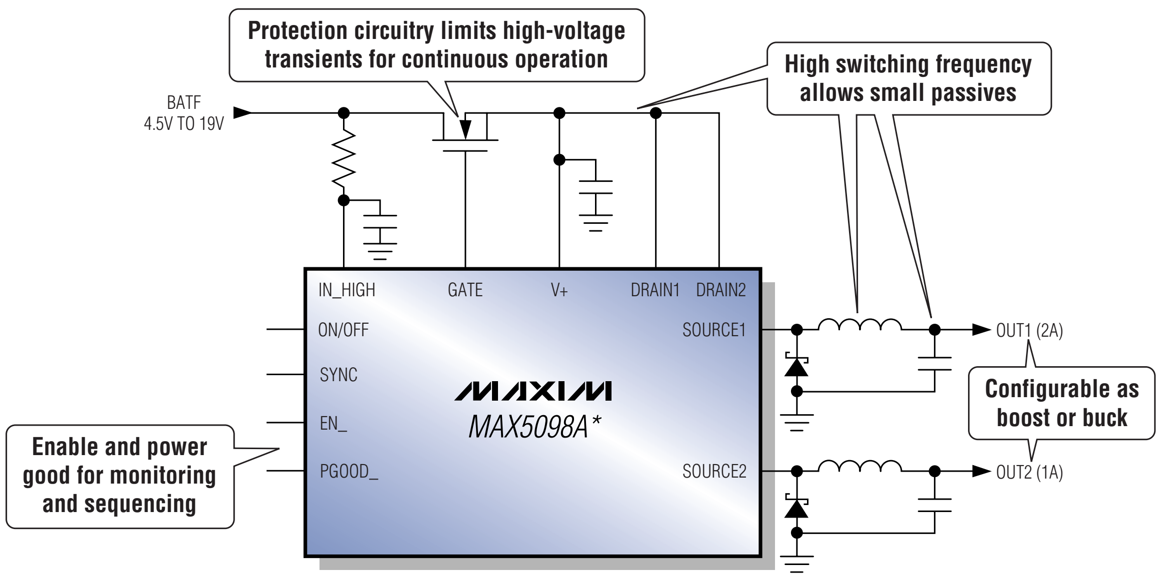
MAXIM

Future products

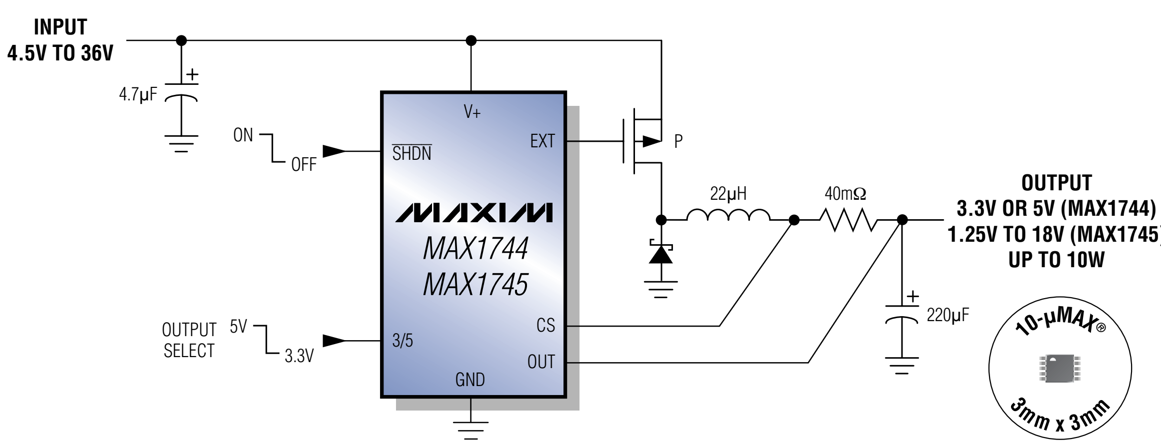
2.2MHz, dual-output switching regulators with 80V load-dump protection

The MAX5098A*/MAX5099* are designed to operate outside the AM radio band, making them suitable for radio head units and instrument clusters.



Small, 36V input, 10W output step-downs have low 90μA supply current

Simple controllers fit in μMAX package and are 95% efficient



- 4.5V to 36V input
- Drives low-cost p-channel switch
- Only 90μA quiescent supply current
- Up to 95% efficiency
- 1.25V to 18V output (MAX1745)
- Fixed 3.3V or 5V output (MAX1744)
- Small, 10-pin μMAX package
- EV kit available to speed designs

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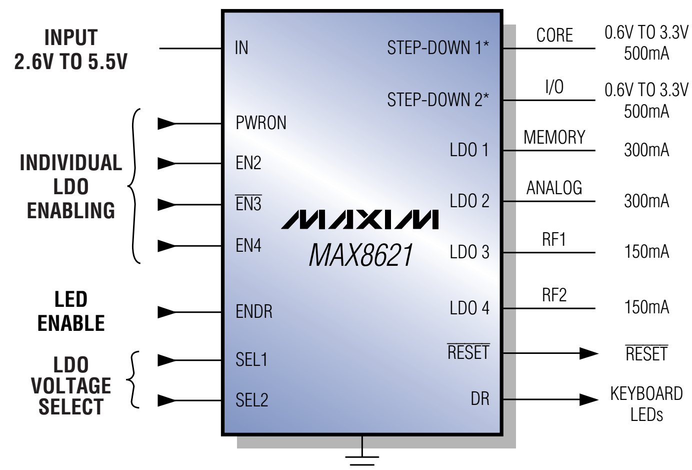
*Future product—contact factory for availability.

Smallest six-output PMIC has 92% efficiency

Highly configurable for your point-of-load automotive applications

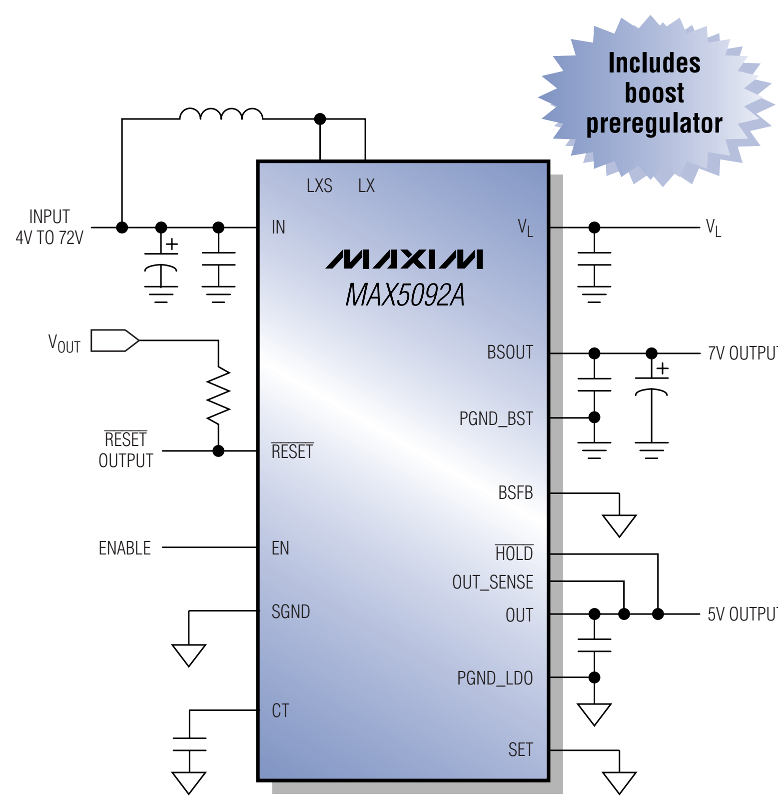
- Small 4mm x 4mm, 24-pin TQFN
- 4MHz step-down DC-DC uses 1µH inductor
- Internal synchronous rectifier for up to 92% efficiency
- 45µV$_{RMS}$ low-noise LDOs
- Pin-selectable LDO output voltages
- Internal soft-start for no inrush current

Integrates six outputs into one IC



Highly integrated, 250mA LDO operates seamlessly from 3.5V cold crank to 80V load dump

- 4V to 72V input-voltage range
- Guaranteed output over entire operating input-voltage range
- 60µA (typ) quiescent supply current, 12µA shutdown
- -40°C to +125°C operating temperature range
- 5mm x 5mm, 16-pin TQFN package dissipates 2.7W

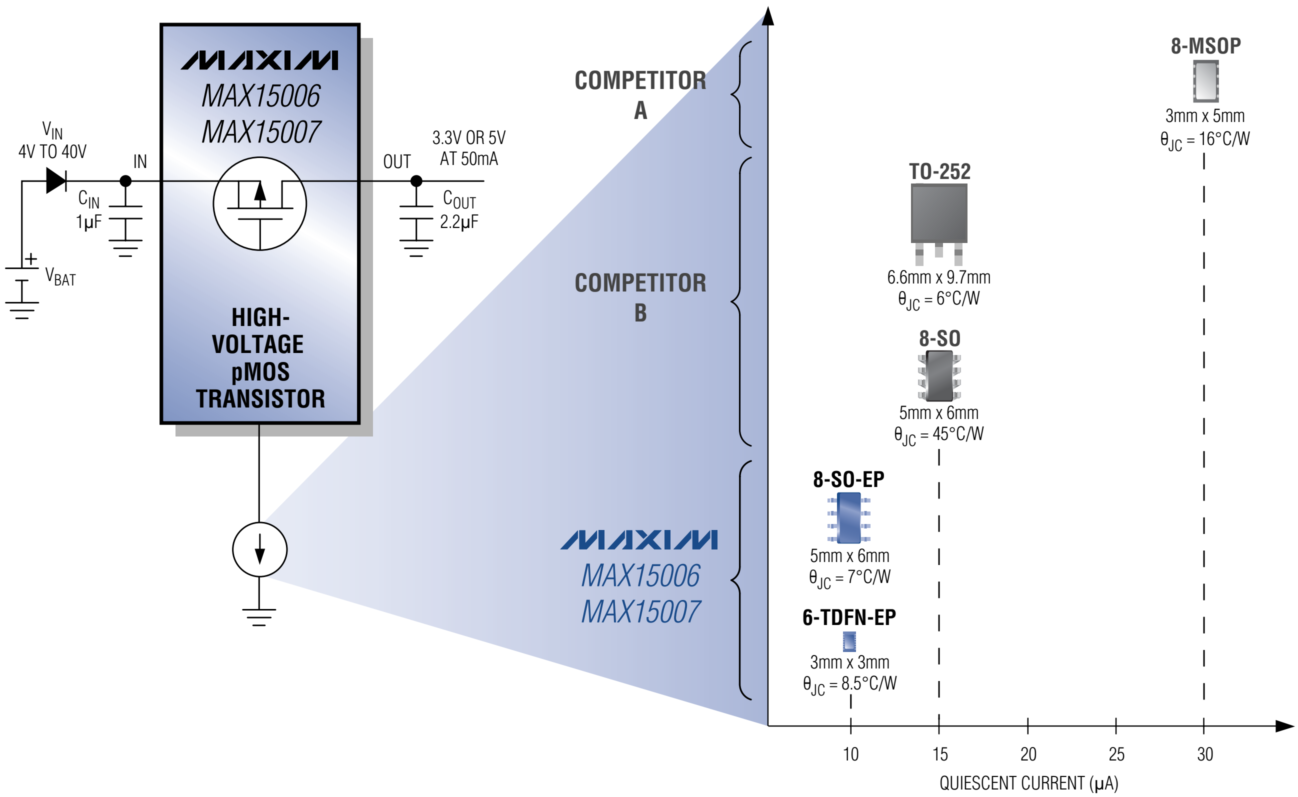


*Needs external components.

50mA, 10µA I_Q, automotive LDOs are best choice for always-on applications

The MAX15006/MAX15007 automotive LDOs integrate a high-voltage, p-channel MOS pass transistor provide low 10µA quiescent current and low-dropout operation from 4V cold crank to 40V load dump.

Smallest size with lowest quiescent current



- **Wide operating input-voltage range (4V to 40V)**
- **Guaranteed 50mA output current**
- **Low quiescent current: 10µA (no load) and 90µA (full load)**
- **Operates through cold-crank conditions**
- **Withstands 45V load dump**
- **Low 300mV dropout voltage (MAX15006B/MAX15007B)**
- **Stable operation with tiny 2.2µF output capacitor**
- **Enable input (MAX15007)**
- **Preset 3.3V and 5V output voltages**
- **Thermal and short-circuit protection**
- **Ideal for TPMS, RKE, and car alarms**

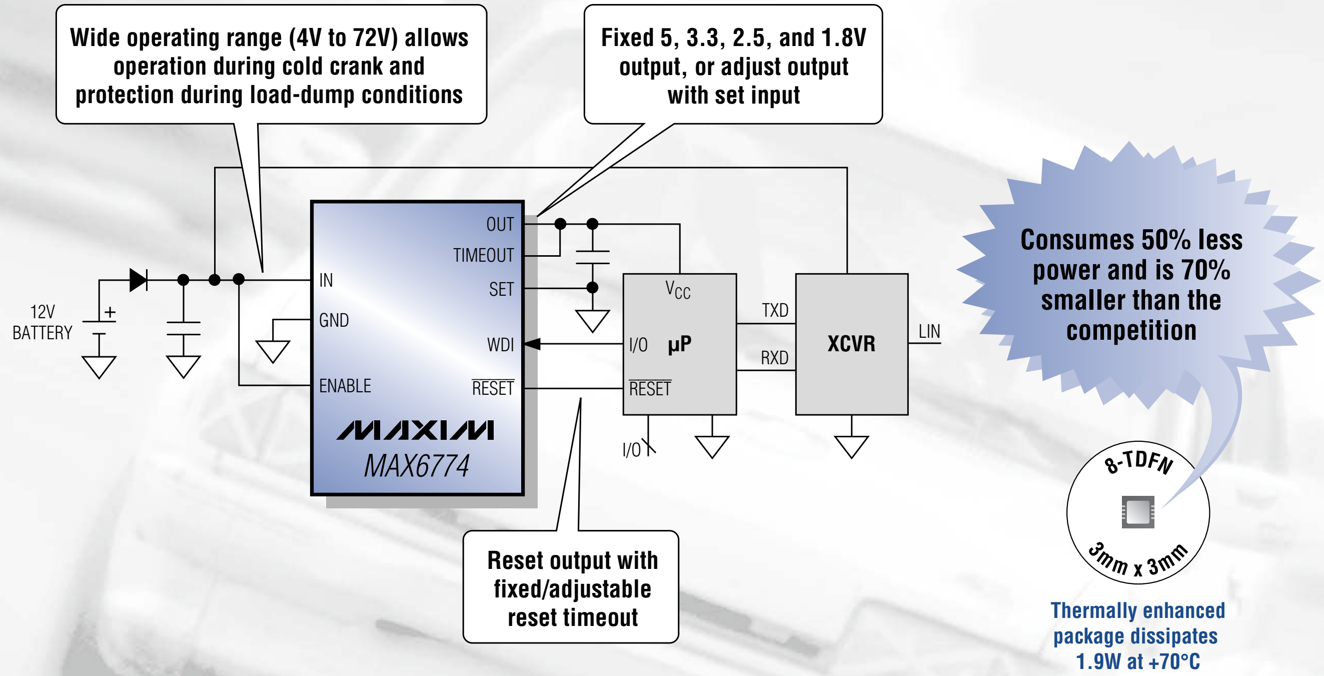
Low-I_Q automotive linear regulators

Part	I_Q (µA)	Input Voltage (V)	Output Voltage (V)	Output Current (mA)	Package (mm x mm)
MAX15006	10 (no load), 90 (full load)	4 to 40	3.3 or 5	50	6-TDFN (3 x 3), 8-SO
MAX15007	10 (no load), 90 (full load)	4 to 40	3.3 or 5	50	6-TDFN (3 x 3), 8-SO
MAX5086	70 (no load), 13 (shutdown)	6.5 to 65	3.3 or 5 (preset), 2.5 to 11 (adj)	250	16-/56-TQFN
MAX5087	70 (no load), 11 (shutdown)		3.3 or 5 (preset), 2.5 to 11 (adj)	400	16-/56-TQFN
MAX5023/MAX5024	60 (no load)		3.3 or 5, 2.5 to 11 (adj, MAX5024)	150	8-SO-EP
MAX5084/MAX5085	50		3.3 or 5 (preset), 2.54 to 11 (adj)	200	6-TQFN (3 x 3)

72V, 100mA automotive LDOs with integrated reset and watchdog timer consume only 30μA

New

Low 30μA quiescent current and thermally enhanced packages make these regulators ideal for always-on automotive modules

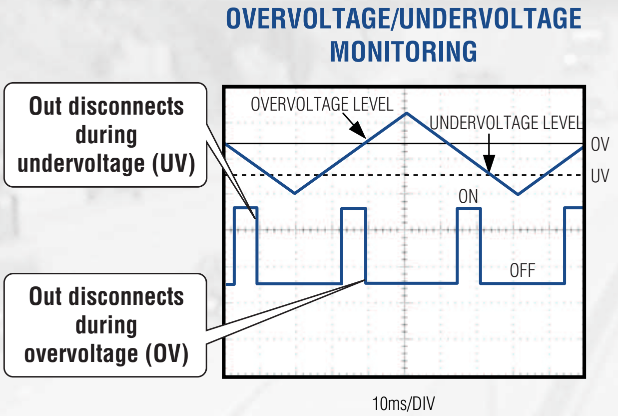


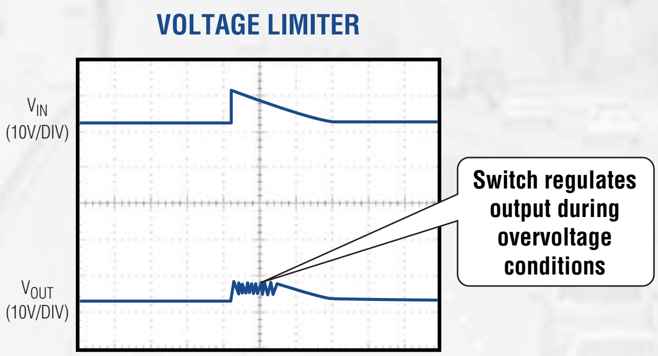
- ±1.5% output accuracy
- 1.8V to 11V adjustable output
- Enable and hold inputs
- Internal watchdog timer
- Output overvoltage protection with sink feature
- Thermal and short-circuit protection
- Fully specified from -40°C to +125°C

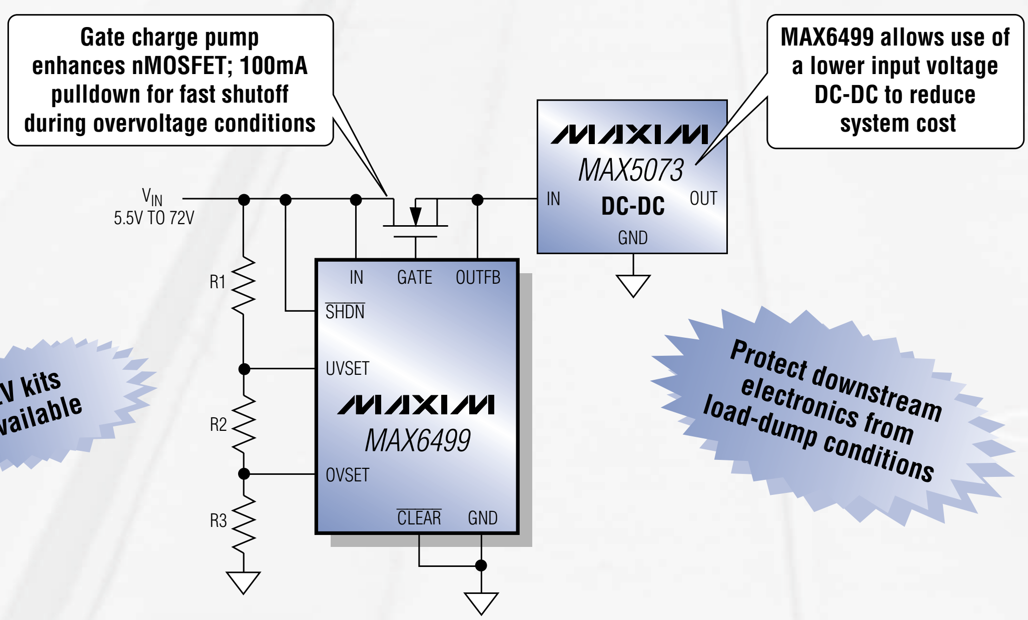
Part	Output Voltage	RESET Output	Additional Features
MAX6765/MAX6766	Fixed	Open drain/push-pull	—
MAX6767/MAX6768	Fixed/adjustable		Hold input
MAX6769/MAX6770			Adjustable reset input
MAX6771/MAX6772			Dual enables
MAX6773/MAX6774			Watchdog timer

72V switch controllers provide robust overvoltage/undervoltage protection

High integration ensures reliability, saves power, and reduces board space compared to discrete solutions







EV kits available

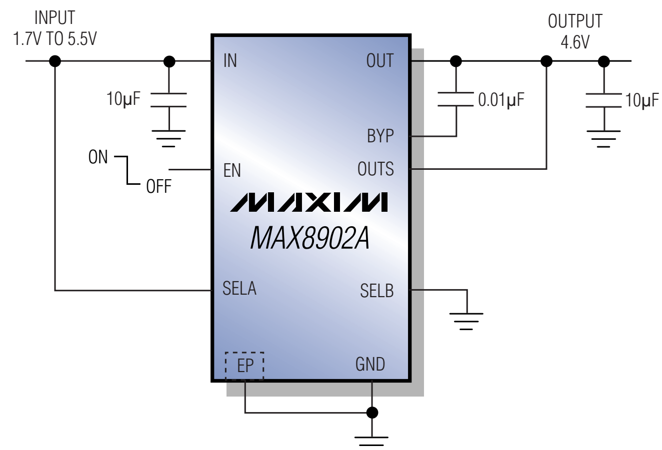
Protect downstream electronics from load-dump conditions

Part	Features
MAX6397/MAX6398	Overvoltage protection, 100mA always-on regulator (MAX6397)
MAX6399	Overvoltage/undervoltage monitoring with POK indicator
MAX6495/MAX6496	Small, 6-pin overvoltage protection circuit
MAX6497/MAX6498/MAX6499	Overvoltage/undervoltage monitoring, POK indicator, overvoltage latch, window monitoring
MAX16010–MAX16014	Window monitoring, output-disable feature, p-channel comparator options

New

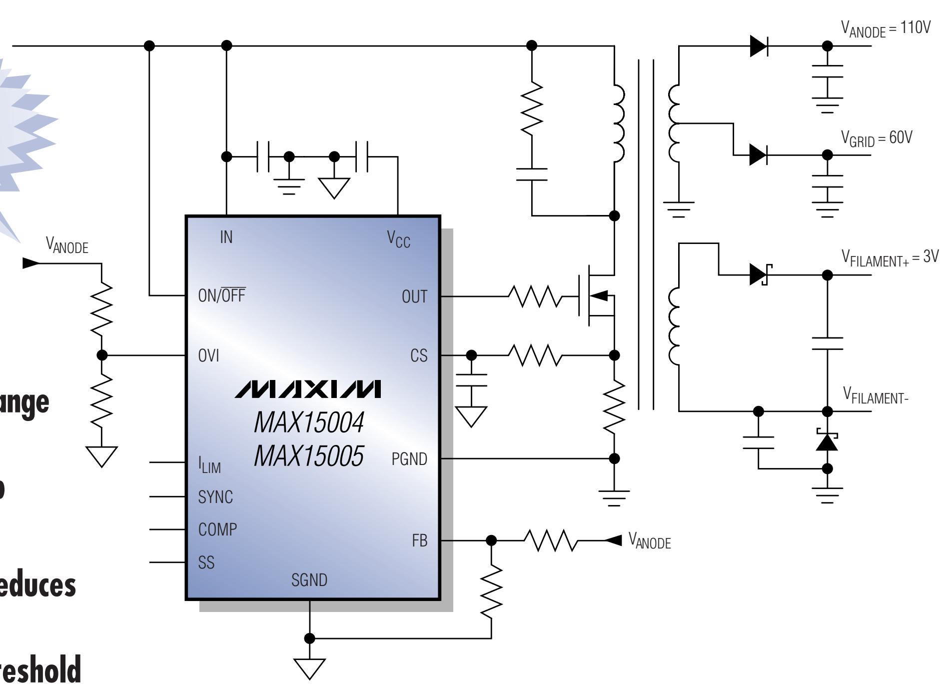
Low-noise, 5.5V_{IN}, 500mA LDO in a tiny, 2mm x 2mm TDFN package

- Guaranteed 500mA output current
- ±1.5% output accuracy over load, line, and temperature
- 16µV_{RMS} output noise at 10Hz to 100kHz
- 92dB PSRR at 5kHz
- 100mV (max) dropout at 500mA load
- 1.7V to 5.5V input-voltage range, ideal for secondary supplies
- 80µA operating supply current with < 1µA shutdown supply current
- 2mm x 2mm x 0.8mm TDFN package



High-voltage flyback/SEPIC/boost converter is ideal for automotive VFDs

Integrated overvoltage protection prevents damage to VFDs

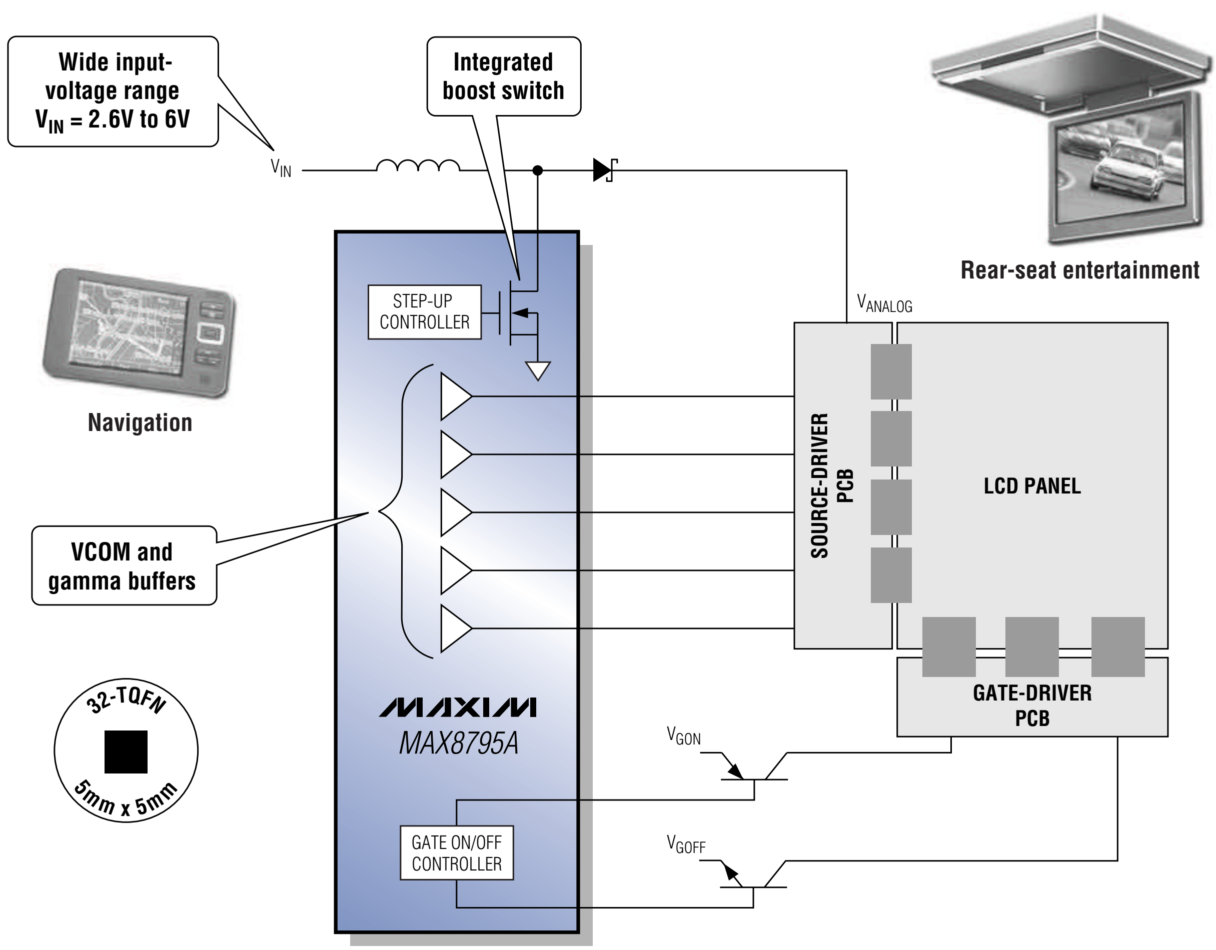


- Wide, 4.5V to 40V operating range
- Operates down to 2.5V for cold-crank startup in bootstrap
- ±1% accurate reference
- Low 10µA shutdown current reduces dark current
- ±5% accurate current-limit threshold allows use of smaller MOSFETs

TFT-LCD DC-DC converter with op amps offers the smallest solution

The MAX8795A DC-DC converter includes: a high-performance step-up regulator; two linear-regulator controllers; a logic-controlled, high-voltage switch with adjustable delay; and five high-current op amps for active-matrix TFT LCDs. This high level of integration enables the smallest solution for GPS and automotive entertainment applications.

Designed to drive the LCD backplane and/or the gamma-correction divider string, the integrated high-performance op amps feature a high ±130mA output current, fast 45V/µs slew rate, wide 20MHz bandwidth, and rail-to-rail inputs and outputs.



- 1.2MHz current-mode step-up regulator
  - Fast transient response
  - High ±1.5% output-voltage accuracy
  - Built-in 20V, 2.4A n-channel MOSFET
- Linear-regulator controllers for V_{GON} and V_{GOFF}
- Timer-delay fault latch for all regulator outputs
- Thermal-overload protection
- High-performance op amps
  - ±130mA output short-circuit current
  - 45V/µs slew rate
  - 20MHz, -3dB bandwidth
  - Rail-to-rail inputs/outputs
- Logic-controlled, high-voltage switch with adjustable delay

Robust high-brightness LED drivers for all automotive lighting applications

Superior efficiency, flexibility, and ease of use

Industry's highest efficiency

Front lights, DRL

MAX16821

- Up to 150W; > 94% efficient; buck, boost, or buck-boost; thermal shutdown and overvoltage protection

MAX16812

- 5.5V to 76V operation; compact; PWM/linear dimming; thermal shutdown

MAX16816/MAX16831

- High-power buck, boost, or buck-boost; programmable LED current simplifies design

Robust drivers withstand load dump and cold crank, +125°C temps, LED short conditions

Simple to use

Interior lights

MAX16803

- Compact; up to 350mA; low EMI

MAX16804

- PWM/theater dimming; no microcontroller required; low EMI

MAX16805/MAX16806

- Programmable for LED binning, eases manufacturing

EV kits available

Tail lamps, CHMSL, sidelights

MAX16823

- Three channels; independent dimming; shorted-LED and open-LED detection

MAX16824

- Three channels; independent dimming; 150mA/channel

MAX16800/MAX16815/MAX16828

- Compact; 350mA/100mA/200mA output; single resistor adjusts current

Widest dimming range

Display backlighting

MAX16807–MAX16810

- Drive 8 to 16 channels; boost or SEPIC modes; 5000:1 dimming range

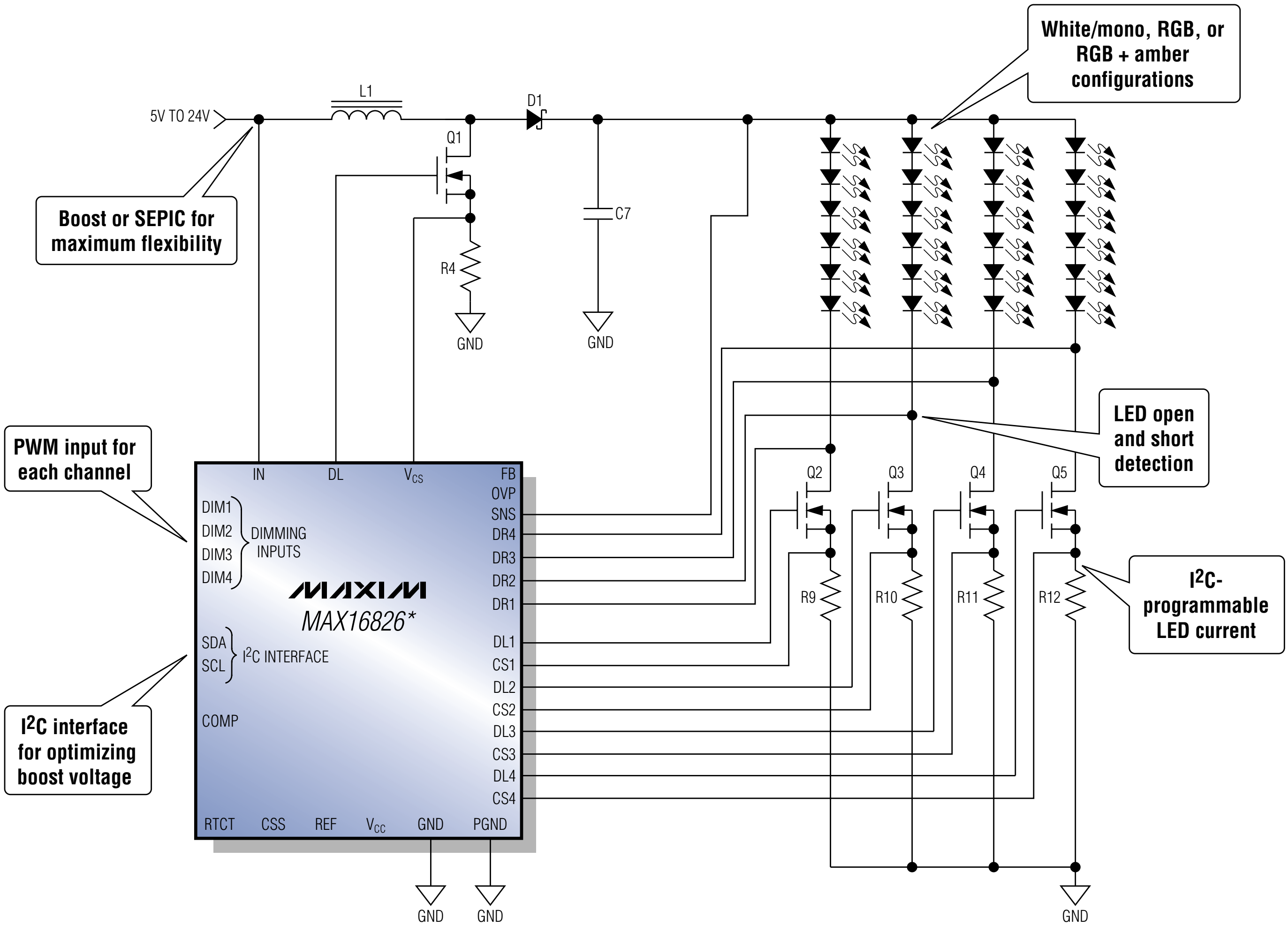
MAX16826*

- I^2C-programmable LED current simplifies designs; shorted-LED detection; boost-voltage optimization

*Future product—contact factory for availability.

4-channel LED driver has voltage monitoring

Programmable current optimizes efficiency and eliminates binning



Flexibility

- 4.75V to 24V operating voltage range
- Boost or SEPIC topologies
- Wide output voltage range
- 20kHz to 1MHz switching frequency

Precise color and dimming control

- Drive all white/mono, RGB, or RGB + amber configurations
- Individual PWM inputs

Efficiency

- Detects and adjusts LED voltage
- Very low, < 20μA standby current

Robustness

- Withstands 40V load dump
- External MOSFETs for thermal management

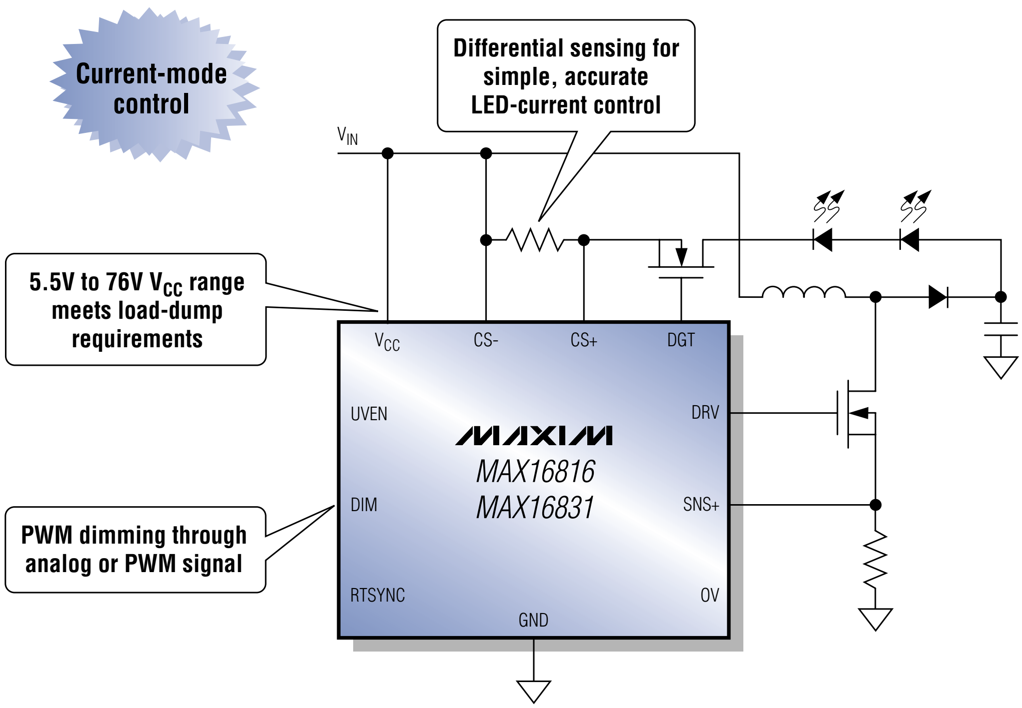
Applications

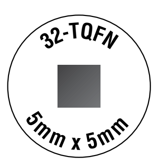
- Navigation display backlighting
- Automotive entertainment display
- Automotive indicator panels

*Future product—contact factory for availability.

High-voltage, high-powered LED drivers simplify dimming

Integrated high-side, n-channel FET drivers provide wide dimming range for automotive lighting



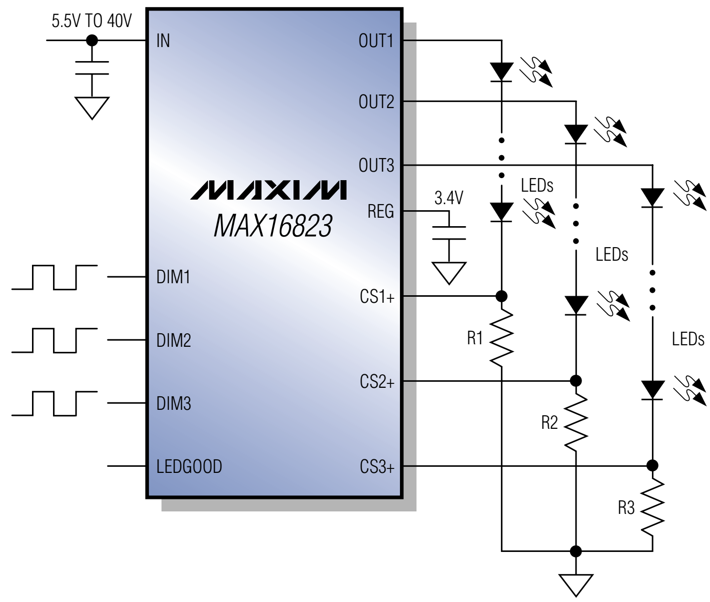


- 100mV high-side, differential LED current sense for high efficiency
- 200mV peak current-mode-control reference
- Boost, buck-boost, buck, or SEPIC topologies
- Nonvolatile LED current adjust (MAX16816)
- Programmable soft-start (MAX16816)
- Programmable dimming edge control (MAX16816)
- Ideal for high-beam/low-beam/turn lights, RCL, DRL, and fog lights

Highest integration LED driver is ideal for automotive applications

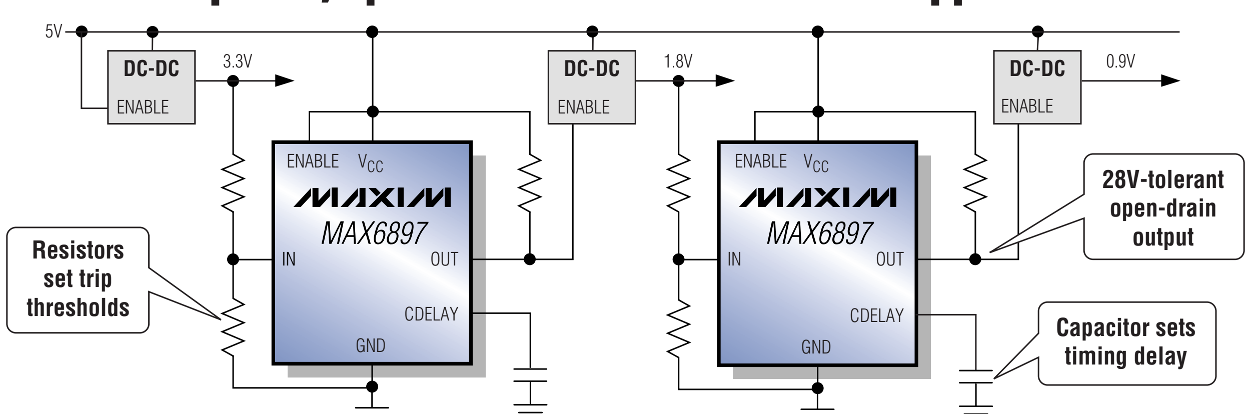
High-voltage, 3-channel linear driver with open-LED detection

- Adjustable constant LED current (up to 70mA, 2A with external BJT)
- ±5% LED current accuracy
- 45V load-dump protection
- Open-LED detection active during dimming
- Linear drive and wave-shaped dimming minimize EMI
- Independent LED-string current adjustment
- Operates from -40°C to +125°C
- 16-pin TSSOP/TQFN package
- EV kit available
- Applications
  - Automotive lighting (RCL, CHMSL, RGB ambient)
  - Warning lights
  - LCD panel backlighting

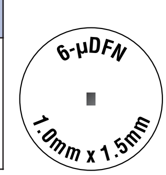


Industry's smallest and most accurate sequencing and monitoring solutions

Ideal for low-power, space-constrained automotive applications

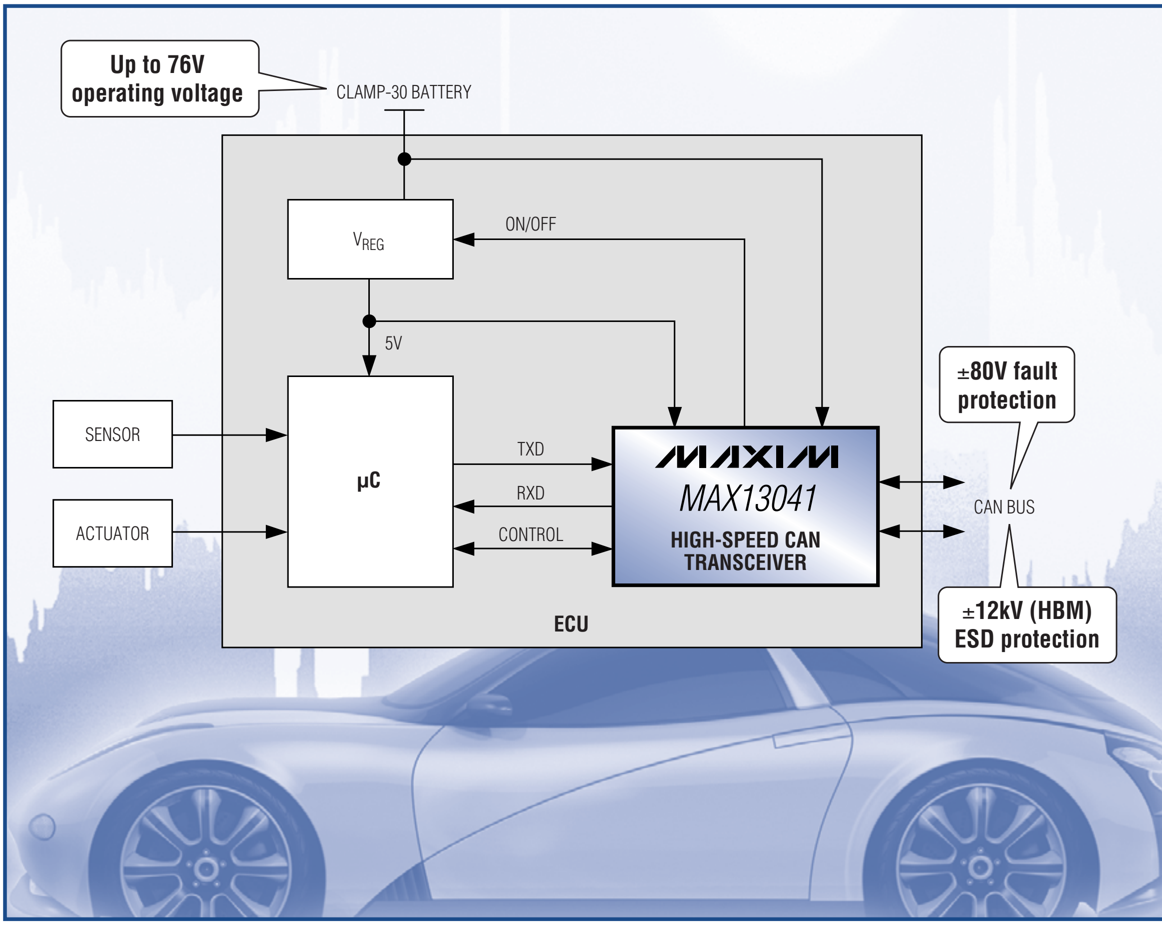


Part	Push-Pull OUT	Push-Pull $\overline{\text{OUT}}$	Open-Drain OUT	Open-Drain $\overline{\text{OUT}}$	Enable Delay
MAX6895A/P	✓				Capacitor adj/1µs
MAX6896A/P		✓			
MAX6897A/P			✓		
MAX6898A/P				✓	



±80V fault-protected, high-speed automotive CAN transceiver

Fully compliant to the ISO 11898-2 standard, the MAX13041 provides the industry's most robust protection, as well as advanced power management. This device reduces the standby current of ECUs in automotive applications that require a CAN interface.



Features

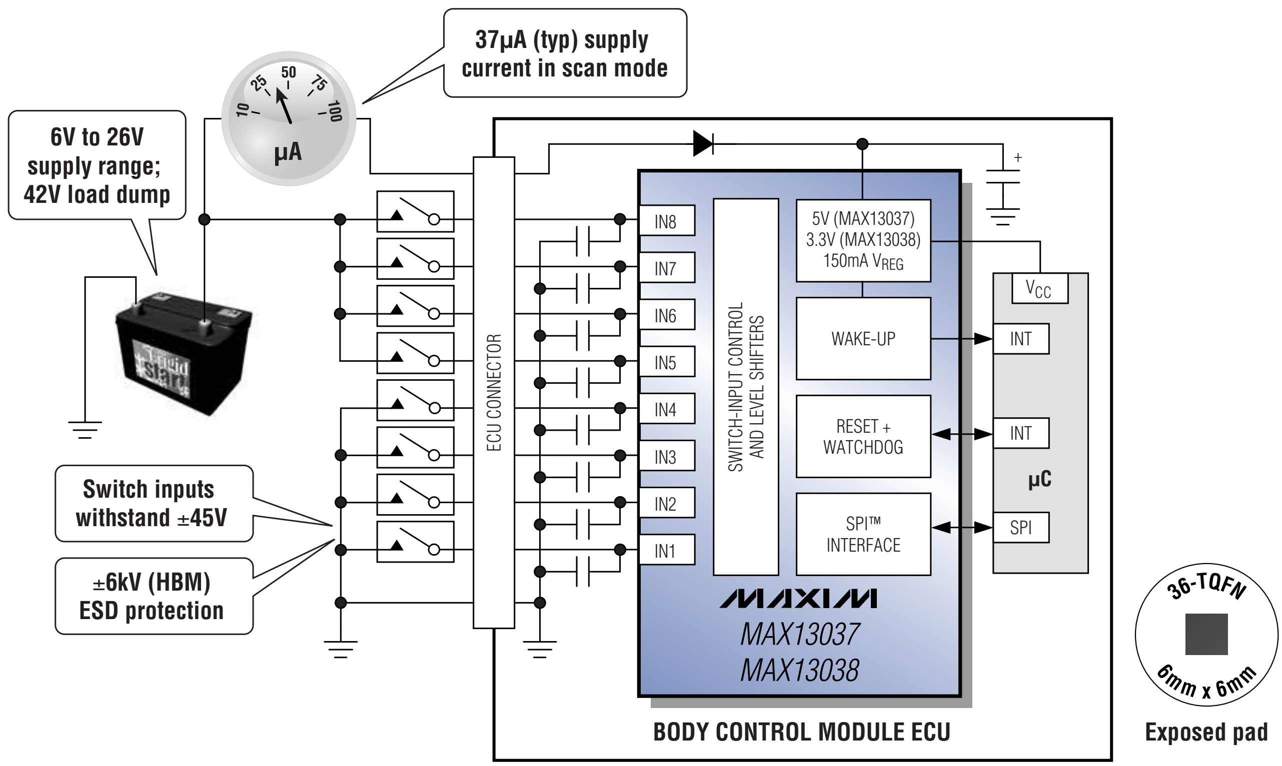
- Low, 18µA (typ), V_{BAT} supply current in standby and sleep modes
- Voltage-level translation for interfacing with 2.8V to 5.5V CAN protocol controllers
- Recessive bus stabilization (V_{SPLIT})
- Allows implementation of large networks
- Direct upgrade to Philips® TJA1041
- ISO 11898-2 compliant

Applications

- 12V automotive clamp-30 modules
- 42V automotive clamp-30 modules
- 24V midheavy truck clamp-30 modules
- Military and commercial aircraft

Monitor eight remote switches while consuming only 37µA

The MAX13037/MAX13038 automotive contact monitor and level shifters are the ideal choice for remote mechanical switch monitoring in harsh automotive environments such as body-controller applications requiring 5V or 3.3V operation.



Features

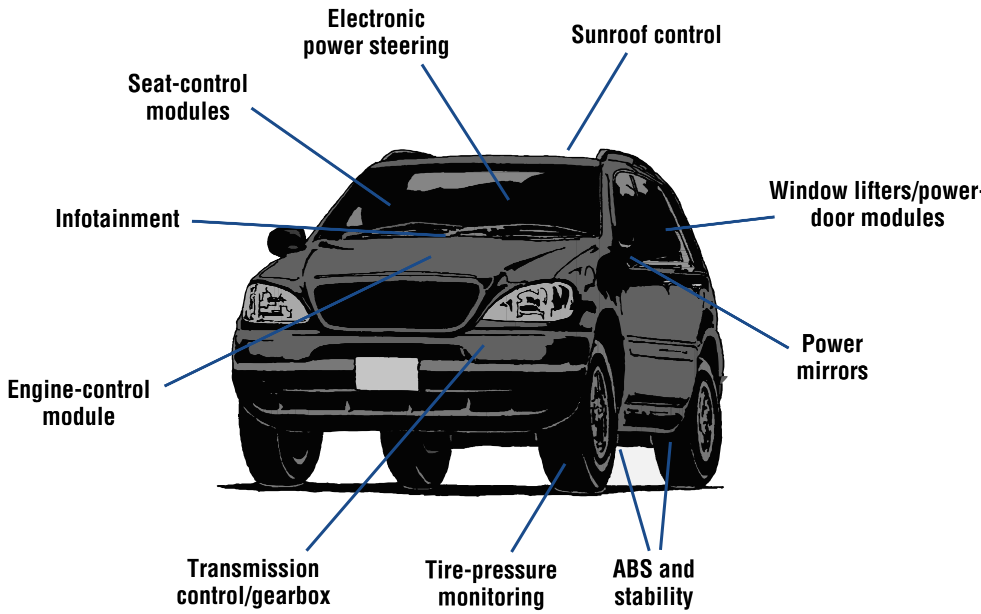
- 150mA LDO with an output V_{REG} of 5V (MAX13037) or 3.3V (MAX13038)
- Watchdog and POR functions
- Configurable ground/battery-connected switches
- No reverse-current flow on switch inputs
- Programmable wetting current up to 50mA
- Programmable switching hysteresis levels
- SPI-compatible interface

Applications

- Electric sunroofs
- Other control ECUs
- Body computers
- Window lifters
- Seat movers

SPI is a trademark of Motorola, Inc.

Amplifier and comparator solutions for -45°C to +125°C automotive operation



Operational amplifiers

Part	No. of Amps	Rail-to-Rail Input or Output	Supply-Voltage Range (V)	Supply Current per Amp (mA)	GBWP (MHz)	Package
MAX4036A/38A	1/2	Output	2.3 to 7	0.0008	0.004	5-SC70/8-μMAX
MAX4230–34	1/2/4	Input, output	2.7 to 5.5	1.1	10	5-SC70/6-SC70/8-SOT23/10-UCSP™/14-TSSOP
MAX4245/46/47	1/2/2	Input, output	2.5 to 5.5	0.375	1	6-SC70/8-SOT23/10-μMAX
MAX4400–03	1/2/4	Output		0.32	0.8	5-SC70/6-SC70/8-SOT23/14-TSSOP
MAX4480-83				0.045	0.14	5-SC70/6-SC70/8-SOT23/14-TSSOP
MAX4484/86/87			2.7 to 5.5	1.9	7	5-SC70/8-SOT23/14-TSSOP
MAX4490/91/92		Input, output	2.7 to 5.5	0.8	10	
MAX4493/94/95		Output	4.5 to 11	0.77	5	
LMX321/58/24		Output	2.3 to 7	0.105	1.3	

Current-sense amplifiers

Part	CMVR (V)	Supply-Voltage Range (V)	Supply Current (μA)	Bidirectional Current Sense	GBWP (kHz)	Package
MAX4069–72	1.35 to 24	2.7 to 24	100	✓	40, 100	10-μMAX/8-TQFN
MAX4073F/73H/73T	2 to 28	3 to 28	500		1600, 1700, 1800, 1800	5-SC70
MAX4376/77/78	0 to 28	3 to 28	1000		1200, 1700, 2000, 2000	5-SOT23/8-μMAX/14-TSSOP
MAX4080/81	4.5 to 76	4.5 to 76	75	—/✓	250	8-μMAX

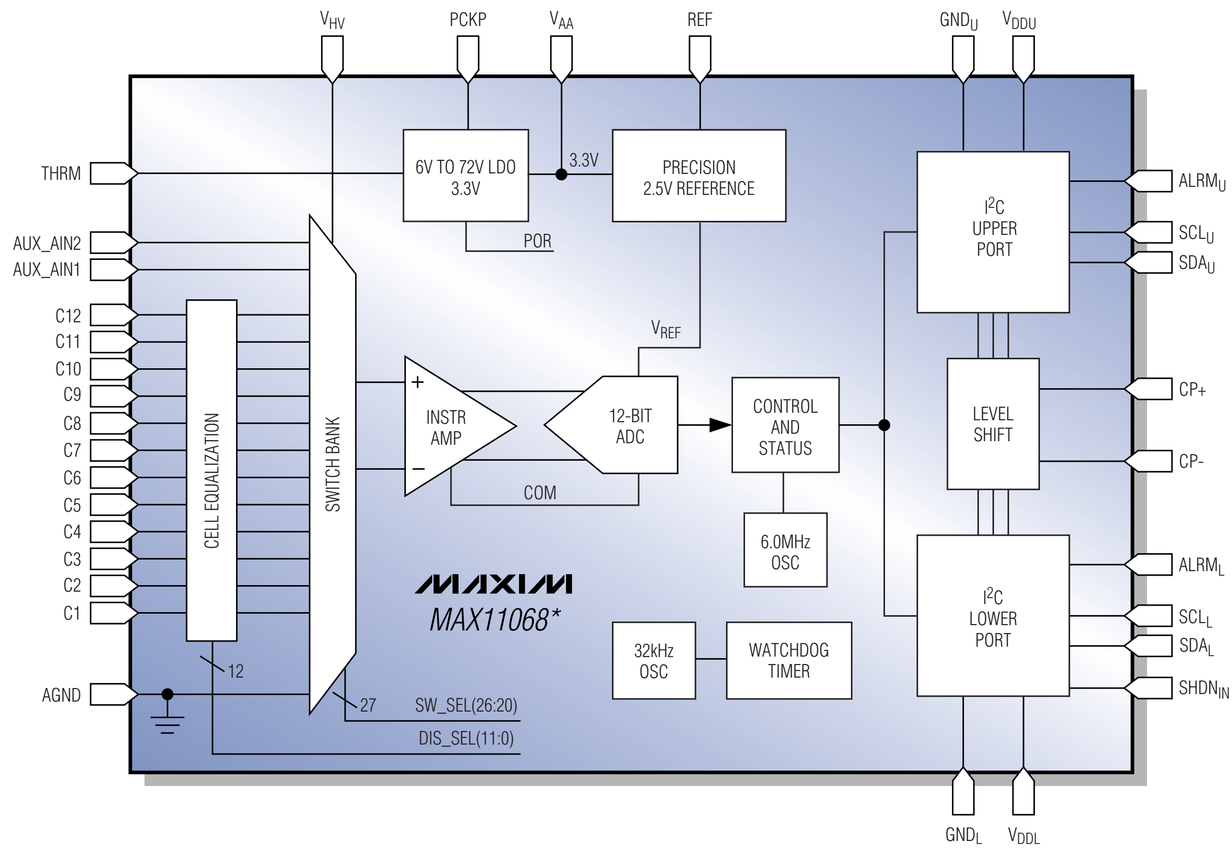
Comparators

Part	No. of Comparators	Supply-Voltage Range (V)	Propagation Delay (ns)	Logic Output	Package
MAX9021/22/24	1/2/4	1.8 to 5.5	3000	TTL/CMOS	5-SC70/8-SOT23/14-TSSOP
MAX9030/31/32/34		2.5 to 5.5	188	CMOS, TTL/CMOS	6-SC70/5-SC70/8-SOT23/14-TSSOP
LMX331/93/39		1.8 to 5.5	100	Open drain	5-SC70/8-SOT23/14-TSSOP

Future product

High-voltage, hybrid electric vehicle battery-measurement IC

The first 80V-tolerant, daisy-chainable, battery measurement and monitoring solution, the MAX11068* is optimized for the new, high-powered cells in hybrid and electric cars.



Monitor and measure up to 12 Li+, NiMH, or double-layer capacitor cells

- 10µs simultaneous sampling window for 120 cells (10 modules)
- Overvoltage and undervoltage detection
- Stack total, minimum, maximum, and mismatch reporting
- Built-in, cell-balancing switches sink up to 250mA
- Low, 70µA average current consumption

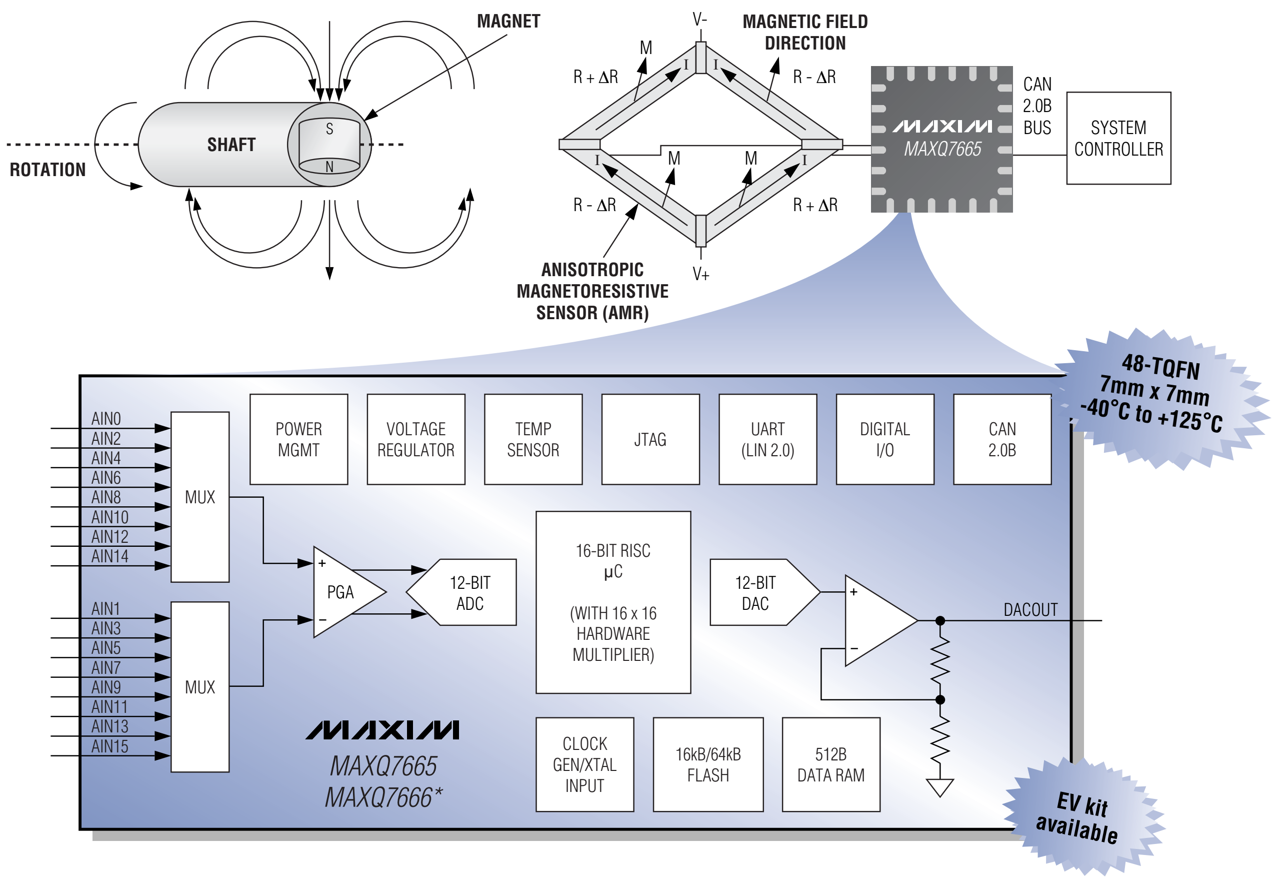
Serial, daisy-chainable communication bus

- I^2C physical interface and SMBus™ protocol
- Fault-tolerant bus with hardware-acknowledge handshaking and packet-error checking
- Auto-addressing supports up to 31 nodes (372 cells)

SMBus is a trademark of Intel Corp.
*Future product—contact factory for availability.

Compact, fully integrated solution for differential sensors in auto body electronics

Process to a signal resolution of 8µV and communicate through CAN 2.0B



Applications

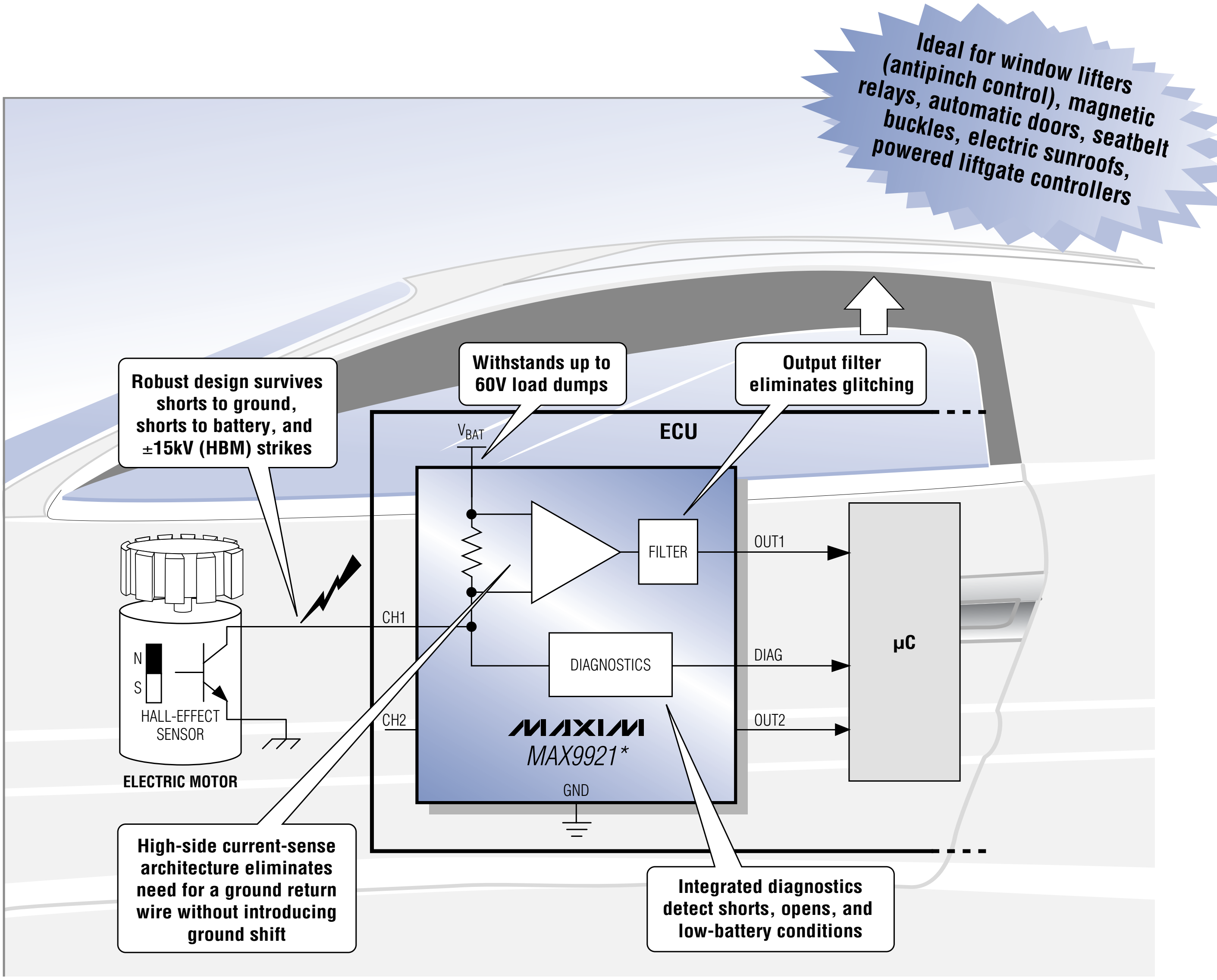
- Automotive steering
- Brake and throttle position sensing
- Shaft rotation sensing
- Valve positioning
- Linear or angular position/ displacement sensing

Part	Flash Size (kB)
MAXQ7665BATM+	64 (32k x 16)
MAXQ7666BATM+*	16 (8k x 16)

*Future product—contact factory for availability.

Future product

Industry's first integrated two-wire, Hall-effect sensor interface solution



Improves performance and reliability

- Integrated diagnostics detect shorts, opens, and low-battery faults
- Withstands up to 60V load dumps
- Robust ±15kV (HBM) ESD protection
- Integrated deglitching output filters
- Single-wire interface is immune to ground-shift voltages

Saves space and cost

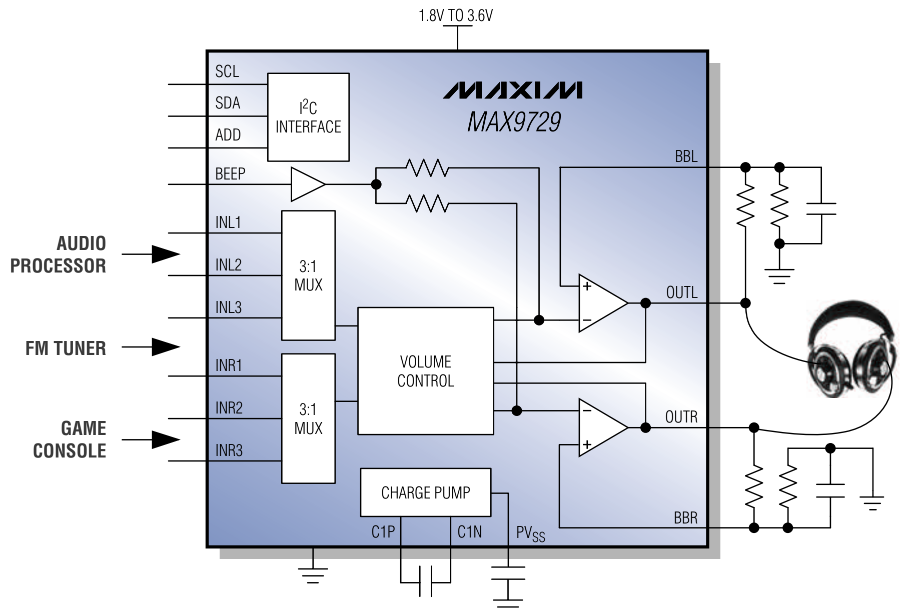
- High-side, current-sense architecture eliminates the need for a ground return wire
- Eliminates up to 10 discrete components
- Integrates two complete sensor interface channels into a single 3mm x 5mm µMAX package

*Future product—contact factory for availability.

Industry's first three-input DirectDrive™ headphone amplifier

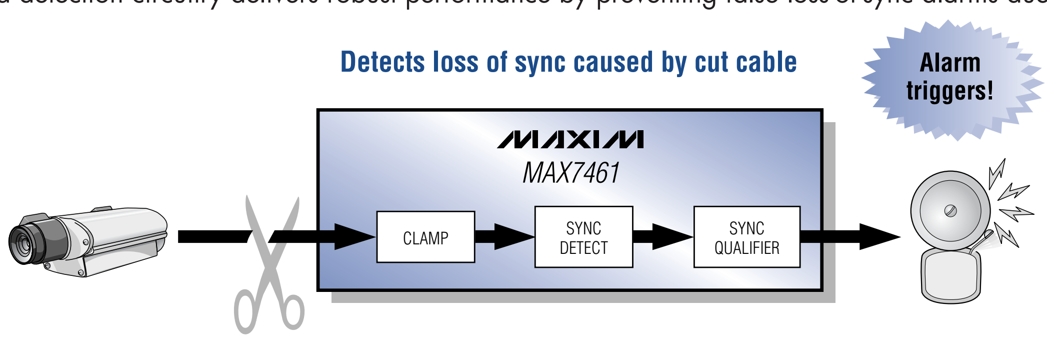
Includes 3:1 mux, volume control, bass boost, and I²C control—ideal for rear-seat entertainment systems

- 3:1 input multiplexers with digital-fade circuitry
- Accepts multiple inputs, such as FM radio, music, and game consoles
- Integrated 32-step volume control
- DirectDrive headphone amplifier eliminates bulky DC-blocking capacitors
- Beep input with programmable output level



First standard-definition, video loss-of-sync alarm

The MAX7461 single-channel loss-of-sync alarm provides video-sync detection of SD television signals. Its advanced detection circuitry delivers robust performance by preventing false loss-of-sync alarms due to noise.

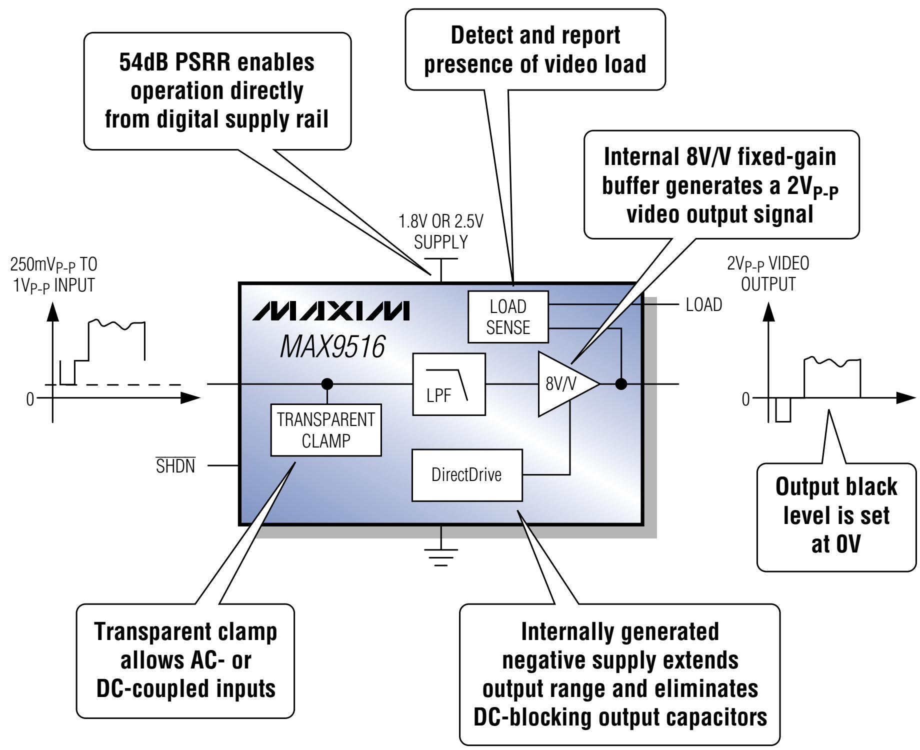


- Accepts AC-coupled CVBS, Y, or any other SD video signal containing sync
- Superior and robust performance optimized for noisy environments
- SOT23 package saves board space
- Ideal for rear-view cameras and rear-seat infotainment systems

1.8V video filter reduces power consumption by more than 76%

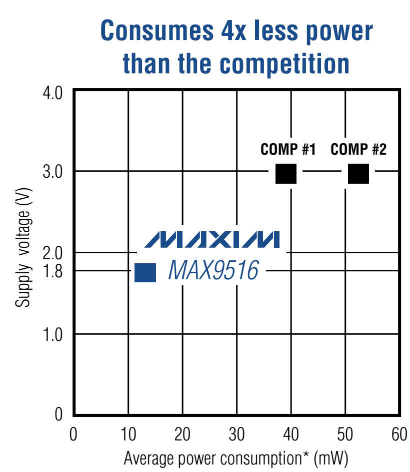
New

DirectDrive technology eliminates the need for bulky, expensive, DC-blocking output capacitors in rear-view cameras and navigation systems



Reduces power consumption

- 54dB PSRR enables operation directly from a 1.8V digital power supply
- 12mW average power consumption*
- 10nA shutdown current



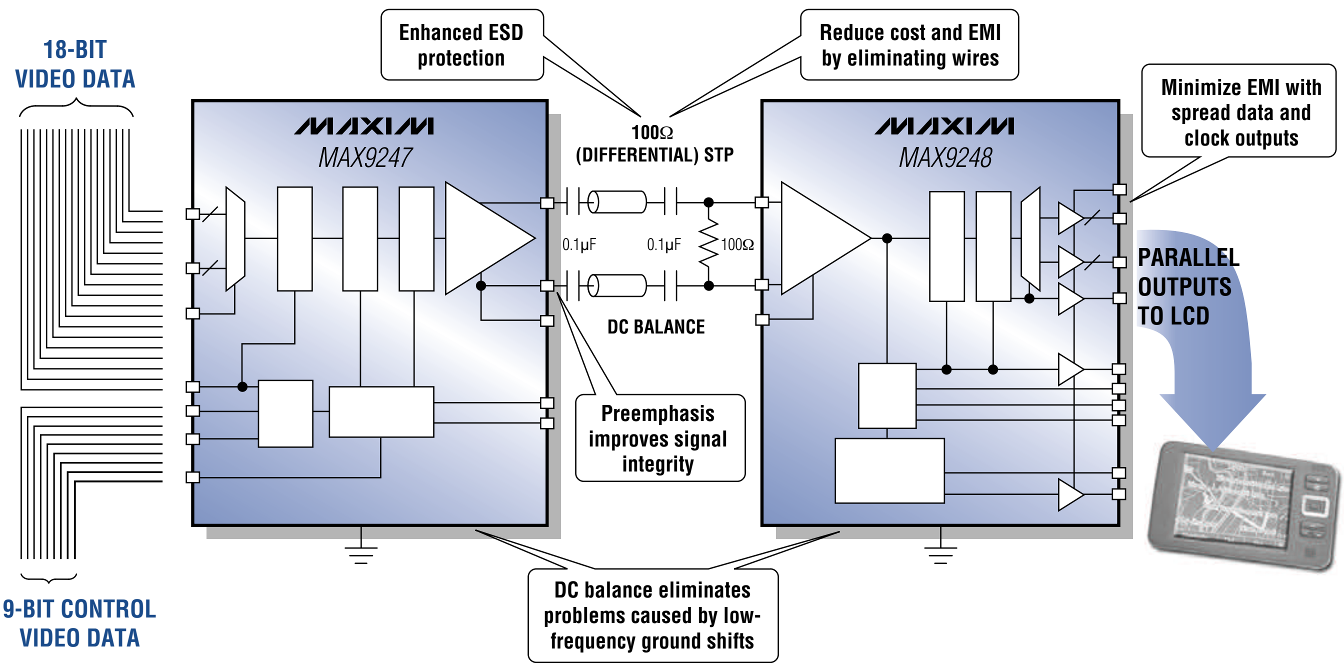
Part	Lowpass Filter (LPF)	DirectDrive	Shutdown	Supply Voltage (V)	Average Power Consumption* (mW)	Package
MAX9509	✓	✓	✓	1.8 or 2.5	11	8-TDFN
MAX9510					10.4	8-μMAX
MAX9516	✓				12	10-μDFN

*Average power consumption is measured with a 50% flat-field video signal and a 150Ω output load to ground.

27-bit LVDS serializers/deserializers for automotive video displays

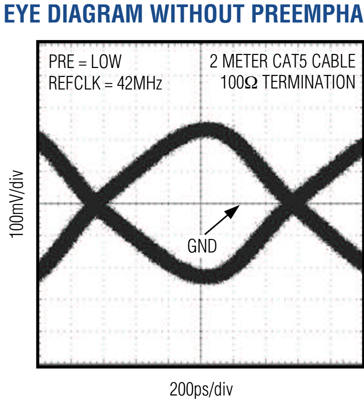
Programmable spread spectrum, feeds displays up to 1280 x 480

The MAX9247/MAX9248/MAX9250 27-bit, DC-balanced serializers/deserializers (SerDes) feature preemphasis and programmable spread-spectrum capability, which spreads both output data and clock for maximum EMI reduction. The spread is programmable for ±4%, ±2%, or no-spread (MAX9250). Preemphasis improves signal integrity at the load over 10m cables. The MAX9247/MAX9248/MAX9250 are ideal for driving WVGA, VGA, and QVGA displays.

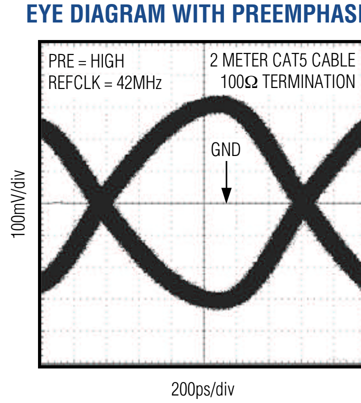


PREEMPHASIS IMPROVES SIGNAL INTEGRITY

EYE DIAGRAM WITHOUT PREEMPHASIS

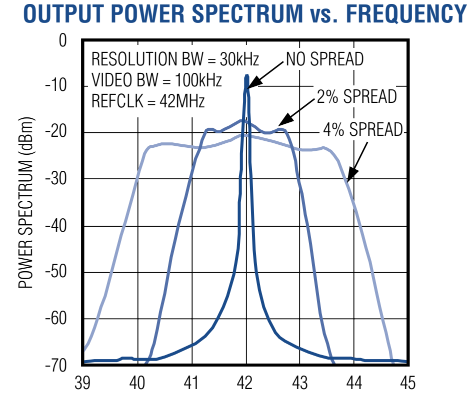


EYE DIAGRAM WITH PREEMPHASIS



SPREAD SPECTRUM REDUCES EMI

OUTPUT POWER SPECTRUM vs. FREQUENCY



Serializers

Part	Clock (MHz)	Features
MAX9247	2.5 to 42	Output common-mode filter, selectable preemphasis
MAX9217	3 to 35	Output common-mode filter

Deserializers

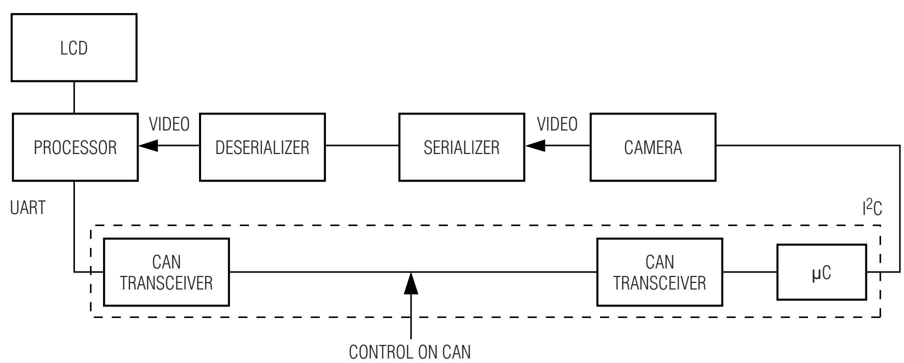
Part	Clock (MHz)	Features
MAX9248	2.5 to 42	Selectable ±2% or ±4% spread spectrum
MAX9250	2.5 to 42	Output enable
MAX9218	3 to 35	Output enable

New

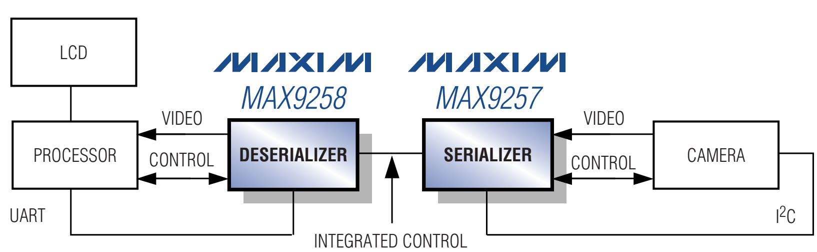
Eliminate CAN or LIN interface with smart 18-bit bidirectional LVDS SerDes

The MAX9257/MAX9258 bidirectional LVDS serializer/deserializer eliminate the need for an external CAN or LIN interface in automotive safety applications. Whereas typical applications require an additional bus for system configuration, the MAX9257/MAX9258 integrate all control functions. They, thus, simplify the design by eliminating the need for this costly bus and its associated wiring. These devices have smart features that enhance bandwidth utilization and suppress EMI, and they operate over the -40°C to +105°C temperature range.

Why do this with the typical automotive safety application?

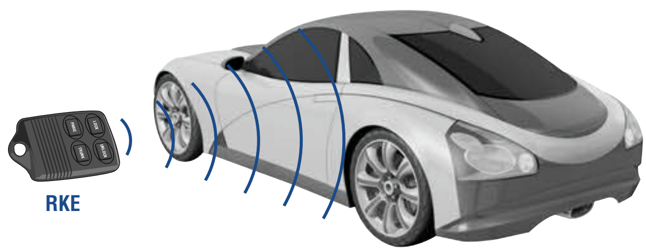


When you can use Maxim's simple solution?



- **Programmable spread-spectrum modulation**
- **Deserializer does not require external reference clock**
- **±10kV (Contact)/±30kV (Air-Gap Discharge) ESD protection**

300MHz to 450MHz transmitters and receivers double the range of your RKE systems



- **High -114dBm receive sensitivity**
- **Ideal for**
  - **RKE and remote start**
  - **RF remote controls**
  - **Security systems**
  - **TPMS**
  - **Garage-door openers**

Part	Type	Temp Range (°C)	Power Consumption (mA)	RF Performance at 315MHz	Modulation	Price† ($)
MAX7057*	Tx	-40 to +125	8.5 (typ)	+10dBm output, SPI tunable from 300MHz to 450MHz	ASK/FSK	1.26
New MAX7058			8.0 (typ)	+10dBm output, dual frequency (315MHz and 390MHz)	ASK	1.32
MAX1472			5.3 (typ, ASK at 50% duty cycle)	+10dBm output	ASK	0.96
MAX7044			7.7 (typ, ASK at 50% duty cycle)	+13dBm output	ASK	1.05
MAX1479			6.7 (typ, ASK at 50% duty cycle)	+10dBm output	ASK/FSK	0.97
MAX1470	Rx	-40 to +85	5.5 (typ)	-112dBm with 53dB image rejection	ASK	1.51
MAX1473		-40 to +85	5.2 (typ)	-114dBm with 50dB image rejection		1.67
MAX7033		-40 to +105	5.2 (typ)			1.69
New MAX7034		-40 to +125	6.7 (typ)			2.50
MAX1471			7.0 (typ)	-114dBm (ASK)/-108dBm (FSK) with 45dB image rejection	ASK/FSK	2.39
MAX7042			6.2 (typ)	-110dBm with 45dB image rejection	FSK	1.80

Industry's highest performance 300MHz to 450MHz transceivers

Increase range and add two-way capabilities to car alarms, RF modules, and remote controls

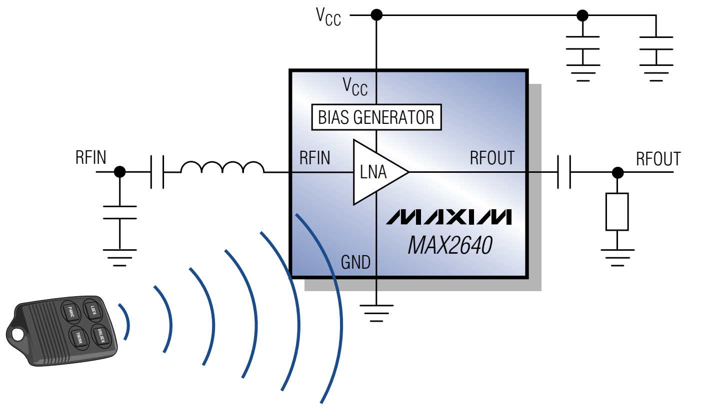
Maxim's MAX7030/MAX7031/MAX7032 family of crystal-referenced VHF/UHF transceivers are easy-to-use, high-performance devices that allow quick, two-way implementation of one-way systems.

- **+10dBm output power**
- **12mA Tx current (FSK)**
- **-40°C to +125°C automotive temp range**
- **-114dBm (ASK)/-110dBm (FSK) Rx sensitivity**
- **6.1mA Rx current**

Part	RF (MHz)	Modulation	FSK Deviation (kHz)
MAX7030LATJ	315	ASK	—
MAX7030MATJ	345		—
MAX7030HATJ	433.92		—
MAX7031LATJ	308	FSK	±51.4
MAX7031MATJ15	315		±15.5
MAX7031MATJ50	315		±49.5
MAX7031HATJ17	433.92		±17.2
MAX7031HATJ51	433.92		±51.7
MAX7032	SPI programmable	ASK/FSK	SPI programmable

*Future product—contact factory for availability.
†1000-up recommended resale. Prices provided are for design guidance and are FOB USA. International prices will differ due to local duties, taxes, and exchange rates. Not all packages are offered in 1k increments, and some may require minimum order quantities.

300MHz to 1000MHz LNA extends range of RKE systems

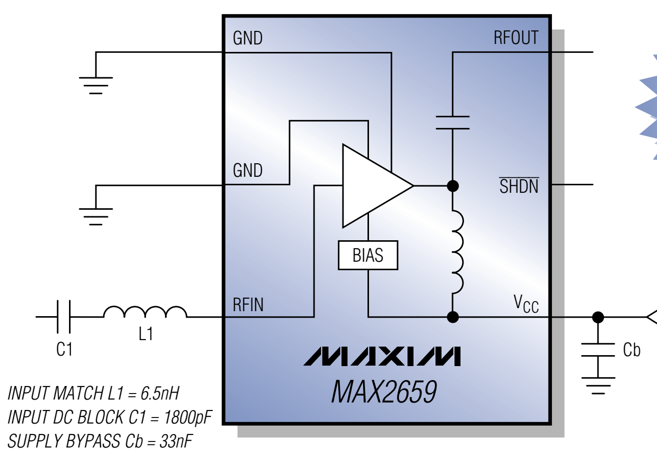


- -40°C to +125°C automotive temp range
- AEC-Q100 qualified
- 3.5mA supply current
- 2.7V to 5.5V single supply
- 1.3dB NF with matching components
- 15dB gain
- Tunable to 308, 315, 345, 433.92, 868, and 902 to 928MHz
- 6-pin SOT23 package

New

0.8dB noise figure, 20dB gain, GPS LNA improves your existing solution

Ultra-small leadless package saves size and cost



Improves your current GPS receiver's sensitivity

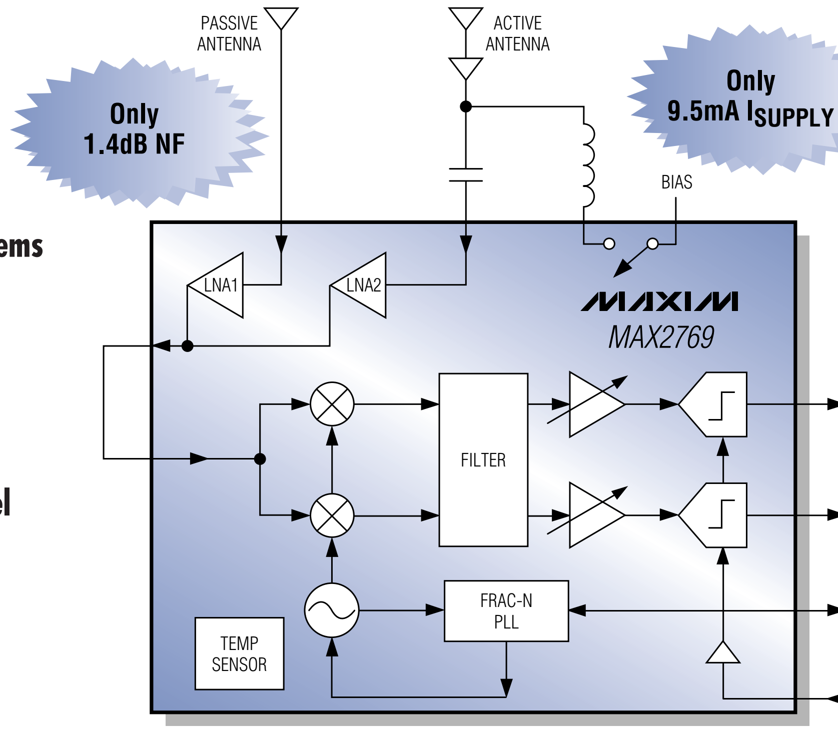
- High 20.5dB gain
- Ultra-low 0.8dB noise figure
- Integrated 50Ω output-matching circuit
- 4.1mA supply current
- 1.6V to 3.3V supply voltage
- Ultra-small, RoHS-compliant, leadless 6-pin µDFN package

New

Is your GPS system performance limited by your RF front-end?

Improve your GPS and Galileo performance and reduce cost with the first fully programmable, universal GNSS RF receiver

- Ideal for portable navigation systems and automotive navigation
- Compatible with most popular GPS baseband processors
- Needs no external IF SAW or discrete filters
- Leadless 28-pin TQFN, wafer-level packaging, or known-good die



Widest range of digital broadcast tuners

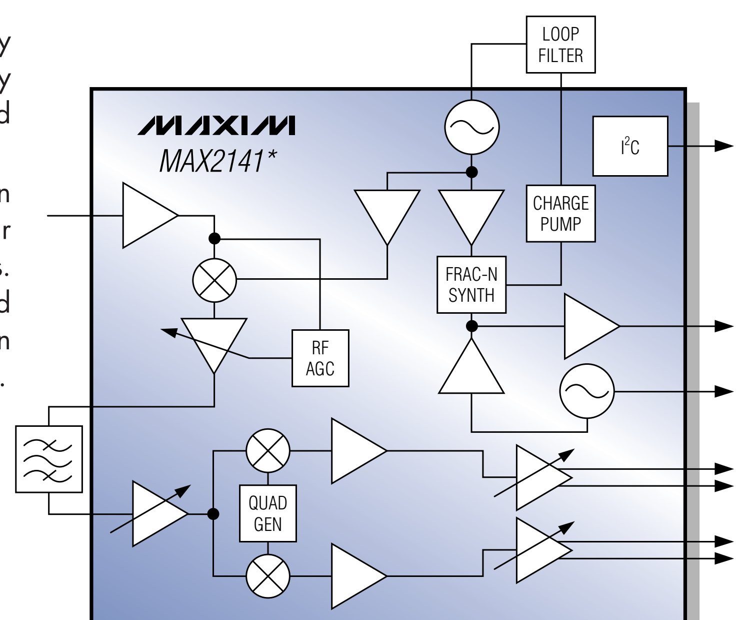
MAX2141* enables low-power broadband XM Satellite Radio receivers

Maxim's digital radio receivers enable highly integrated, cost-effective designs that are very space efficient. Digital radio is going global, and Maxim has solutions for every region of the world.

The MAX2141 is Maxim's second-generation dual-ensemble receiver featuring low power consumption for XM Satellite Radio® applications. It is pin compatible with the industry-standard MAX2140. Also, its much lower heat dissipation allows for placement into an automotive radio head.

Digital audio receivers for international standards

Part	Standard	Region
MAX2140/MAX2141*	SDARS	North America
MAX2161/MAX2162	ISDB-Tsb	Japan/Brazil
MAX2170	DAB	Europe/Canada



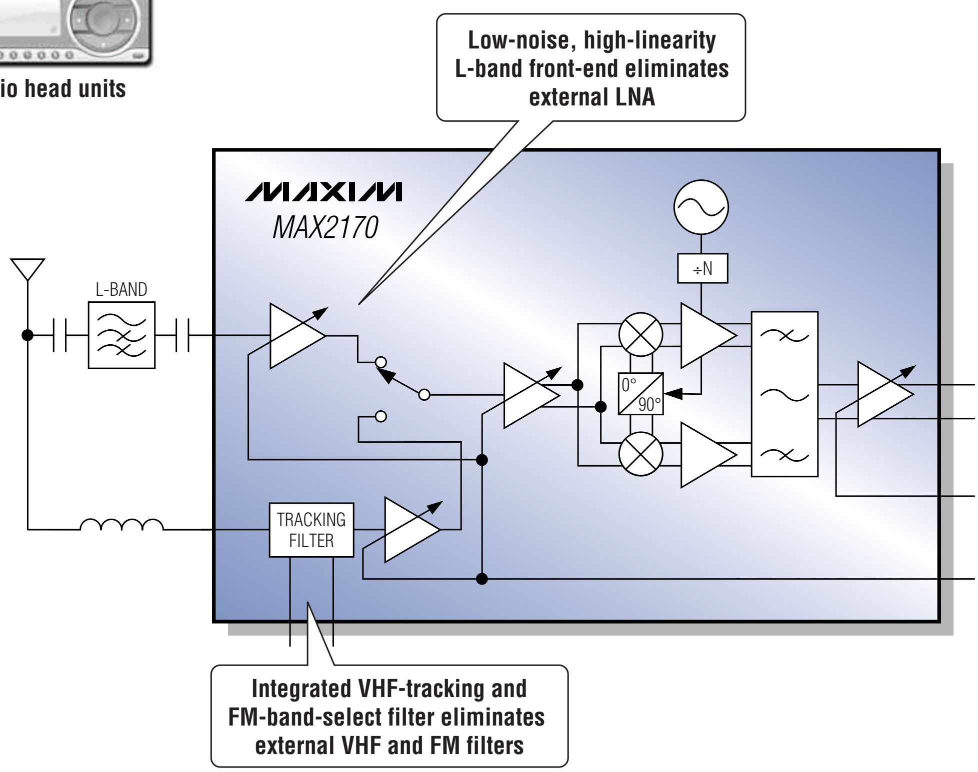
*Future product—contact factory for availability.

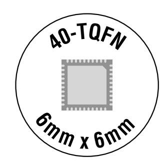
Highest integration triple-band tuner for DAB, DMB-T, and FM applications

Eliminates the need for external LNAs and VHF/FM filters

The MAX2170 is a fully integrated, RF-broadcast tuner for DAB, DMB-T, and FM applications. The integrated LNA achieves an L-band sensitivity of -99dBm, thereby eliminating the need for external amplifiers. At VHF frequencies, the integrated channel-selection filter achieves an adjacent-channel protection ratio of better than 45dBc; in high-interference environments, it also increases performance while doubling as an FM-band-select filter.

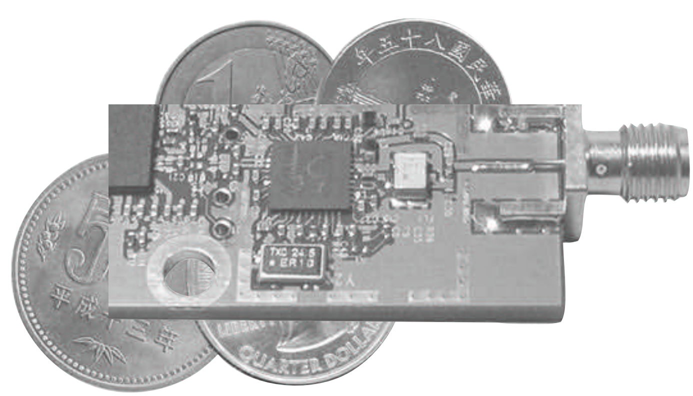
Radio head units





- First adjacent-channel handling of > 45dBc in VHF band
- -100dBm VHF band-III sensitivity
- -99dBm L-band sensitivity
- Industry-standard 2.048MHz low-IF interface
- 2.7V to 3.5V power supply
- Integrated closed-loop RF AGC
- Sigma-delta fractional-N synthesizer
- Low power consumption (170mW in L-band mode, continuous operation)

Reference designs available (contact factory)



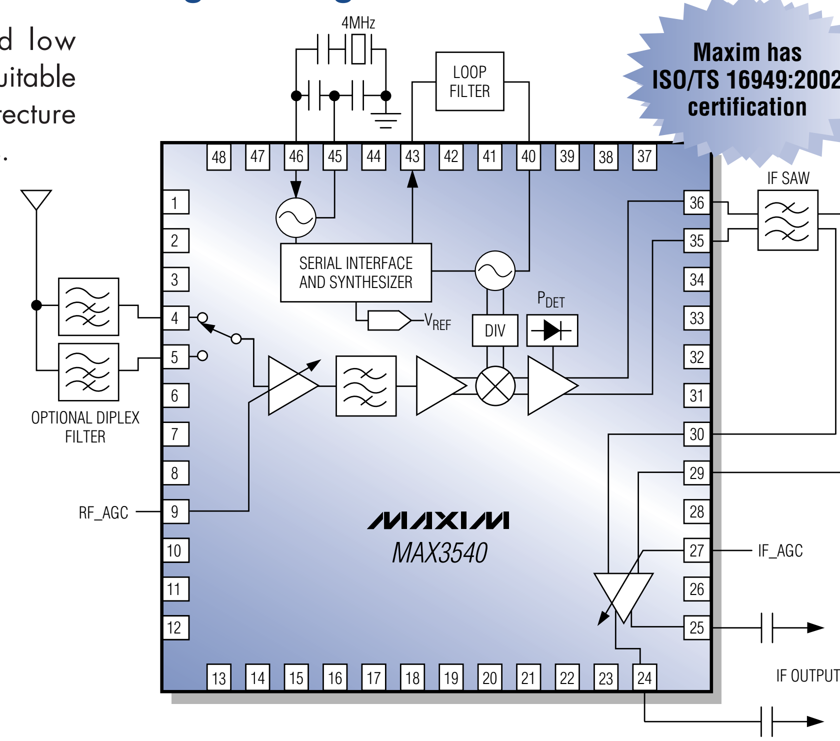
Analog/digital tuners run cool and save space in automotive TVs

Ultra-compact MAX3540 tunes analog and digital TV

The MAX3540's small size and low power consumption make it uniquely suitable for automotive TV. Its traditional architecture tunes both analog and digital TV signals.

Maxim has ISO/TS 16949:2002 certification

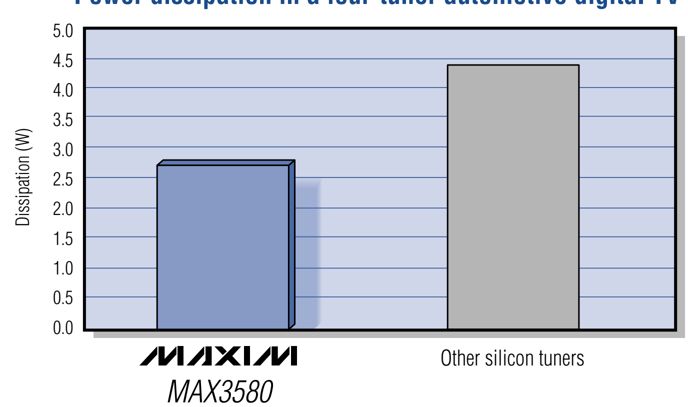
- 50MHz to 860MHz frequency range
- 36MHz/44MHz IF frequency
- On-chip, triple-band tracking filter
- ATSC, NTSC, and PAL compliant
- 800mW power consumption
- 3.3V supply



MAX3580's novel architecture drastically shrinks automotive diversity tuner designs, meets MBRAI and NorDig requirements

The MAX3580 is a multistandard digital TV tuner covering DVB-T (Europe), DMB-T/H (China), and ISDB-T 13 segment (Japan). Its direct-conversion architecture eliminates SAW filters. On-chip RF filtering reduces the need for external RF filtering, typically required by traditional CAN-type tuners. This integration results in a greatly reduced overall solution size. The MAX3580 is specified to operate over the -40°C to +85°C temperature range.

Power dissipation in a four-tuner automotive digital TV



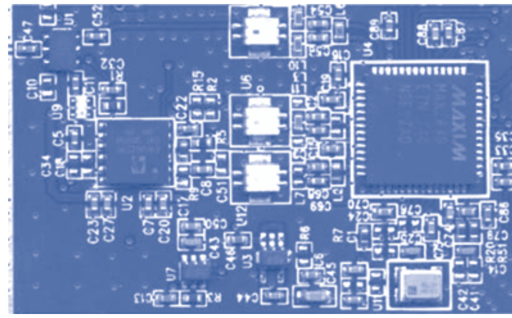
Maxim's full range of mobile TV tuners

Broadcast standards dedicated to mobile TV are becoming established or are on the way in many countries around the world. Maxim offers a full range of solutions for mobile TV tuners.

Part	Standard	Region
MAX2160	ISDB-T 1 segment	Japan/Brazil
MAX2165	DVB-H, DVB-T	Europe
MAX2170	DMB-T	Europe/China
MAX3540	ATSC, NTSC, PAL	All
MAX3580	DVB-T, DMB-T/H, ISDB-T 13 segment	Europe/China/Japan

RF transceivers enable WiMAX in automobiles

MAX2839 1 Tx, 2 Rx RF in 22mm x 35mm



Unsurpassed RF performance

- Zero-IF RF transceiver
- No external LNAs required
- 1.75MHz to 28MHz channel bandwidths
- 2.3dB noise figure
- -35dB Rx EVM
- 0dBm linear Tx power
- -37dB Tx EVM
- -39dBc integrated VCO phase noise

IEEE℠ 802.16e mobile WiMAX℠ RF transceivers

Frequency (GHz)	No. of Tx	No. of Rx	Part
2.3 to 2.7	1	1	MAX2837
	1	2	MAX2839
3.3 to 3.8	1	1	MAX2838

Coming soon: 2 Tx/2 Rx MIMO solution for 3.3GHz to 3.8GHz.

Digital wireless audio/video solution provides CD-quality audio and H.264 video

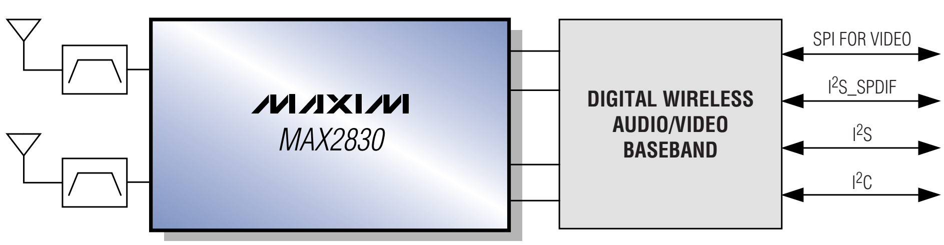
In-car display screens

MP3 audio and video docking stations

Headphones

Front and rear cameras

Digital wireless audio/video solution



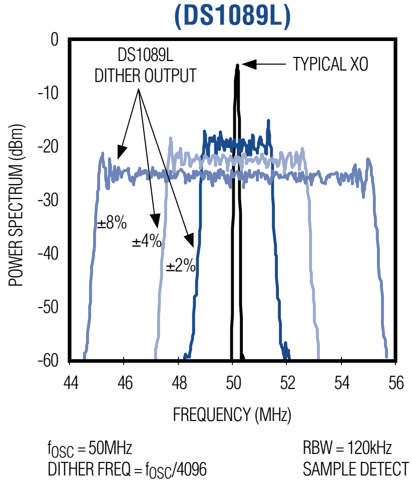
- Uncompressed, 24-bit/96kHz audio
- Supports 8Mbps SD or MPEG4 video
- Supports eight uncompressed audio channels
- Features MAX2830 2.4GHz zero-IF transceiver
- Contact WLAN@maxim-ic.com for more details about this digital wireless audio/video solution

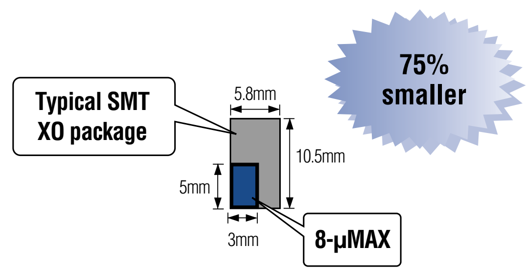
Spread-spectrum EconOscillators reduce peak EMI by over 20dB

Factory-trimmed frequency and dither settings reduce time to market

Most applications must meet the stringent radiated-emissions compliance standards established by government agencies. Yet, most crystal oscillators (XOs) do not offer inherent EMI reduction, forcing designers to use expensive shielding, filtering, or PCB-layout techniques to meet these EMI-compliance standards. Our spread-spectrum EconOscillator™ devices solve this problem by spreading radiated emissions over a narrow spectrum, thus reducing peak energy at any one frequency. These oscillators are ideal for use as a frequency source for µPs in applications with RS-232, USB, CAN, or LIN peripherals, including automotive infotainment/GPS.

> 20dB EMI IMPROVEMENT OVER XOs (DS1089L)





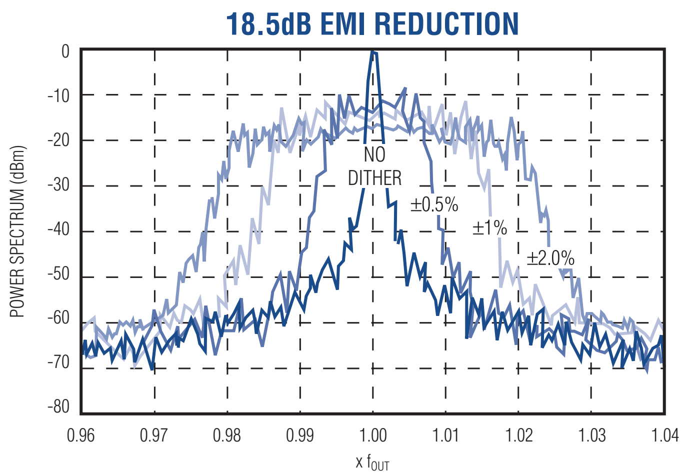
- **Reduce peak EMI by over 20dB**
- **75% smaller than typical SMT XO**
- **Lower active and standby power than typical XO**
- **Fast, reliable startup**
- **Less sensitive to shock/vibration than typical XO**
- **Operate over automotive temperature range**
- **No price premium for higher frequency selections**
- **Factory trimmed; no programming required**
- **No external timing components required**

Part	Min Output Freq (kHz)	Max Output Freq (MHz)	Spread Spectrum	Dither-Mag Range (%)	Dither-Freq Range (f_{OSC}/x)	Power Supply (V)	Temp Range (°C)	Package
DS1086	260	133	Down	0 to -4	4096	5, ±5%	0 to +70	8-SO
DS1086L	130	66.6	Down	0 to -8	2048 to 8192	2.7 to 3.6	-40 to +85	8-µMAX
DS1087L	130	66.6	Down	0 to -4	4096	2.7 to 3.6		
DS1089L	130	66.6	Centered	0 to ±8	2048 to 8192	2.7 to 3.6		
DS1090	125	8	Centered	0 to ±4	512 to 4096	2.7 to 5.5		
DS1091L	130	66.6	Centered, down	0 to ±4, 0 to -8	16 to 8192	3.0 to 3.6	-40 to +125	
DS1094L	31.25	2	Down	0 to -8	128 to 1024	3.0 to 3.6	-40 to +85	

Spread-spectrum clock modulators reduce peak EMI

Pin-selectable dither rate and magnitude reduce radiated emissions by up to 18.5dB

The DS108x and DS118x spread-spectrum clock modulators have an integrated phase-locked loop (PLL) that modulates the output clock around the center frequency at a pin-selectable magnitude, thus reducing peak EMI at fundamental and harmonic frequencies. This reduced EMI is accomplished without changing clock rise/fall times or adding the space, weight, design time, and costs associated with mechanical shielding.



Head unit/GPS

Flexibility

- -40°C to +125°C temperature range
- 8.0MHz to 150MHz output frequencies
- ±0.5% to ±2.0% user-selectable dither rate

Key benefits

- EMI reduction saves shielding costs and minimizes redesign
- ±75ps cycle-to-cycle jitter maintains lock with downstream PLL

Spread-spectrum clock modulators for EMI-sensitive applications

Part	Input	Output Frequency Range (MHz)	Dither Selections (%)	Power Supply (V)	Package
DS1080L	XTAL/clock	16 to 133	±0.5 to ±1.5	3.0 to 3.6	8-µMAX
DS1080CL*	XTAL/clock	8 to 64	±0.5 to ±1.5		8-µMAX
DS1081L	Clock	20 to 134	±0.5 to ±2.0		8-TSSOP
DS1083L*		16 to 134			6-SOT23
DS1181L		20 to 134			8-TSSOP

*Future product—contact factory for availability.

Maxim has your automotive IC quality covered

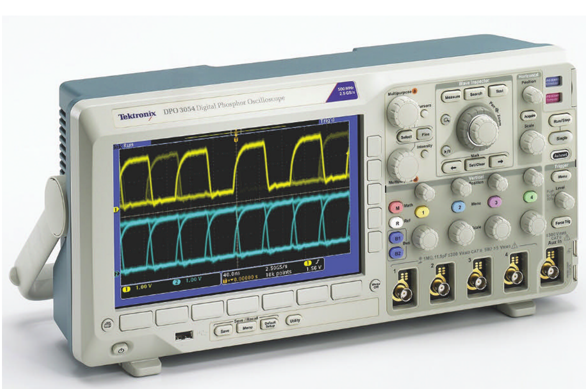
AEC-Q100	**AEC-Q100 reliability reports** Our reliability testing is extensive and fully compliant to AEC-Q100. All reliability reports are readily available on our website.
PPAP	**PPAP library and request form** Our automotive ICs meet the stringent *AIAG Production Part Approval Process* (4th edition) requirements. To date, our dedicated team has delivered over 700 customer-specific PPAPs.
ISO/TS 16949	**Fully ISO/TS 16949:2002 certified** Complying with strict automotive quality standards, we are fully ISO/TS 16949:2002 certified.
Fit Rate PPM	**Reliability calculator** Calculate the FIT rate and PPM (with confidence interval) for your specific sample size.
EMI ESD	**Rugged ICs for harsh environments** Acquire samples of automotive products with low EMI ratings and/or rugged ESD protection.

Review our quality resources at:
www.maxim-ic.com/auto/quality

Small footprint value-priced scopes offer bigger displays, deeper memory, bus debugging, and more

Tektronix's new DPO-3000-series of lunch-box-sized, two- and four-channel, 100-, 300-, and 500-MHz-bandwidth scopes provides more than three times the screen area and 500 times the waveform-memory depth of Tek's largest selling scopes, based on unit volume—the small-footprint TDS3000 series. The DPO3000s, which target embedded-system developers, accomplish these feats in a 9-lb package whose height and width are only marginally greater than those of the TDS3000s and whose 5.4-in. depth is approximately 10% less. Prices for the new scopes are about 10% higher than those of their counterparts in the older series. The new units incorporate the company's Wave Inspector technology, which facilitates searching through long waveform records for anomalous events. Additionally, for debugging, the new units trigger from and decode the activity on five popular embedded-system buses: SPI (serial peripheral interface), I^2C (inter-IC), RS-232, CAN (controller-area network), and LIN (local-interconnect network).

Despite capabilities that eclipse those of the nearly decade-old TDS3000 series at only modestly greater prices, the new series will not replace the older products for the foreseeable future, according to David Pereles, value-scope-product manager at the company. He says the older series has won more devotees than any family of digital scopes in history, and, despite increasing calls for the DPO3000s' new features at prices close to those of the older units, many customers find that the older products can still meet their measurement needs, making it unnecessary to mix product types within instrument inventories.



Scopes in the DPO3000 series provide more than three times the screen area and 500 times the waveform-memory depth of their predecessors.

Tektronix believes the DPO3000s to be the first scopes to incorporate 800× 480-pixel WVGA (wide-screen video-graphics-adapter) displays. The screens measure 9 in. diagonally. All models can capture 2.5G samples/sec/channel for an oversampling ratio of at least five times, and all provide a memory depth of 5M samples/channel. The screen-update rate is 50,000 waveforms/sec. Connectivity features include an Ethernet port and two USB ports—a front-panel port for memory devices and a rear-panel port for connection to a PC. For bus debugging, the display switches to a text-only mode, but waveform views are just a button press away. US list prices range from $4450 for a two-channel, 100-MHz unit to $10,900 for a four-channel, 500-MHz unit. These prices include National Instruments' (www.ni.com) LabView SignalExpress, base version, which you can upgrade to the complete Tektronix Edition for a US suggested price of $699.—**by Dan Strassberg**

▷**Tektronix Inc**, www.tektronix.com.

FEEDBACK LOOP

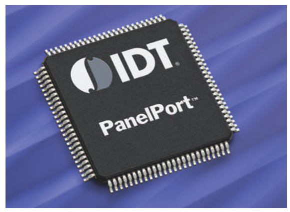
"I have talked to clients that are in a rush to make lithium-ion car-battery chargers; they won't spend a dime on PF (power-factor) correction. Again, shortsightedness masquerading for 'green.'"

—Reader "Steve," signing himself as "Perplexed in California" in *EDN*'s Feedback Loop at www.edn.com/article/CA6544740. Add your comments.

Receivers reinforce digital-display-interface ecosystem

I'm admittedly a bit more bullish about DisplayPort (www.displayport.org) than I was at the beginning of last year (see "Connecting systems to displays with DVI, HDMI, DisplayPort: What we got here is failure to communicate," *EDN*, Jan 4, 2007, pg 46, www.edn.com/article/CA6402885). Supporters of the standard have followed through on their promise to broaden DRM (digital-rights-management) support beyond relatively unknown Certicom (www.certicom.com) to encompass pervasive and Hollywood-blessed HDCP (high-bandwidth-digital-content protection). And the backing of Intel (www.intel.com) has substantially evolved since early 2007's rumors into current integration plans within next-generation core-logic chip sets.

Nonetheless, even the most fervent DisplayPort backers privately admit that they will be unable to fully shed the yoke of Silicon Image (www.siliconimage.com) control and royalty payments. While DisplayPort specification development crawled toward completion, HDMI (High-Definition Multimedia Interface)-silicon shipments were rapidly ramping into a diversity of CE (consumer-electronics) equipment, leading to today's HDMI dominance in both video sources, including optical-disc players, set-top boxes, and camcorders, and destinations, such as displays and capture peripherals. To wit, although LCDs targeting use in office environments may be able to get away with DisplayPort-only digital inputs, any display with even the slightest possibility of requiring a CE tether will also need to encompass HDMI support.



The VPP1600EMG receiver IC comes in a 100-lead TQFP and is now available for sampling.

Either a single-interface dominance or dual-port détente suits Integrated Device Technology just fine because the company is focusing its DisplayPort product-development efforts on display-intended receiver ICs, thereby explaining their PanelPort marketing monikers. IDT's first offering is the $5 (10,000) VPP1600EMG, which comes in a 100-lead TQFP and is now available for sampling; full production should occur by the end of this summer.

The device builds on a conventional DisplayPort 1.1a foundation by also integrating TCON (timing-controller) circuitry, and its adaptive-equalization capabilities make it a candidate for not only external-display configurations, but also internal-display buses, in which it would replace, for example, an LVDS (low-voltage-differential-signaling) interface within a notebook PC. IDT also plans a series of VPP11xx DisplayPort receivers, which will eliminate the TCON function block to reduce cost.

Although display interfaces represent a new product category for IDT, the company has leveraged its expertise in mixed-signal integration, SERDES (serializer/deserializer), and other relevant technologies that it honed over many years' worth of high-speed-memory, buffer, PHY (physical-layer), clock-management, and similar semiconductor designs. Near-term competitors include Analogix (www.analogix.com) and Genesis Microchip, which STMicroelectronics (www.st.com) acquired in late January.

—by Brian Dipert

▷**Integrated Device Technology**, www.idt.com.

DILBERT By Scott Adams

05.01.08

RF SCREEN COATING SAVES SPACE

MicroShield screening technology from RF Micro Devices integrates RF screening on the surface of a molded package. The protected device might contain a single chip or a multichip module. The company developed the process to replace metal screening cans that designers must often mount on PCBs (printed-circuit boards) either to shield the enclosed circuitry from external interfering signals or to prevent RF-interference leakage.

The sprayed-on conductive coating makes conductive contact with a "skirt" contact band that runs around the bottom edge of the molded package. When the assembly process solders the package to the PCB in the usual way, the skirt contacts a grounded ring that surrounds the package site. A ground-plane under the package, with vias for connections, completes the screen.

A company spokesman indicates that results are competitive with those of metal cans and that the technology reduces height and volume for RF-circuit sections by 25 to 50%. RF Micro will employ the process on its own product lines as an option, and it will also license it to other manufacturers.

—by Graham Prophet

▶**RF Micro Devices, www.rfmd.com.**

Rugged, high-voltage RF transistor uses vertical process, yielding better gain

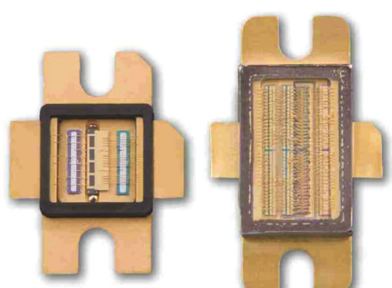
Start-up HVVi recently introduced the three-member HVVFET (high-voltage-vertical-field-effect transistor) family of RF-transistor products. Targeting pulsed-radar and avionics applications, the devices employ a process from the company's investment partner, On Semiconductor. The process employs a vertical structure rather than a lateral structure, providing the devices with better current density and a better thermal path to the heat sink than do LDMOS (laterally diffused metal-oxide-semiconductor) devices. The vertical structure and unique silicon process give the transistors properties rivaling or exceeding those of gallium-nitride and other transistors. The HVVFET's low gate capacitance improves frequency response, its low drain-to-source capacitance improves efficiency, and its low on-resistance improves power handling.

The HVVFET's small footprint, high efficiency, thermal performance, and ruggedness make it appealing in phased-array-radar systems, which can require as many as 1000 RF power devices. Because the HVVFET can withstand a 20-to-1 VSWR (voltage-standing-wave ratio) at rated output power and nominal operating voltage, it requires no heavy circulators and isolators such as those that protect conventional RF transistors. The devices tout at least 15-dB gain, often eliminating the need for gain stages and maintaining the overall signal-path gain. The devices have a 48V power rating, meaning that one power supply can feed both the output and the driver transistors.

All three devices operate at a junction temperature as high as 200°C. The 25V HVV1214-25 has 19-dB gain, operates in the 1.2- to 1.4-GHz range, comes in a 0.2×0.17-in. ceramic surface-mount package, and has a thermal resistance of 1.5°C/W. The 100W HVV1214-100 has 20-dB gain; operates in the 1.2- to 1.4-GHz band; comes in a two-lead, metal-flanged NI-400 package; and has a thermal resistance of 0.8°C/W. The 300W HVV1011-300 has 15-dB gain; operates in the 1.03- to 1.09-GHz band; comes in a two-lead, metal-flanged NI-400 package; and has a thermal resistance of 0.2°C/W. The parts and evaluation kits are available now. HVVi can design parts with custom bandwidth requirements in as little as 90 days. Prices are $135.69, $226.15, and $398.31 (one to 49) for the three devices, respectively.

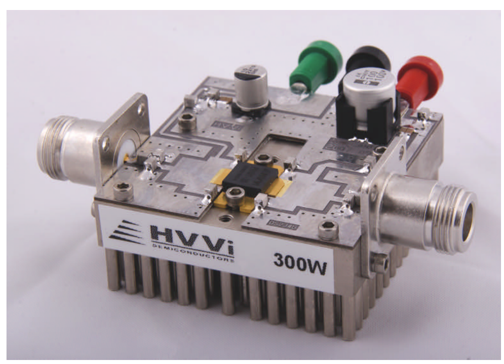
—by Paul Rako

▷**HVVi**, www.hvvi.com.



(a) (b)

The HVVFET (a) employs a vertical structure, providing better current density and a better thermal path to the heat sink than an LDMOS device (b).



HVVi can supply evaluation kits for all of its vertical MOSFET-RF-power transistor products.

PROCESSOR SUPPORTS CAPACITIVE TOUCH SENSING FOR BUTTON AND SLIDER REPLACEMENT

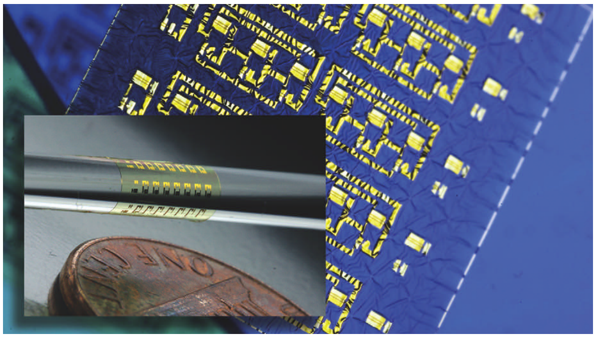
Cypress Semiconductor's CapSense Express devices, working with the PSoC (programmable-system-on-chip) Express visual embedded-system-design tool and the CapSense Express configuration tool, enable designers to monitor and tune the performance of as many as 10 button-and-slider interfaces in real time using a graphical user interface. The CY8C201X0 and CY8C201X2 CapSense Express devices support capacitive or general-purpose I/Os to implement combinations of buttons, multisegment sliders, and LED controls. These devices consume 1 mA of active current and 2.6 μA in sleep mode and support an operating voltage of 2.4 to 5.25V across the industrial-temperature range of −40 to +85°C. The CY8C201X0 and CY8C201X2 CapSense Express devices are available in eight- and 16-pin SOIC and 16-pin QFN packages for less than $1 (10,000). These devices feature 2 kbytes of flash memory and an I²C communication interface to support programming loading over I²C at power-up.

Three evaluation kits are available for the CapSense Express devices. The CY3218-CAPEXP1 kit features three CapSense buttons, three backlighting LEDs, three LEDs for status, and one mechanical button. The CY3218-CAPEXP2 kit offers a five-segment slider with four status LEDs and one mechanical button. The CY3218-CAPEXP3 features two CapSense buttons with two status LEDs using the smallest eight-pin SOIC package. The three kits sell for $45 each. Developers can complete CapSense designs with preconfigured and verified user modules within Cypress' PSoC Designer 4.4 integrated design environment.

—by Robert Cravotta

▶**Cypress Semiconductor, www.cypress.com/capsense.**

05.01.08



◀Optimized mechanical layouts and fabrication strategies create "wavy" silicon circuits that conform to curves and even tolerate folding and bending while they operate.

RESEARCH UPDATE

BY MATTHEW MILLER

Process makes silicon circuits that can fold, bend, and stretch

A new process creates ICs that not only can bend to conform to various surfaces, but also can operate while stretching, compressing, and folding. Scientists at the University of Illinois—Urbana-Champaign, working with colleagues at Northwestern University (www.northwestern.edu) and Singapore's Institute for High Performance Computing (www.ihpc.a-star.edu.sg), have developed fabrication strategies for circuits that can, for example, play a role in wearable medical devices or wrap around airplane wings for structural monitoring.

The researchers use conventional planar IC-fabrication techniques, along with printing methods that lay down aligned nanoribbons of single-crystal silicon, to build circuit elements on top of a thin plastic sheet. They then bond the resulting IC to a piece of prestrained silicone rubber. Releasing the strain allows the rubber to return to its original shape, thus applying compressive stresses to the circuit. This step leads to a complex pattern of buckling and creates a geometry that in turn allows the circuit to fold, bend, and even tolerate deformation during operation.

The team has constructed circuits containing transistors, oscillators, logic gates, and amplifiers and claims that these ICs exhibit electronic performance similar to their more rigid, conventional-silicon counterparts.

▷**University of Illinois at Urbana-Champaign**, www.uiuc.edu.

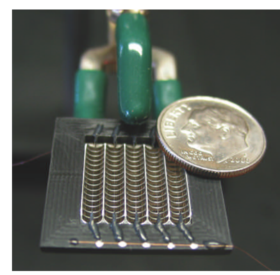
Solid-state cooling device harnesses corona discharge

Thorrn Micro Technologies has demonstrated a small, silent, no-moving-parts cooling device that generates more airflow than mechanical fans four times its size while consuming less power and space. The 15×15×2-mm RSD5 creates a breeze of 2.4m/sec, outperforming the 1.7m/sec that a mechanical fan measuring 40×40×10 mm can produce, according to the company.

The product of six years of National Science Foundation (www.nsf.gov)-funded research, the technology nestles live wires within half-cylinder beds that the company carves into a nonconducting plate. Application of a voltage through the wires causes a corona discharge, creating a microscale plasma. Free ions in the plasma then migrate from the wires to the plate, displacing air molecules as they go and generating a sustained wind.

Thorrn's innovation lies in the structure that channels the airflow effectively enough to cool a 25W chip with a device smaller than 1 cm^3 without risk of sparks or arcing. In the company's current design, the contoured plate resides atop a heat sink, but plans call for integrating the technology directly onto ICs.

▷**Thorrn Micro Technologies**, www.thorrn.com.



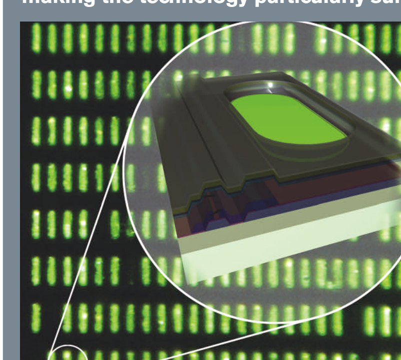
This device pushes air molecules around to create a cooling breeze for laptops and handheld gadgets.

ACTIVE-MATRIX DISPLAY EMPLOYS NANOWIRE TRANSISTORS

05.01.08

A research group including members from Purdue University, Northwestern University, and the University of Southern California claims it has developed the first active-matrix display based on nanowire transistors, which offer better transparency and flexibility than conventional silicon circuitry. In the proof-of-concept display, indium-oxide-nanowire transistors, indium-tin-oxide electrodes, and plastic capacitors form an array of OLEDs (organic light-emitting diodes).

The display looks like slightly tinted glass when idle, according to the researchers, making the technology particularly suitable for heads-up displays. The demonstration unit supports only row-by-row addressing, but the researchers expect to soon achieve pixel addressing. Moreover, they state, the demonstration display proves that they can create OLEDs that measure 176×54 microns–ideal for small displays in portable consumer-electronic devices–and achieve brightness approaching that of LCD TVs.



▶Purdue University, www.purdue.edu.

▶Northwestern University, www.northwestern.edu.

▶University of Southern California, www.usc.edu.

BY HOWARD JOHNSON, PHD

Scrape it

To probe a microstrip trace with no accessible test points or vias, you have to remove some of the solder mask. I know of only six ways to do it: scraping, milling, grinding, microblasting, chemical stripping, and UV (ultraviolet) illumination.

The UV-laser idea (US Patent No. 7081209) gives me the willies. It reminds me of a warning label I once saw on a powerful carbon-dioxide laser: "Do not look into this orifice with your remaining good eye." My lab is dangerous enough without adding invisible death rays.

Chemical stripping sounds like an appealing idea, unless you've ever tried to remove the old finish from an antique chair. It seems that, unless you know precisely what finish is on the surface, the strippers never react properly. Most likely, the technique will just make a big gooey ball on your PCB (printed-circuit board). Especially when you consider the huge variety of new coatings manufacturers are trying to mitigate tin-whisker problems, chemical stripping is not a good idea.

Eliminating those techniques leaves the mechanical approaches. Microblasting with a tiny sandblasting tool does quickly remove material, but it builds an incredible static charge across your board. Yikes! We are trying to measure signals on the board, not blow it to kingdom come. You can control the static buildup with a special ionized-air environment, but you can't deploy that sort of technology in an ordinary lab setting.

Grinding and milling are powerful techniques that both involve rotating machinery. Their biggest problem is that they are too powerful. You will spend a lot of effort throttling back

If you wear nice slacks to work every day, then you probably won't like this idea.

their strength so you don't cut completely through the trace.

Now you're down to my favorite tool, the lowly scraper. I like a scraper with a rounded blade. The curvature contacts your board over only a limited area. Given the right curvature, you can scrape a path just wide enough to reveal a trace under test without exposing other nearby features. Right before I set down my probe, I dress the exposed trace with a tiny piece of No. 600 sandpaper that I've heat-glued to the cut end of a Q-tip. This approach thins the copper oxide for better conduction.

So, where do you get a round-bladed scraper? If you wear nice slacks to work every day and you think digital engineers should always have clean, manicured fingernails, then you probably won't like this idea: Make it yourself. All you need are a hobby knife and a whetstone. I use a stone with a rough side and a smooth side. All hardware stores have them. Just ask for something that will sharpen a small pocketknife.

Some people recommend using a canine-tooth scraper (tartar scraper). It can work, but you'll have to grind it down to the width of your trace and then keep it sharp. Either way, you'll end up using a whetstone.

I start with a hobby knife that has a straight, sharp edge about 0.15 in. long. Holding the knife blade against the rough side of the whetstone, I make about 20 small circles. Then I turn the knife over and do the same on the other side. Try to hold the knife at a constant angle from the stone, about 20 to 30° from the horizontal. Whatever angle you choose will be the angle at which the stone grinds. Repeat the process on the smooth side of the stone, holding a 5° higher angle. The higher angle concentrates the final polishing on the sharp edge of the blade. Clean the stone with a paper towel.

With these basic instructions, you can make a sharp, straight blade. To form the curve, twist the blade back and forth as you circulate. You'll grind the ends of the sharp edge more than the middle, curving the blade.

When you're done, your knife will make clean scrapes the width of just one trace. EDN

MORE AT EDN.COM

Go to www.edn.com/080501hj to post a comment on this column and to see brief video clips of the sharpening and scraping processes.

Howard Johnson, PhD, of Signal Consulting, frequently conducts technical workshops for digital engineers at Oxford University and other sites worldwide. Visit his Web site at www.sigcon.com or e-mail him at howie03@sigcon.com.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Military Environmental
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EDN's 2007 INNOVATOR AND INNOVATIONS OF THE YEAR: THE WINNERS

For more details on the winners and all of the finalists, visit www.edn.com/innovation18.

2007: YET ANOTHER VINTAGE YEAR FOR ENGINEERING GENIUS.

***EDN*'s 18th Annual Innovation Awards** ceremony has once again recognized outstanding individuals, team efforts, and great ideas from the year past. We would like to take a moment to present to you the winners, with a brief summary of their achievements.

This year, the judges—a team effort that involved editorial staff, our editorial advisory board, and you, the readers of *EDN* and edn.com—had a serious challenge to decide among closely matched and highly qualified entrants. Categories included special awards we recognize every year: the Innovator of the Year and the best contributed article of 2007. In addition, we examined nominations for awards in no fewer than 19 product and technology categories, searching for the best of the best.

Now, we've counted the votes, feted the winners at our annual awards dinner in San Jose, CA, made the toasts, cleared the glasses from the tables, and swept the confetti from the floor. But our commitment to finding and recognizing the best in electronics engineering is far from over. We will continue to report on the progress of these innovations throughout the year. In addition, we will seek out key opinion leaders at the edge of technology, preparing a midyear report on the big ideas and vital debates in electronics. And we will be back next year with a new crop of award-winners, representing the best of the best of 2008. Business may have cycles, markets may come and go, but the stream of intellectual progress that drives our engineering profession moves inexorably forward.

Please join us in celebrating the winners, and good fortune on your endeavors in the coming months.

ANALOG ICs

BGA700L16, BGA734L16 low-noise amplifiers (Infineon Technologies AG)

Infineon has developed the BGA700L16 and BGA734L16 RF low-noise amplifiers with a proprietary silicon-germanium-carbon process. By combining this process with an innovative, low-resistance, on-chip ground contact, the silicon-based part outperforms gallium-arsenide parts. The BGA734L16 for the 800-, 1900-, and 2100-MHz cellular bands has a 1.2-dB noise figure for the 2100-MHz band as well as 1-kV ESD (electrostatic-discharge) protection. The BGA700L16 targets use in wireless-LAN 802.11a/b/g/n applications. It has a noise figure of 1.3 dB in the 5.5-GHz band.

MIXED-SIGNAL ASSPs

LMH0340/LMH0341 serializer/deserializer (National Semiconductor)

National Semiconductor has used its extensive background in LVDS (low-voltage-differential-signaling) to provide an innovative approach to test equipment in TV-broadcast and -editing facilities. The LMH0340/LMH0341 serializer/deserializer operates over 75Ω coaxial cable rather than the ribbon cable that displays use. By applying the LVDS technology from the deserializer to the host FPGA and by using cable-equalization techniques, these parts allow uncompressed transmission of 1080p60 signals over a single coaxial cable at 2.97 Gbps.

POWER ICs

LT3080 adjustable low-dropout regulator (Linear Technology)

You can mount the LT3080 three-terminal linear regulator in parallel rather than using surface-mount techniques. The device has a 10-μA set current, meaning that a 100-kΩ resistor produces a 1V output. By leveraging Linear Technology's low-offset-voltage-design expertise, the voltage at the output remains within 1 mV of the set pin. Hence, multiple surface-mount regulators can all share one set resistor and the output current. A copper-clad board can dissipate approximately 5W per device, so designers can parallel enough devices to achieve their power requirements and eliminate the need for bulky, expensive mechanical heat sinks.

INNOVATOR OF THE YEAR

The 45-nm-process Innovation Team at Intel Corp

Shrinking geometries have pushed one critical part of the transistor to its limits: the silicon dioxide that acts as an insulation layer between the gate and the channel in which current flows. With each new generation of Intel chips, this layer had become increasingly thinner—just five atoms thick at 65 nm—and it became harder to skim off one more atom.

Intel's team embraced a radical change. For the first time in 40 years, the insulation layer would be made not of silicon dioxide, but of hafnium-oxide, a metal that helps reduce current leakage by a factor of 10.

The change brought problems. For example, the new material is incompatible with the transistor gate. To address that problem, this team developed a new metal material for the gate. In November, the company introduced a generation of 45-nm chips using these new materials. Because the 45-nm transistors are smaller than the previous generation, they require as much as 30% less energy for switching on and off, offering both power savings and a boost in performance. Industry experts generally consider the resulting Intel Core 2 Extreme QX9650 quad-core processor the fastest PC processor on the market.


Tahir Ghani


Kaizad Mistry


Kelin Kuhn


Mark Bohr


Robert Chau

DIGITAL ASSPs

Ezairo 5910 hearing-aid IC (AMI)

Many hearing aids process just the voiceband. However, a wider band allows hearing-impaired people to fully enjoy richer sounds, including music. AMI Semiconductor's Ezairo 5910 RASSP (reconfigurable application-specific signal processor) provides hearing aids the processing power to handle a wider portion of the frequency spectrum, low power for long battery life, and the ability to fit into tiny packages.

Ezairo has high-performance, 24-bit digital-signal processing and consumes less than 1 mA at full processing power. The 24-bit processor supports sophisticated algorithms for adaptive-noise reduction, directional-sound pickup, and feedback cancellation. Ezairo can capture a 12-kHz range and has an input dynamic range of 110 dB compared with earlier devices' typical 90 dB, ensuring that users clearly hear soft and loud sounds.

NETWORK AND COMMUNICATION ICs

BCM4325 Wi-Fi and Bluetooth IC (Broadcom)

Broadcom's BCM4325 combines support for Wi-Fi, Bluetooth, and FM radio onto a single silicon die for multimode handsets. The company claims that the chip both delivers better performance than discrete wireless approaches and significantly reduces the system's size, power consumption, and cost.

In addition to solving Bluetooth/Wi-Fi-coexistence issues, the BCM4325 is notable in that it integrates an 802.11a/g power amplifier. The power amp is crucial to maximizing range. Most 802.11 systems use discrete power amplifiers made with expensive GaAs (gallium arsenide) or SiGe (silicon germanium) to meet the performance requirements. Broadcom claims to be the first company to achieve good power-amp performance in CMOS technology.

MULTIMEDIA ICs

88DE2710 video-format converter (Marvell)

The transition from NTSC (National Television System Committee) to ATSC (Advanced Television Systems Committee)—only about a year away—will make high-resolution displays even hotter. Those displays handle ATSC feeds; high-definition content from cable, IPTV (Internet Protocol television), and satellite pipes; and Blu-ray and

BEST CONTRIBUTED ARTICLE

"Choose capacitor types to optimize PC sound quality"

Kymberly Schmidt, Maxim Integrated Products, www.edn.com/article/CA6430345

A key challenge to designers of audio subsystems that must conform to Windows Vista requirements may be choosing coupling capacitors. These devices' capacitance varies with the voltage across them and introduces audio distortion. To minimize the effect, start by understanding the interactions among the dielectric material, voltage rating, device size, and voltage coefficient. Then, get ready to make trade-offs.

HD-DVD optical discs. But what about standard-definition DVDs, low-resolution material from Apple TVs or video-capable iPods, YouTube displays, and VHS decks? Marvell's 88DE2710 can handle all those formats. It provides high-quality rescaling, artifact compression, 3-D video-noise reduction, 3-D adaptive deinterlacing, adaptive contrast enhancement, and intelligent color remapping. It also supports one high-definition-capable video output and one standard-definition video output.

DIGITAL ICs, MEMORY, AND PROGRAMMABLE LOGIC

All-In-OneMemory (SST)

NAND memory touts the highest silicon efficiency and lowest cost per bit, but it does not provide fast random access for direct code execution. EPROM-derived NOR can allow directly executed code but costs more per bit than NAND. Systems need both, but designers have wanted both capabilities in one device, not two.

SST's NAND-based All-in-OneMemory also includes 4 Mbytes of PSRAM (pseudo SRAM) in the initial SST88VP1107 member of the product family. The PSRAM acts as a directly executing cache. Caching the NAND contents extends flash-memory endurance and improves reliability by minimizing direct read/write-access cycles. The cache's demand-paging scheme also eliminates the need for shadowing the OS and application code, thus reducing the amount of required system RAM.

MICROCONTROLLERS AND CORES

LPC2478 ARM-based microcontroller (NXP Semiconductors)

NXP's LPC2478 ARM7-based microcontroller splits the AHB (advanced high-performance bus) into two so that the system can handle the data and processing loads to simultaneously support the integrated Ethernet, USB, and QVGA LCD interfaces in addition to the other more than one dozen serial peripherals in the system. The LPC2478 also features 512 kbytes of flash that supports 128-bit accesses and, along with a memory accelerator, enables the system to execute serially from flash directly at speeds as high as 72 MHz without moving the code into RAM.

MULTICORE MICROPROCESSORS

QX9650 Core 2 Extreme processor (Intel)

Intel implements its Core 2 Extreme QX9650 quad-core processor on the company's 45-nm manufacturing process, which enables more performance with better energy efficiency. The process incorporates a hafnium-base high-k-metal-gate formula into each of the 820 million transistors in each processor. Further enhancements include a larger dual 6-Mbyte shared L2 cache (12 Mbytes total) and support for new Intel SSE4 media instructions. Each of the four cores can simultaneously complete as many as four full instructions.

EDA: DIGITAL-IC-DESIGN TOOLS

Calibre nmOPC optical-proximity-correction tool (Mentor Graphics)

Calibre nmOPC delivers technology that supplies the required performance for 45-nm computational lithography without the high cost of specialized, dedicated hardware or massive increases in general-purpose computers.

The nmOPC product's single most important innovation is to combine general-purpose computers with Cell BE-based coprocessor accelerators. This architecture allows designers to maximize the performance of their standard clusters simply by connecting the standard, commercially available Cell-processor cluster to the general-purpose cluster using Ethernet. Calibre nmOPC users can achieve a fourfold to tenfold improvement in runtime with little to no increase in general-purpose computing requirements.

EDA: PCB, FPGA, AND CUSTOM-IC TOOLS

Sentinel-CPM power- and signal-integrity tool (Apache Design Solutions)

Apache claims the Sentinel-CPM is the industry's first compact, Spice-accurate model of the full-chip PDN (power-delivery network). It enables chip-package-board co-design and co-verification for dynamic power integrity, and package designers use it early in the design flow and throughout the entire process. During early design, package designers can take CPM based on floorplan data for more accurate and predictable package selection, as well as power-pad-to-signal-pin ratio and package-decoupling-capacitance optimizations. Later in the flow, package designers use CPM based on detailed layout to accurately run power-integrity analysis of the package including the PDN behavior of the IC, to diagnose potential chip-package LC resonance issues, and to validate package/board dynamic-voltage noise margin.

BOARDS, MODULES, AND PERIPHERALS

9014 CompactRIO controller (National Instruments)

National Instruments' latest CompactRIO platform combines a Freescale processor and a Wind River real-time operating system with a built-in Xilinx FPGA to deliver the extra performance for a variety of embedded- and industrial-system applications, such as high-speed machine control, in-vehicle data logging, and embedded-device prototyping. CompactRIO allows developers to define custom embedded-hardware circuitry using plug-in I/O modules, a reconfigurable FPGA, and LabView graphical-development tools. The new cRIO-9014 controller combines a 400-MHz Freescale MPC5200 processor with an integrated floating-point unit, a hardware-based memory-management unit, 128 Mbytes of memory, and 2 Gbytes of nonvolatile storage.

SOFTWARE

Mobilinux 5.0 (MontaVista)

Mobilinux 5.0 is an optimized Linux operating system and development platform for wireless handsets and other mobile devices, such as GPS (global-positioning system) devices, portable medical devices, and wireless POS (point-of-sale) terminals. Monta Vista claims it is in use in 90% of Linux-based smartphones, more than 35 million phones, and other mobile devices. In addition to providing a platform for the features common in today's smartphones—such as touchscreen control, e-mail processing, Bluetooth and Wi-Fi connectivity, videocameras, multimedia, and Adobe flash display—Mobilinux 5.0 enables developers to easily provide custom functions. Mobilinux supports Linux standards, so designers can add functions by including off-the-shelf Linux utilities without worrying about function loss due to incompatibility.

DEVELOPMENT KITS

eZ430-RF2500 wireless-development tool (Texas Instruments)

Laying claim to the world's smallest low-power wireless development kit, Texas Instruments introduced a tool for designing embedded systems that combines MSP430 microcontrollers with wireless communications. Packaged in a USB-stick form factor, the eZ430-RF2500 development tool includes two RF-enabled microcontroller target boards and a PC-based debugging interface. The USB development interface plugs into a PC port and connects directly to the microcontroller-RF target board, providing the developer with the essential elements of a wireless network.

The eZ430-RF2500 kit comes with all the software needed to program wireless MSP430 applications. The user can choose either the IAR Embedded Workbench or TI's Code Composer Studio Essentials development environments to write and download code and then debug the application at full speed using hardware breakpoints and single stepping.

POWER SOURCES

ZY8160 60A point-of-load converter (Power-One)

Power-One's ZY8160 POL (point-of-load) regulator combines I^2C, GUI (graphical-user-interface)-programmable sequencing, and tracking with more-than-92% efficiency in a compact 1U-blade-server-compliant design for an 8 to 14V input-voltage range and a 0.5 to 2.75V output-voltage range at a continuous output current of 60A. ZY8160 POL regulators can work as part of a system comprising as many as 32 devices, including as many as four analog components, such as fans, VRMs (voltage-regulator modules), linear regulators, and POL regulators. To avoid damaging multivoltage ASICs, voltage-supply-rail differentials must be tightly controlled.

SENSORS

Image-sensor technology (Eastman Kodak)

In the past, designers have based most color-image sensors on the Bayer pattern, which Eastman Kodak developed in 1976. Kodak's new image-sensor technology employs a color-filter pattern that adds panchromatic pixels to the red, green, and blue pixels of the standard Bayer pattern, allowing a significantly higher proportion of light to strike the sensor. Kodak developed new software algorithms to work with the raw data that these sensors capture, providing a two- to four-times increase in sensitivity and retaining the overall image quality and color fidelity of the sensor.

The pattern allows development of cameras that can take better pictures under low light or reduce motion blur when imaging moving subjects. In addition, the pattern gives designers the ability to design smaller pixels, leading to higher resolutions in a given optical format without compromising image sensitivity.

PASSIVE COMPONENTS AND INTERCONNECT

EPIC thin-film-resistor chip (Vishay)

Applications as diverse as air bags, military-pilot-ejection systems, and electronically triggered blasting in mining and demolition systems require resistive elements that convert electrical energy into heat energy over a precise electrothermal profile to initiate a series of pyrotechnic events in a controlled energetic reaction. In the past, designers had to rely on bridge-wire resistors made of short lengths of wire welded between two terminals whose value depended on the positioning and the quality of the welded joints, which are difficult to control.

Vishay's EPIC (electro-pyrotechnic-initiator-chip) resistor is the first device to offer joule-effect ignition for firing times as low as 50 µsec and a no-fire/all-fire ratio as high as 70%.

TEST & MEASUREMENT: POWER

N6705A dc-power analyzer (Agilent)

The Agilent N6705A dc-power analyzer is the first instrument to perform complex dc sourcing and measuring tasks without programming, thereby providing test insights in minutes, not hours. It integrates several instruments into an easy-to-use benchtop package and represents a new instrument category for R&D engineers, who operate under tight schedules and work on complex designs.

The N6705A eliminates the need for multiple pieces of equipment and complex test setups. With all functions available at the front panel, it provides test insights in minutes because R&D engineers need not develop and debug programs to control collections of instruments. In a typical case, a user reported cutting test-setup time from 45 minutes to 30 seconds.

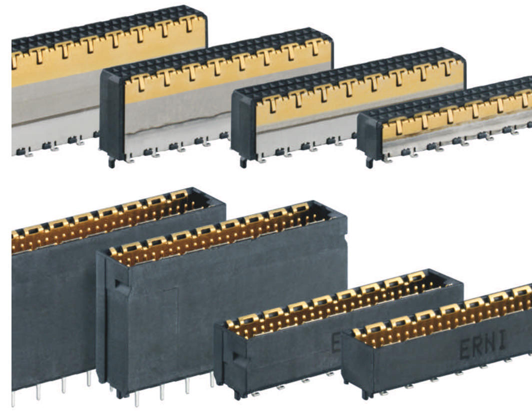
TEST AND MEASUREMENT: GENERAL

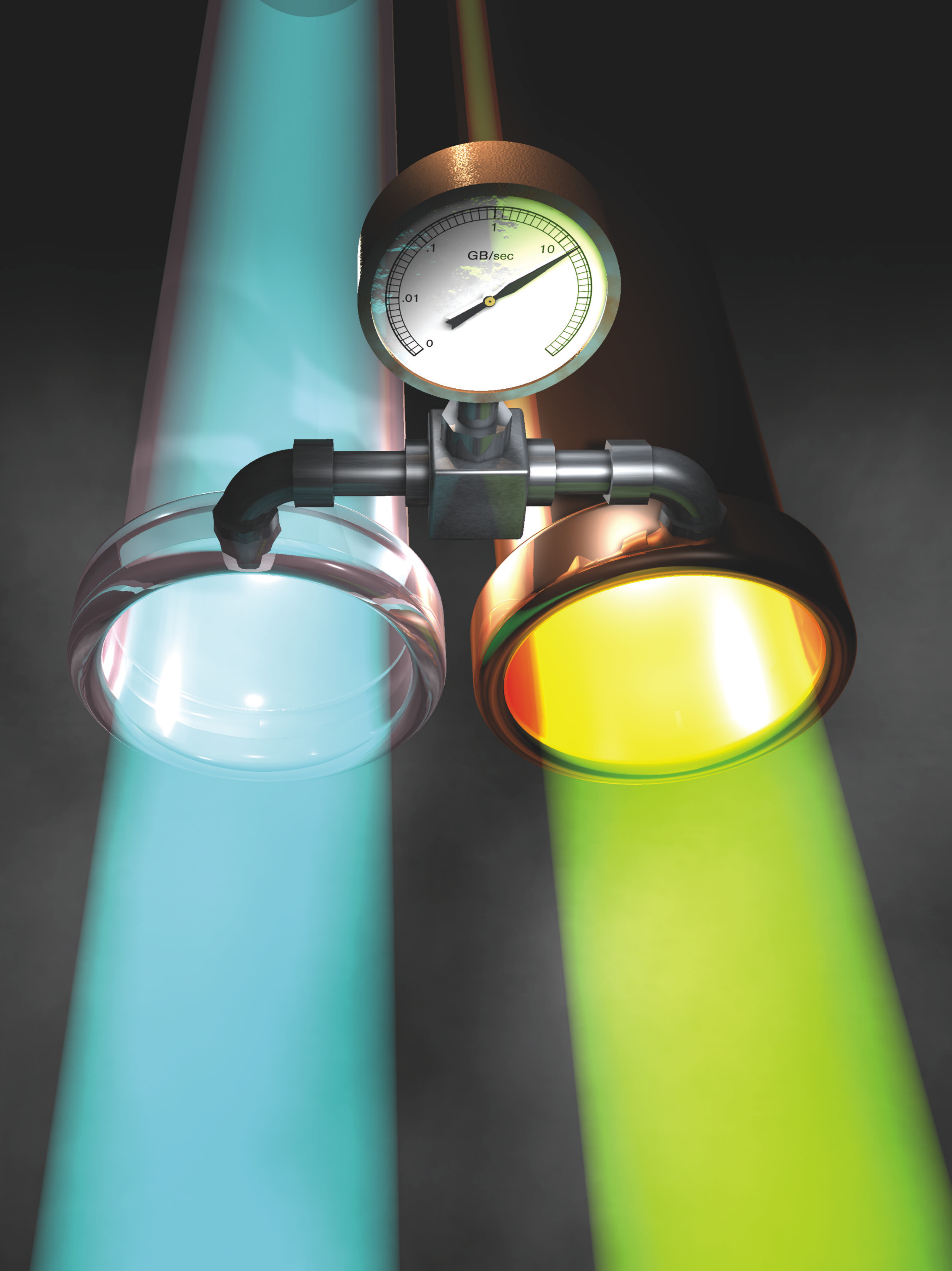
WaveExpert 100H sampling oscilloscope (LeCroy)

LeCroy Corp's WaveExpert 100H is the first sampling oscilloscope that can acquire, measure, and process signals that you cannot physically probe. The instrument fully addresses the analysis and compliance requirements of the long serial-data patterns required by standards such as PCI Express 2.0, serial ATA (advanced-technology attachment), XAUI (10-Gbps attachment-unit interface) and 10-Gbps Ethernet.

The WaveExpert 100H features LeCroy's Eye Doctor, a DSO (digital-sampling-oscilloscope)-based instrumentation and simulation system that addresses these measurement challenges and represents a dramatic leap in interoperability- and compliance-testing capability.

Eye Doctor provides the tools to undo or balance many common forms of distortion, thereby increasing SNR (signal-to-noise ratio), opening eyes, increasing rise time, reducing jitter, restoring lost bandwidth, and improving waveform fidelity.





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10-GBE EDGES CLOSER TO MAJOR PRODUCT ROLLOUTS AS SILICON PRICES AND POWER CONSUMPTION FALL. BUT IT MAY BE TWO YEARS OR MORE BEFORE WIDESPREAD DEPLOYMENTS START MEETING DEMAND.

BY ANN R THRYFT • CONTRIBUTING TECHNICAL EDITOR

10-GbE in the MAINSTREAM

For several years, next-generation Ethernet capable of 10-Gbps speeds has been on the brink of entering the mainstream. Some areas of the network have for some time been using optical technology, and demand is increasing for 10-GbE (gigabit-Ethernet) data rates as traffic increases. But vastly more complex technology than in previous generations of Ethernet is necessary to run 10-GbE over 100m lengths of copper. That requirement has resulted in expensive MAC (media-access-controller) and switch silicon and costly and inconvenient PHY (physical)-layer-interface chips, limiting the speedy LAN to high-performance applications covering shorter distances within data centers.

This picture is beginning to change, but widespread deployment of 10-GbE is not likely for at least two years (**Figure 1**). In June 2006, the IEEE finalized the 10GBaseT P802.3an spec for operation over 100m copper. Switch and controller chips that meet the spec are now available, but, along with PHY chips, they are expensive and consume too much power. These problems have been especially severe with 10GBaseT PHY-layer chips.

Silicon power consumption must be less than 5W/port for use in commercially available equipment in chips such as switches and NICs (network-interface controllers). "That's not the case with most of these chips now," says Alan Weckel, senior analyst for Dell'Oro Group. "In contrast, optical pluggable [transceiver] modules consume less than 1W." Most 10GBaseT PHY chips currently consume 8 to 10W per port.

Although per-port prices have for some time been falling, lower component prices alone don't necessarily create demand. "It will take time to ramp up volumes in the next couple of years," says Jag Bolaria, senior analyst for The Linley Group. Meanwhile, the cost of optical fiber is decreasing, "and the early stages of 10GBaseT could be the next kicker in the road in getting volumes up."

THE NEED FOR SPEED

Analysts expect a fairly rapid ramp for 10-GbE technology over the next four to five years. Drivers include sheer bandwidth demands because of server-performance increases and other factors, such as virtualization (see **sidebar** "Virtualization and 10-GbE"). The demand for 10-GbE over copper, including 10GBaseT, comes from the fact that copper costs less and is easier to install than fiber, even though 10GBaseT requires unshielded Category 6A or shielded Category 7 cable to meet the spec's maximum distance of 100m. Although fiber will still find use for longer runs, the shorter enterprise and data-center runs need less expensive, 10-Gbps links.

During the next five years, 10-GbE should replace 1-GbE in two major applications that will drive significant port growth, according to Dell'Oro Group. In wiring-closet-switch uplinks, most 10-GbE fixed ports will be uplinks on 24- and 48-port 1-GbE switches, and the remaining 10-GbE ports will be 10-GbE-only switches, those finding use at the top of the stack for aggregation. The other major application area is in direct server connections.

AT A GLANCE

- The difficulty of implementing 10-GbE (gigabit Ethernet) over 100m copper, which the 10GBaseT spec stipulated in June 2006, has delayed the widespread deployment of 10-GbE. Major drivers for 10-GbE include server virtualization and 1-GbE link aggregation.
- 10GBaseT's complex technology has resulted in expensive PHY (physical)-interface chips that run too hot.
- Second-generation 10-GbE PHY silicon at the 65-nm-process node, due in 2008 and 2009, will help cut PHY-chip power consumption to approximately 5 to 6W, will improve design, and will lower costs through greater integration.
- Manufacturers are developing direct-attachment copper-twinaxial cables for use with smaller-footprint, lower-power SFP+ optical hot-pluggable-transceiver modules, offering an alternative for 10-GbE over distances of 10 to 15m within data centers.

Currently, copper finds use mainly between switches and PCs and between switches and servers. The uplinks from wiring-closet switches to data centers that are currently optical links will remain optical and will have significant potential for volume, says Weckel. Because enterprises are undergoing a major wiring-closet upgrade, the market for switching is increasing, as well. In switch-to-switch connections, the medium for 1-GbE is now optical and will remain optical at 10-GbE. In direct-server connections, the medium is copper, and it will remain copper at the higher speed.

As the number of 1-GbE ports increases, aggregation of those ports becomes a major reason to begin using 10-GbE technology. Without it, the uplink bandwidth is less than the bandwidth of the downstream ports, and blocking occurs. Tier 1 OEMs are selling 1-GbE gear for around $100/port, says Kamal Dalmia, vice president of marketing for Teranetics. For 10GBaseT switches at their introduction, the price will be approximately $500/port, a per-gigabit cost of roughly half that of 1-GbE equipment. Another main driver is the need to connect high-performance computing-blade servers in data centers with bandwidth commensurate with their processing speeds. Those servers include eight or 16 processors, each of which is increasingly likely to contain four or even eight cores, ramping up power requirements and speed.

Aside from the combined power-consumption and technology issues in implementing the technology, another major issue could hinder the rate of 10-GbE deployments, says The Linley Group's Bolaria. If the cost of implementing one 10-GbE port is too high, it may make more sense to aggregate links by combining two to four 1-GbE ports; more than that number would be expensive and cumbersome.

MORE COMPLEXITY, POWER

The first 10-GbE standard, IEEE 802.3ae, which originated in 2002, specified several PHY interfaces for optical-transmission media. In 2004, the IEEE 802.3ak-2004 short-reach amendment allowed 10-GbE over 15m coaxial cabling using 10GbaseCX4 PHY-layer chips. Compared with 1000BaseT, 10GBaseT data rates require highly complex digital-signal processing in silicon to deal with echo cancellation and crosstalk cancella-

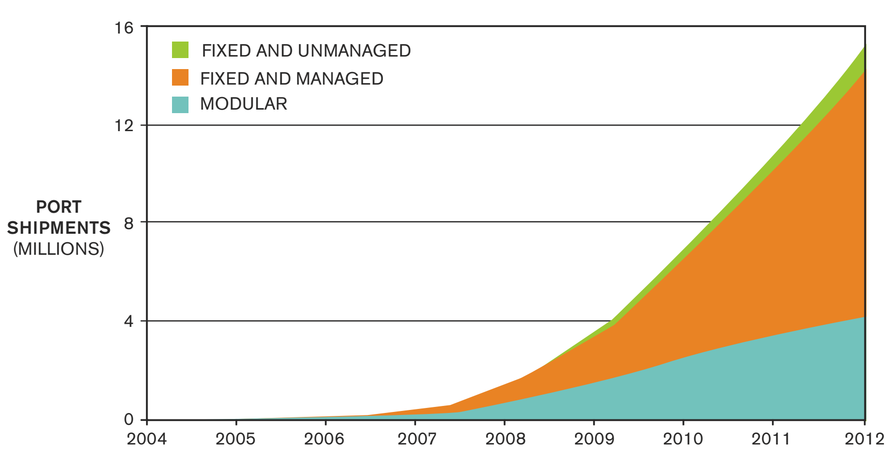

Figure 1 Total 10-GbE port shipments will grow from slightly more than 700,000 in 2007 to 15 million in 2012 (courtesy Dell'Oro Group).

Like Energy Saving Bulbs...
Ultra Low-Voltage CML Family Saves Power

SY54xxx Family of Buffers, Multiplexers and Crosspoint Switches Saves Significant Power

Micrel's new Ultra Low-Voltage Current Mode Logic (CML) family of buffers, multiplexers and crosspoint switches has lower-power consumption compared to its counterparts.

The SY54xxx product family can interface to either 1.2V or 1.8V receiver. The CML family of products is useful in applications that have stringent power specifications.

These devices are aimed for high-speed clock and data applications. The internal termination feature simplifies designs and keep total jitter below $10ps_{rms}$.

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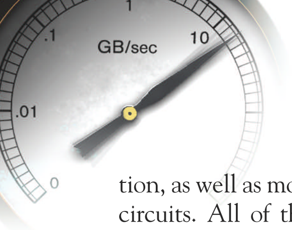


tion, as well as more sophisticated analog circuits. All of this processing to clean up the received signal must take place on links that are 10 times faster than the 1000BaseT spec. The 1000BaseT spec left a wide margin for compensation, but 10GBaseT does not, says Brad Booth, who acted as chairman of the IEEE 10GBaseT task force and is chairman of the Ethernet Alliance.

The 10GBaseT spec includes a subset for a short-reach PHY interface over a maximum 30m of Category 6 four-wire UTP (unshielded-twisted-pair) cable as a means of going to a lower-power operation mode. When the spec's developers wrote the draft, the concern was that most devices for a 100m range would consume 10 to 12W of power, and those levels of power consumption limit 10-GbE deployment in switch applications, says Booth. In a shorter-reach application with the 30m option, the PHY-layer device could drop to

VIRTUALIZATION AND 10-GBE

One reason for slow 10-GbE (gigabit-Ethernet) deployment is the lack of demand from end devices. Before virtualization, servers needed only a few 1-Gbps connections, and utilization rates weren't 100%. "With virtualization, utilization has increased, and throughput is now higher," says Alan Weckel, senior analyst for Dell'Oro Group. "Now, the demand for a 10-Gbps pipe is growing, and cost is becoming one of the barriers."

As internetworking of computers has increased, dependence on data centers has grown, in turn increasing the move toward virtualization. "Today, everyone is using everyone else's computers, such as for Web-based storage," says Bob Nunn, president and chief executive officer of Fulcrum Microsystems. "But the goal of a virtualized data center won't be achieved without a high-bandwidth interconnect technology that is common to the entire data center." For many, including Nunn, 10-GbE is that interconnect technology.

The increase in storage, server, and switch clustering is behind the move toward virtualization, and latency becomes critical. "To the user, it must look like one server, and that [scenario] won't happen if server response takes longer than expected," says Kamal Dalmia, vice president of marketing for Teranetics. 10GBaseT increases by a factor of five the density of bits moving in a rack (Figure A). It also halves the cost of bits moving in the rack and increases server-utilization rates by two to four times using virtualization, enabling the network to move bits at a much lower cost, says Matt Rhodes, Teranetics' CEO.

A virtualized data center shares and distributes resources to improve scaling and reduce costs. In conventional arrangements, a local bus interconnects centralized components, whereas in virtualization, fabrics interconnect distributed components, including remote storage. Managing the data during heavy traffic becomes an issue, so switches must incorporate congestion-management and load-balancing features, says Nunn.

In a virtualized server, virtualized guest operating systems run simultaneously on a multicore machine using a "hypervisor," or virtual-machine monitor. Although data-center applications themselves don't scale well across the multiple cores of server CPUs, virtualization changes that scenario, says Steve Pope, co-chief technology officer at Solarflare. "You can have a virtual operating system on each core, each of which runs a virtual application." However, the hypervisor can become a bottleneck when it comes to I/O across those cores.

The Solarstorm vNIC (virtual-network-interface-controller) hypervisor-bypass technology operates on Solarflare's Solarstorm Ethernet controllers. It offloads the hypervisor's I/O burden and provides solid I/O performance to virtualized guest operating systems. Because controller silicon must provide DMA (direct-memory-access) queues, which can also scale across cores, Solarflare's virtualization architecture provides more than enough virtual interfaces. With advanced virtualization schemes, you can realize significant performance benefits from allocating multiple DMA queues to each core and to each guest operating system, says Pope. Guest operating systems can also bypass the hypervisor to program the virtual interfaces using a set of open-source silicon-vendor-mutual APIs (application-programming interfaces) that Solarflare developed. These APIs let any silicon vendor take advantage of guest-operating-system access.

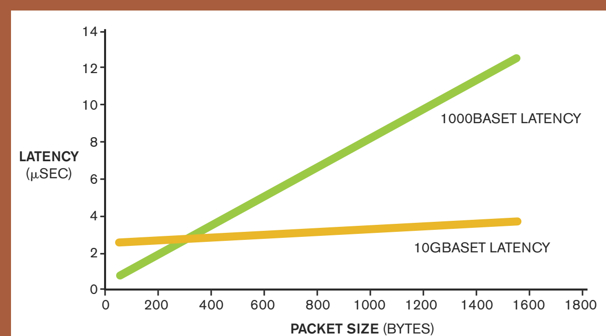
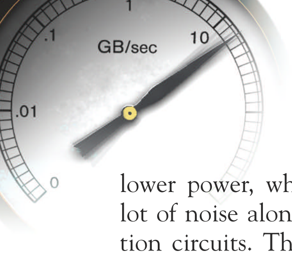


Figure A Even though its PHY-layer latency is greater than that of 1000BaseT, 10GBaseT's higher speed gets packets more quickly to their destinations (courtesy Teranetics).



lower power, which helps eliminate a lot of noise along with many cancellation circuits. The spec also allows the use of Category 6 cable for distances as long as 55m, because 70% of data centers' reach is 55m or less. However, operation over this distance doesn't buy lower power consumption.

Additional PHY-silicon issues are the need for multiple ports to pare down the cost per port, and the inclusion of multispeed ports for backward compatibility with 1-Gbps and even 100-Mbps Ethernet. An alternative method of connecting 10-GbE over copper may be possible using a new form factor in hot-pluggable optical-transceiver modules. The SFP+ (small-form-factor-pluggable-plus) module has a smaller footprint than the previous SFP form factor and consumes less power, allowing greater module density on a line card and offering lower per-port costs. Manufacturers are also developing direct-attachment SFP+ copper-twinaxial cables for distances of approximately 10 to 15m, which are adequate for connections within a data center.

10-GBE-SILICON ISSUES

The process technology for most chips now implementing 10-GbE over copper is 130 or 90 nm. The next generation may go to 65 nm, which is the next-lowest-cost node at which volumes may increase, says The Linley Group's Bolaria. Some in the industry believe that it will take a 45-nm process to reach the lower power consumption required to drive volumes and are trying to integrate some of the analog circuitry necessary for 10GBaseT at that process node. But the high amount of analog circuitry could be a problem in such smaller geometries, says the Ethernet Alliance's Booth. "One alternative may be multichip modules with analog front ends running in one process technology and digital back ends," he says.

Definitions of "high volume" can vary. Huge volumes are on the order of 10 million and 20 million ports, says Bolaria. In 2007, volumes for 10-GbE-switch ports with 10W PHY interfaces were approximately 640,000, and they contained 10W PHY-layer chips. "The next tier would be less than 5W, which will enable [manufacturers to ship] a few million ports," he says. "But, to get to

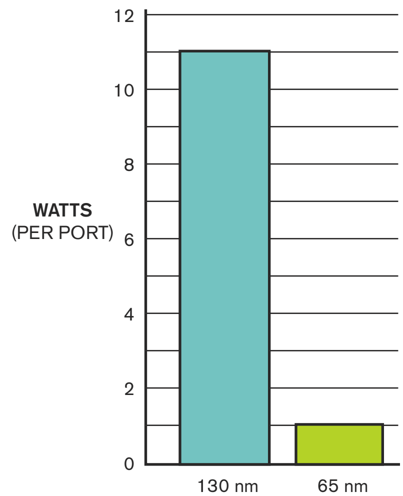


Figure 2 Moving to next-generation process technology will reduce 10GBaseT-silicon power consumption and make possible additional features (courtesy Broadcom).

20 million in port volume, PHY silicon will probably need to consume less than 2W." As ports per chip increase, chip volumes will decline somewhat.

The power budget of a typical first-generation 10-GbE endpoint NIC is approximately 25W, but designers usually want to stay closer to 15W, says Blaine Kohl, vice president of Tehuti Networks. You can build a single-port-10-GbE NIC with a 7W PHY chip, but you can tweak the power allocation even more in some designs. Manufacturers will most likely build single- and

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dual-port adapters for endpoints using this year's generation of 10GBaseT PHY silicon. However, switches need PHY chips closer to 3W. By 2010, 3 to 4W 10GBaseT PHY chips will probably be available. At that point, with 2 to 3W controllers, you may be able to integrate a controller chip and a PHY chip in one package. Switches could then adopt a 10GBaseT PHY chip, endpoints could adopt the 10GBaseT package, and manufacturers could be shipping 10GBaseT equipment in volume.

After offering samples of 10-GbE-controller and 10GBaseT PHY chips for a year and a half, Solarflare Communications has just introduced second-generation, 65-nm parts. The SFT9000 10GBaseT PHY chip consumes less than 6W and features multispeed autonegotiation at speeds as low as 100 Mbps. The SFC4500 10-GbE controller chip consumes 2.2W and features virtualization acceleration. Solarflare expects next year to make available a single-chip LAN-on-motherboard device that will integrate 10GBaseT-PHY and 10-GbE-controller silicon, according to Bruce Tolley, vice president of marketing.

Teranetics' first-generation all-CMOS TN1010 10GBaseT multirate PHY chip supports 1-GbE and 100-Mbps Ethernet. The company's next-generation 65-nm chip will be available this year, with 30 to 40% less power consumption than the current total of about 10W, says CEO Matt Rhodes. Fulcrum Microsystems' single-chip, 24-port FM4000 10-GbE IP (Internet Protocol) Version 4/6 switch/router chips target use in data-center-switching platforms in high-performance-computing, server-, and storage-host interconnection, and data-center-aggregation applications. The Layers 2/3/4 chips have full line-rate performance on all ports with a total throughput of 360 million packets/sec. Their 300-nsec latency provides a highly responsive network fabric that exceeds the performance of specialty fabrics, such as InfiniBand and Fibre Channel, and suits high-performance-clustered-computing applications, says Bob Nunn, Teranetics' president and CEO.

Broadcom makes single-chip, 10-GbE switch and controller silicon and optical transceivers. The 65-nm process technology for these chips requires a significant effort, especially for the switches, because they are large, highly integrated chips with both analog and digital components, says Eric Hayes, director of marketing for the network-switching line of business. The 65-nm BCM56820 switch chip's power consumption is 1W per 10-GbE port—a drastic reduction from the previous 130-nm switch chip's 11W per port (**Figure 2**). "We're seeing a clear requirement to go to 10-GbE with all of the features and capabilities that were available at 1-GbE, such as security, strong Layer 4 classification for QOS [quality of service], and Layer 3 routing," he says.

Tehuti Networks based its new SFP+-adapter-reference designs, which include the single-port TN7587-S and dual-port TN7587-D NICs for optical 10-GbE, on the company's single-chip TN3016 10-GbE single- or dual-port controllers. The reference designs include AMCC's (Applied Micro Circuits Corp's) 10-GbE SFP+ QT2025 PHY chip. When you populate the NIC with two SFP+ optical modules, the TN7587-D's power dissipation is 15W. The single- and dual-port controllers dissipate 6 and 7W, respectively.

WHAT'S NEXT?

Many enterprises have just begun to consider 40- and 100-GbE for aggregating 10-Gbps links in data centers. "Even telephone companies are requesting 100-Gbit products," says The Linley Group's Bolaria. "There's demand for it now in the core of the network." Because of video-on-demand and Web-based applications with millions of simultaneous users, such as Facebook, Netflix, and YouTube, some industry observers predict that the bandwidth-scaling needs of carriers and ISPs (Internet-service providers) may bypass 40-GbE.

For the first time, however, no aggregation technology is in place for the upcoming lower speed of Ethernet, which could hinder the market, says Dell'Oro Group's Weckel. For the lower speed to be successful, manufacturers must be shipping products using the higher speed, even if not in high volumes. But with 10-GbE to the server, no 40- or 100-GbE line cards exist to provide uplinks to data centers on the aggregation side. "The higher-speed uplink technology must be present for there to be truly widespread adoption," he says.

The pressure will increase even more when servers begin to appear with 10-GbE interfaces on the motherboard, which may occur with the next generation of Intel server CPUs. Ultimately, 10-GbE may go all the way to the desktop. For many, Ethernet has become the fabric of choice in the network, and that situation is also driving 10-GbE deployment. **EDN**

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Contributing Technical Editor Ann R Thryft has been writing about technology, including wired and wireless networking, for more than 20 years. You can reach her at athryft@earthlink.net.

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BUCK-BOOST CONVERTERS CHANGE WITH THE TIMES

BY PAUL RAKO • TECHNICAL EDITOR

BUCK-BOOST CONVERTERS PROVIDE VOLTAGES BOTH ABOVE AND BELOW THE INPUT VOLTAGE. THIS FEATURE IS USEFUL IF YOUR DESIGN'S INPUT VOLTAGE CHANGES DRASTICALLY OR IF ITS LOAD VOLTAGE VARIES.

Buck-boost converter topologies fit into a wide range of applications. Whether you are charging a battery from a battery, powering a string of LEDs, or running a handheld device from a single cell, the buck-boost topology can provide an important weapon in your arsenal of design tricks. Whether you need low cost, high efficiency, or low noise, some version of buck-boost topology can solve the problem. And, if your buck-boost design works for multiple products, you can save yourself the considerable effort of designing separate power supplies for each load voltage. However, as with any type of design, the buck-boost-converter brings its share of design challenges.

For example, consider one common application for buck-boost converters: battery-to-battery charging, such as using a car battery to charge a 10.8V NiMH (nickel-metal-hydride) battery (**Figure 1a**). At first blush, you might think that you could use a low-dropout linear regulator for this task because the regulator's 10.8V voltage is close to the 12V lead-acid battery's voltage. If the car is running, however, the battery's charging voltage is 13.75 to 14.2V, indicating that you might need to use a switching regulator to prevent power loss. You might still think that a simple buck regulator should do the job. However, NiMH batteries receive their charge from a constant current, so their cell voltages rise to 1.4 to 1.6V per cell. Thus, for a nine-cell, 10.8V pack, the charge-termination voltage must reach 12.6V. A modern synchronous-buck regulator that can deliver power with 100-mV drop might still do the job, but this approach assumes that the car is running. In a real-world application for test equipment that diagnoses cars, however, you must assume that some cars won't start. A lead-acid automobile battery charges at 13 to 14V, but the no-load voltage is 12V. Clearly, you cannot charge a nine-cell NiMH battery to its 12.6V termination with a 12V source and a buck regulator.

The automotive-test-equipment application may be esoteric, but system designers face a far more common problem: how to power a 3.3V handheld electronic system from one lithium-ion cell (**Figure 1b**). Consider a handheld computer that uses Windows. Its digital electronics, including memory, must operate from a 3.3V power supply, and one lithium-ion cell delivers 3 to 3.7V of power, so it may be tempting to just operate 3.3V ICs at 3V. However, digital processes are less forgiving than analog when it comes to power-supply-voltage range—to the point that some manufacturers refuse to characterize chips at 3V.

Another approach employs two lithium-ion cells; this method has several disadvantages, however. First, consider that a battery is a more problematic power source than a cell. You must worry about reliability: If either cell fails in an open circuit, the system loses power. If either cell short circuits, the internal fusible link blows—and let's hope it blows before a fire breaks out. In any case, after a short circuit, your product cannot function. Just as troublesome is the problem of balancing the cells' charge. Because batteries are metal-plating devices, you charge them by plating lead, lithium, or nickel from the cathode to the anode. When you discharge the battery, the metal or metal ions discharge from the anode to the cathode. Another problem occurs when you recharge the battery: If one cell in a string accepts less charge, it limits the pack's output. With two lithium-ion cells, this approach would limit the charge voltage to 8.4V. But this approach does not ensure that exactly 4.2V exists across each cell. To ensure that amount of voltage, you must implement complex and expensive charge-balancing circuits that charge and discharge each cell at the optimum voltage. For these reasons, most modern handheld products use a single cell. Because lithium-ion cells output 3 to 3.7V, handheld devices requiring 3.3V are appropriate applications for buck-boost converters.

AT A GLANCE

- Buck-boost converters find use in automotive, consumer-electronics, and other applications.
- Simple buck-boost and Ćuk converters invert the input voltage.
- SEPICs (single-ended-primary-inductance converters) and four-switch synchronous H-bridge buck-boost converters do not invert the input voltage.
- Many companies are producing synchronous four-switch buck-boost converters for the handheld-system market.
- Most buck-boost architectures have 80 to 85% efficiency, whereas the synchronous-four-switch topology has better-than-92% efficiency.

Other broad applications for buck-boost converters are automotive-LED drivers (**Figure 1c**). They share the same battery-voltage-range issues as the automotive-test equipment. Indeed, even more important restrictions exist for automotive use. When the car is starting, the battery may sag to 8V as it cranks the starting motor. A charger circuit for automotive-test equipment would have to function for a longer time than it takes a car to start. If the power converter is operating a string of brake lights, however, you would not want the output of the circuit to drop out due to input-voltage swings. Buck-boost architectures can handle those cold-cranking periods, as well as a 40V transient from a clamped-load-dump event.

A similar application is driving LED-flash units in a cell phone (**Figure 1d**). The forward voltage of the LED may be higher or lower than that of a single-cell lithium-ion cell. A buck-boost topology ensures that the flash LED receives the same current no matter what the state of the battery and no matter what process variations of the LED change its forward voltage. "Look at a cell-phone camera where an LED is used in a flash application, perhaps one where you can drive a 0.5A through the LED," says Sam

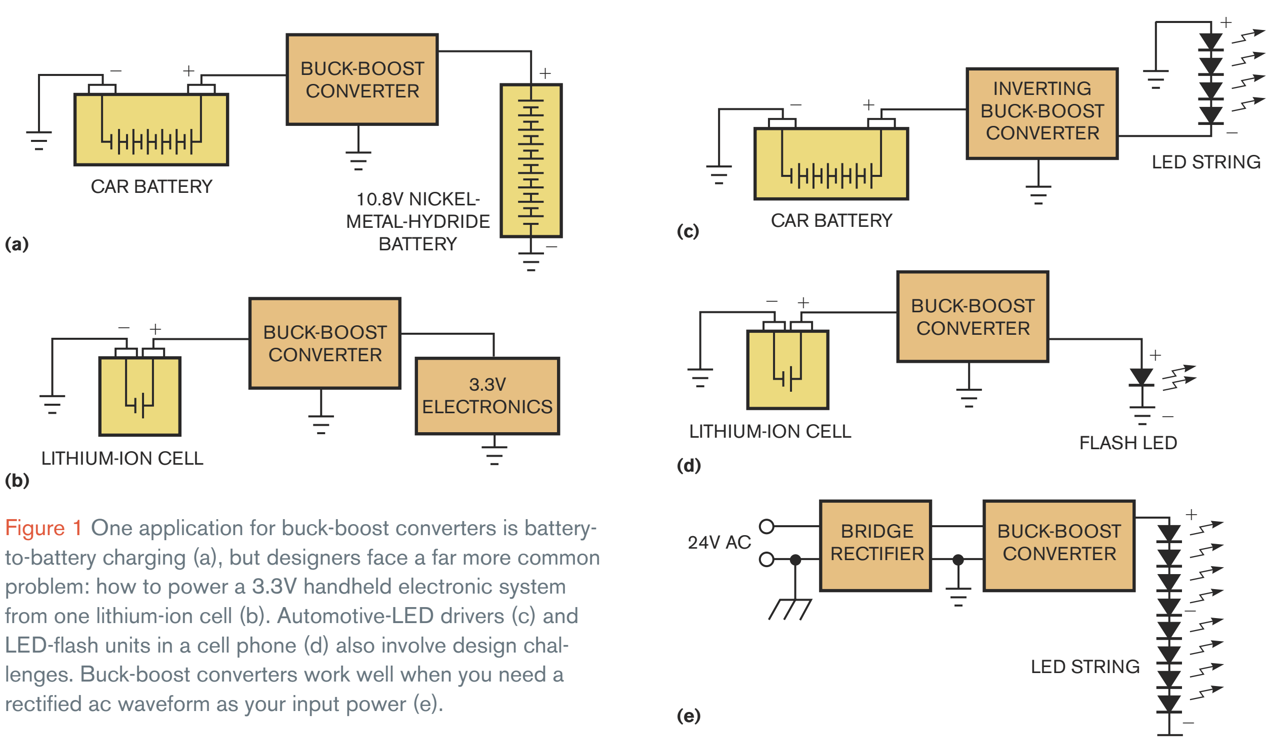


Figure 1 One application for buck-boost converters is battery-to-battery charging (a), but designers face a far more common problem: how to power a 3.3V handheld electronic system from one lithium-ion cell (b). Automotive-LED drivers (c) and LED-flash units in a cell phone (d) also involve design challenges. Buck-boost converters work well when you need a rectified ac waveform as your input power (e).

Nork, a design manager at Linear Technology. “Under those conditions, the forward-voltage drop of the LED is around 3.6V. Depending on temperatures, part variations, and battery conditions, that [situation] is a classic case where you would like a buck-boost converter to get the best performance.” The same design benefits apply to LED flashlights that use lithium-ion cells for power.

Although you might think of buck-boost converters when dealing with a widely variable input voltage, they also work well in applications in which the output voltage varies due to component variations. Rohit Tirumala, staff application engineer at Supertex, points out that some general-lighting applications use an inexpensive 24V “brick” supply. Although the input voltage is fairly regulated, the output voltage across an LED string can vary widely from part to part. “Because of the LED-voltage variation, the string of LEDs might require a buck or a boost,” he says. “For example, each LED can vary by as much as 1V. The forward voltage can be 3 to 4V, so a six-LED string might require 18 to 24V.”

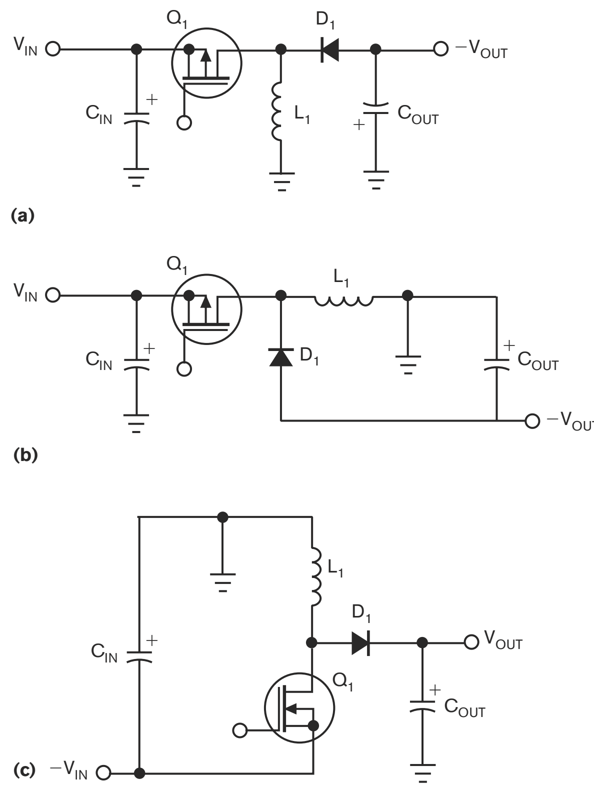


Figure 2 The conventional buck-boost architecture inverts the input voltage (a). You can see that the same circuit with a 5V input would work just as well, producing −4 and −6V (b). Buck-boost circuits can also invert a negative voltage to a positive one (c).

Brian Wengreen, product-marketing manager at Analog Devices, points out that Panasonic and other lithium-ion-battery manufactures are creating modified battery chemistries that produce more energy as the battery discharges from 3 to 2.5V. “A cell phone or camera that operates from a single [lithium-ion] cell may have a zoom lens or some sort of actuator that requires a steady voltage that provides torque to a mechanical system,” he says. These camera manufacturers use buck-boost converters in this case because they can wring that last bit of energy from the battery.

These examples show how buck-boost converters provide power as both the input- and the output-voltage requirements vary. These converters are also versatile. “Some engineers want to have different models of product that use the same power supply,” says Tirumala. “One model might use four LEDs; one model might use six LEDs. They can use the same buck-boost power supply, [so] the cost will go down, and the volumes will increase.” He also points out that a buck-boost converter works well when you are using a rectified ac waveform as your input power (**Figure 1e**). One such application is an LED replacement for the ubiquitous 12V halogen bulb, such as an MR16. The halogen-lamp fixture drives the bulb with an ac or rectified-ac waveform. By using a buck-boost circuit in the base of the replacement-LED bulb, designers can ensure a more constant average current as the input voltage varies.

DELVE INTO DETAILS

Knowing that so many applications exist for buck-boost circuits, it behooves diligent analog-system engineers to learn more about them. Start with the terminology. An isolated-flyback converter can provide a fixed output voltage even as the input voltage swings higher and lower than the output. Yet no one refers to a flyback converter as a buck-boost converter. Another example is the PFC (power-factor-correction) circuit in an offline power supply. Even though the first stage is a boost converter and the second stage is a buck, engineers rarely refer to this architecture as a buck-boost converter. Switched-capacitor buck-boost circuits, such as National Semiconductor’s LM3355, exist, but most designers think of inductive converters when they hear the term “buck-boost.” Other sophisticated converter topologies, such as the isolated Tesla-Converter from Tesla, can perform the buck-boost function, but engineers also do not refer to them as “buck-boost” converters.

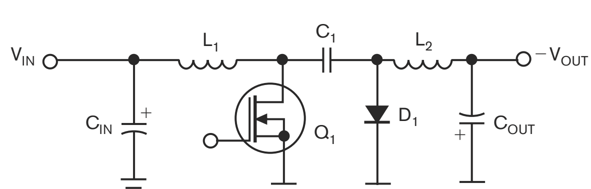


Figure 3 The Ćuk buck-boost topology also inverts. It uses two inductors, which lower the fast-slewing currents into both the input and output capacitors.

The classic buck-boost is a single-switch converter with an inverting architecture (**Figure 2a**). Because it is inverting, the circuit can have an output voltage either higher or lower than the input voltage, no matter which voltage is changing or whether both are changing. When the switch closes, the inductor builds up a current. When the switch opens, the inductor still tries to flow that current, so the switch side of the inductor goes negative, and the inductor current then charges up the output capacitor to a voltage that is negative with respect to the input voltage. With a 5V input, the circuit would work just as well, producing −4 and −6V (**Figure 2b**). As with most other power architectures, there are many valid variations on the single-switch converter. By rearranging the inductor, you can make a negative-to-positive buck-boost converter (**Figure 2c**). Like simple buck or boost architectures, the buck-boost converter can operate in either continuous or discontinuous mode.

The simple inverting buck-boost topology certainly works, but one drawback is that the switching action of the power transistor creates a high current ripple in the input capacitors. California Institute of Technology Professor Slobodan Ćuk solved this problem in 1976 when he invented the Ćuk-converter topology (**references 1** and **2** and **Figure 3**). By adding a second inductor and using a capacitor to transfer the energy, the Ćuk converter surrounds the switch with inductors. Because the input capacitor feeds the nonswitching side of an inductor, no input current changes faster than a triangle wave. Similarly, the circuit feeds the output capacitor with the nonswitching side of a second inductor, so a triangle wave of current also charges those capacitors, yielding less ripple voltage and, therefore, less heat in the capacitors. Although using two inductors is more expensive, you can often use lower-value input and output capacitors, which can provide cost savings. The slower-changing capacitor currents cause the circuit to generate less EMI (electromagnetic interference) and RFI (radio-frequency interference)—a boon for automotive applications. The slow-input-current variation means that you can eliminate the use of an input capacitor, and, because the current over the car's wiring is a triangle wave, the converter circuit does not generate much objectionable electrical noise.

One limitation of both conventional buck-boost and Ćuk converters is that, unlike a SEPIC (single-ended-primary-inductance-converter), they invert the input voltage. Like the Ćuk converter, the SEPIC uses two inductors (**Figure 4**). The SEPIC transposes the position of the inductor and the diode so that the output voltage is positive. The downside is the inductor and the diode are

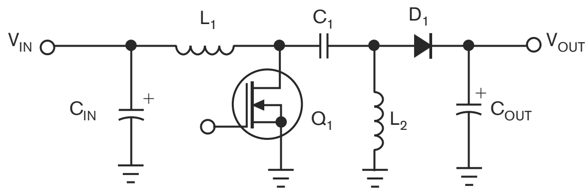


Figure 4 The SEPIC (single-ended primary inductance converter) can buck or boost one positive voltage to another positive voltage. The capacitor in the power path prevents backflow from the output to the input.

in the opposite place from those in the Ćuk converter and thus impress a higher instantaneous rate of current change across the output capacitor. The SEPIC also provides a noninverted output voltage, so you can adapt almost any boost-converter IC to a SEPIC topology. Some companies, including Linear Technology, label parts, such as the LT1513, as SEPIC ICs.

One benefit of both the Ćuk and the SEPIC architectures is that they do not allow power to flow back through the converter because they include a capacitor that transfers the energy from the input to the output. This feature may provide a significant benefit in battery charging. The capacitor prevents current from flowing from the battery backward though the part and into the input.

Another application that needs the input and output voltages to be the same polarity is a circuit that converts a 4.2 to 2.5V lithium-ion cell voltage to 3.3V. You could use SEPICs in this application, but they commonly have efficiency of only 82 to 85%. When trying to squeeze every last bit of energy from a lithium-ion cell, this efficiency is unacceptable. In this case, designers can turn to a four-switch synchronous-buck-boost architecture (**Figure 5**). This topology uses only one inductor but four power transistors to make the inductors serve as buck or boost converters, depending on the input voltage. The input and output current may experience greater ripples than those for a Ćuk converter, but handheld devices now use ceramic power capacitors that have low ESR (equivalent-series resistance) and ESL (equivalent-series inductance) so the ripple currents create no associated ripple voltage. As you might imagine, the challenge with the synchronous-buck-boost converter is control. Two power switches act to convert between buck and boost modes. The other two transistor switches are synchronous rectifiers just as they are in synchronous-buck or synchronous-boost converters. All four transistors must switch seamlessly as the converter slews between the buck and the boost modes.

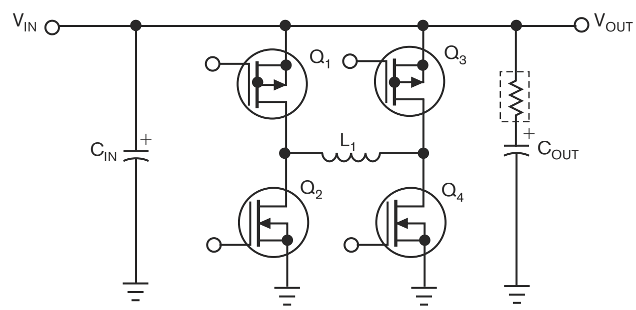
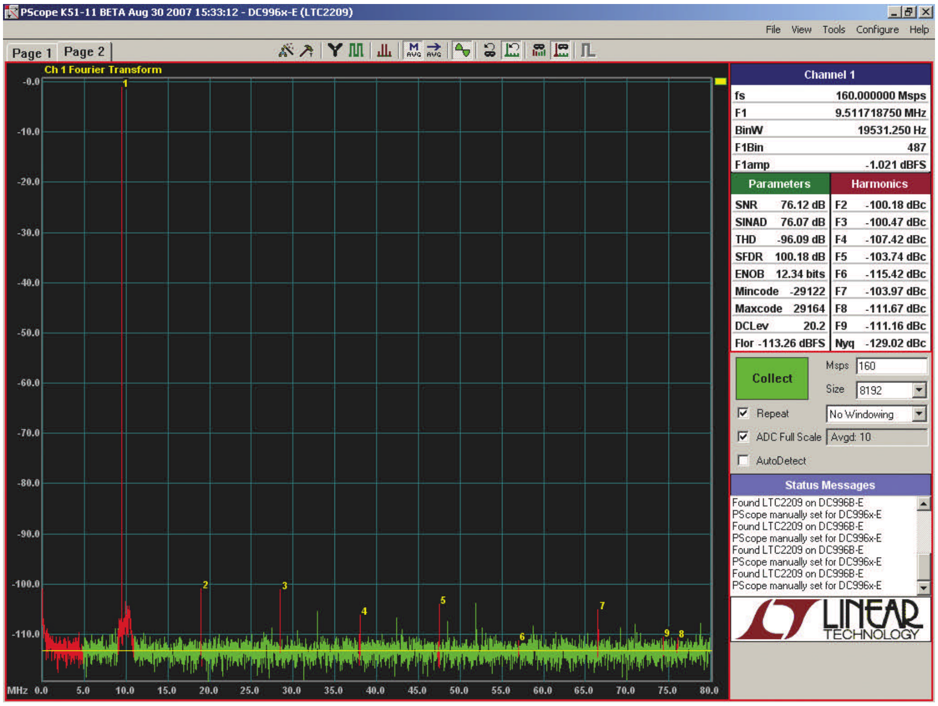


Figure 5 The synchronous-H-bridge four-switch buck-boost converter also creates a positive voltage but with higher efficiency than the other architectures.

160Msps, 16-Bit ADC



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The handheld-system market, with its high volumes and good margins, has caused many vendors to rise to the challenge of making synchronous buck-boost converters. "We have taken that traditional four-switch buck-boost and broken it up into two control loops to give you either a boost converter or a buck converter," says Michael Day, an applications manager at Texas Instruments. "We have optimized the control system to provide maximum efficiency at a 3.6V input voltage." According to Day, some conventional four-switch buck-boost topologies operate all four switches at once when the input and output voltages are close to each other.

Carl Nelson, an analog designer at Linear Technology, calls this mode "flyback" because the part stores energy in the inductor and then switches it into the output capacitor. The TI TPS63000 uses its two control loops to operate either the buck or the boost switches but never all four. This approach allows the units to achieve better than 95% efficiency over a wide input range. As the part switches between buck and boost operation, it may seem as though all four switches are operating at once, but the part is first performing one buck cycle and then a boost cycle. As soon as the input and output voltages diverge, the part locks into one mode of operation. Because the part never operates in four-switch mode, the synchronous FETs are simply serving as low-loss diodes.

Similarly, Linear Technology offers the LTC3440, which debuted in 2001 and now includes more than a dozen parts. The company also offers the LTM4605 module, whose efficiency never falls below 93%, along with a buck-boost controller that allows you to use four external transistors. The LTC3780 can take as much as 36V on the input, so you can use it in automotive and industrial applications requiring the buck-boost function.

Because the number of applications using lithium-ion batteries is growing, many analog-design companies are making parts to buck and boost the battery voltage. For example, Analog Devices recently released the four-switch H-bridge-synchronous ADP2503 and ADP2504 buck-boost converters with a switching frequency of 2.5 MHz. The devices use an average-current-mode architecture to improve transient response, providing good load regulation and preventing overshoot when delivering a sudden current surge. Like other synchronous-buck-boost parts, the ADP2503 can provide power from one lithium-ion cell and maintain more-than-92% efficiency. The part also has a low quiescent current, so efficiency remains high even at low output-power levels. Another device, National Semiconductor's LM3668, bucks or boosts a lithium-ion cell to 3.3V or similar voltage, outputs 1A, and switches at 2.2 MHz.

IC vendors have reduced the complexity and the design challenge of compensating a system that may have as many as four poles in the power path. This feature allows system designers to concentrate on the architecture of the products rather than the minutiae of the control algorithms for a power converter. Ćuk, SEPIC, and buck-boost topologies are all becoming as easy as the ubiquitous buck regulator to use. Be sure to consider these topologies in your next design. **EDN**

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1 "Ćuk converter," http://en.wikipedia.org/wiki/Buck-boost_converter.

2 Middlebrook, RD, and Slobodan Ćuk, "A general unified approach to modelling switching converter power stages," *International Journal of Electronics*, Volume 42, Issue 6, June 1977, pg 521.

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DESIGN NOTES

Versatile TFT LCD Bias Supply and White LED Driver in a 4mm × 4mm QFN – Design Note 440

Eddy Wells

Introduction

The makers of handheld medical, industrial and consumer devices use a wide variety of high resolution, small to medium sized color TFT LCD displays. The power supply designers for these displays must contend with shrinking board area, tight schedules, and variations in display types and feature requirements. The LTC®3524 simplifies the designer's job by combining a versatile, easily programmed, TFT LCD bias supply and white LED backlight driver in a low profile 4mm × 4mm QFN package.

The LTC3524's 2.5V to 6V input supply range is ideally suited for portable devices powered from Li-Ion or multiple alkaline or nickel cells. Both the LCD and LED drivers operate at 1.5MHz, allowing the use of tiny, low cost, inductors and capacitors.

The TFT bias portion of the circuit consists of a synchronous boost converter, adjustable between 3V and 6V, providing the main analog V_{OUT} for the TFT. Low current gate drive voltages (VH and VN) are generated using integrated charge-pump circuits. These low noise outputs are programmable to ±20V, allowing optimal bias for multiple display types and makers. The TFT outputs are sequenced at power-up and discharged at power-down as shown in Figure 1.

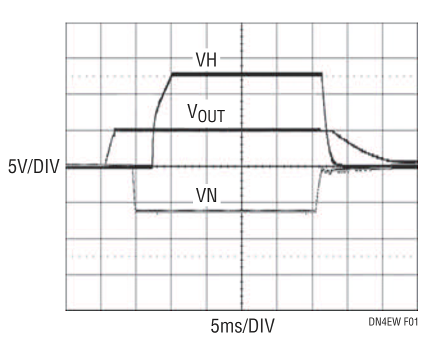

Figure 1. LTC3524 TFT LCD Supply Sequencing at Power-Up and Power-Down

A second nonsynchronous boost converter generates the voltage required to regulate one or two LED strings at up to 25mA each. LED current can be adjusted by either analog or digital means, optimizing the TFT display for varying ambient light conditions. Each string is independently enabled and can contain 1 to 5 LEDs in series. Internal circuitry maintains equal current in the strings, even when the forward voltage drops of the LEDs do not match. Open LED protection is provided to prevent the output from exceeding 24V.

3-Output TFT Supply with Digitally Dimmed LED Backlight

A LTC3524-based TFT and backlight solution for a 4 to 6 inch LCD is shown in Figure 2. High frequency operation of the power components and the QFN package shrinks the total converter footprint to approximately 120mm^2 (single sided).

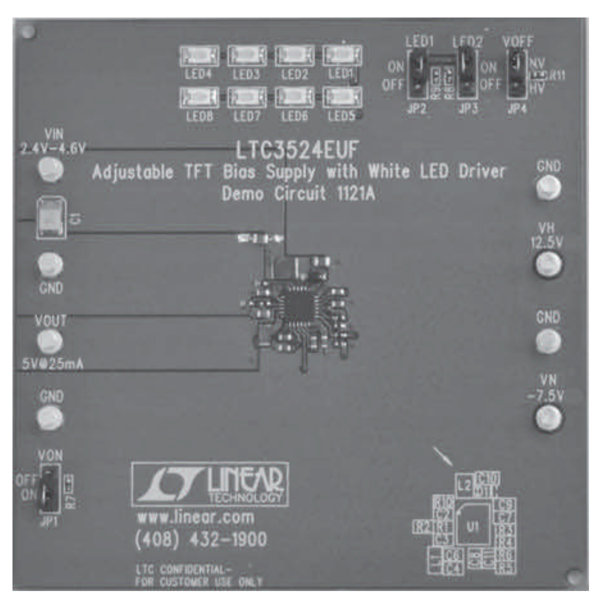

Figure 2. LTC3524-Based LCD and White LED Supply

The circuit schematic is shown in Figure 3. The TFT bias portion of the circuit provides a 5V, 25mA output for the TFT drivers as well as 12.5V and –7.5V outputs with up to 2mA for the gate bias. These voltages are programmed using the FBVO, FBH, and FBN pins respectively.

As shown in Figure 1, these outputs are sequenced with V_{OUT}, VN, then VH powered, as required by most displays. The outputs are actively discharged when ELCD is brought low, removing voltage from the display.

The white LED backlight for the Figure 3 circuit consists of two strings with four series LEDs. The LEDs are driven from the high side with the LTC3524, allowing the strings to terminate at ground, reducing the number of wires required to power the display. With R_{PROG} = 100k, each LED is regulated to 20mA. Maximum power for the backlight is approximately 600mW, assuming a forward voltage around 3.6V per element.

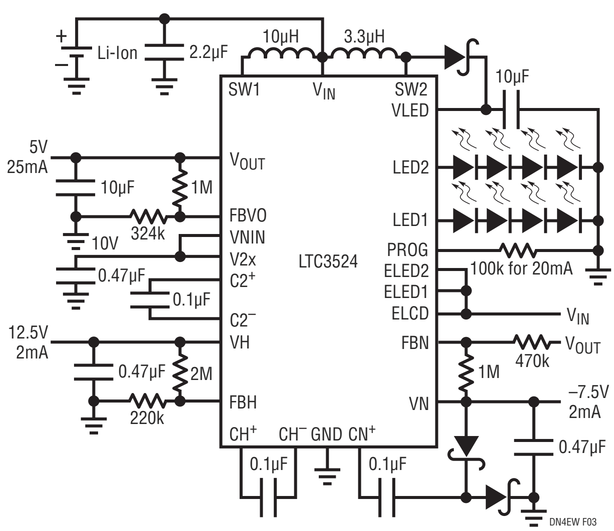

Figure 3. Complete TFT and LED Solution

Dimming is achieved by changing the duty cycle of a 200Hz power signal applied to the LED strings. The frequency is high enough to prevent visually detectable flickering, but low enough to allow a better than 100:1 dimming range. Dimming is implemented by simply connecting a microprocessor controlled port to ELED1 and ELED2. Scope waveforms at 50% duty cycle are shown in Figure 4.

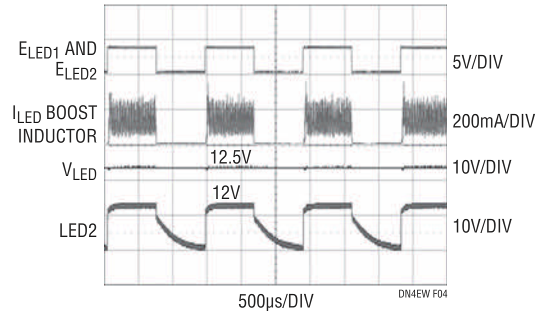

Figure 4. Burst Dimming Waveforms

Efficiency results for this design are given in Figure 5 with a 3.6V input. The LCD efficiency curve shows the performance of the synchronous boost converter with V_{OUT} at 5V and varying load current. This curve includes the no load quiescent current of the charge-pumps, which are powered from V_{OUT}.

Analog dimming of the LEDs can be implemented by adjusting the current through the PROG pin. Efficiency for analog dimming is shown in Figure 5. Efficiency with PWM dimming would remain close to 78% over a wide dimming range.

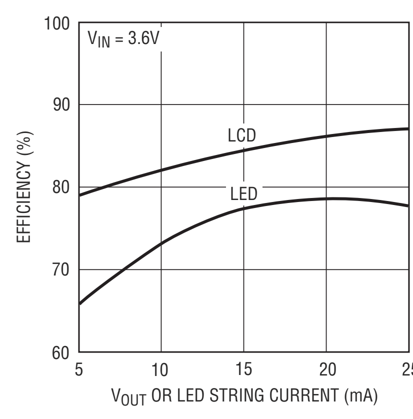

Figure 5. LCD Bias and LED Efficiency

Conclusion

The LTC3524 shrinks and simplifies the design of small to medium sized TFT LCDs by combining the LCD supply and LED driver in a single compact package. LCD bias voltages and LED currents are programmable, making it possible to simplify parts stock by using the LTC3524 for a wide variety of displays.

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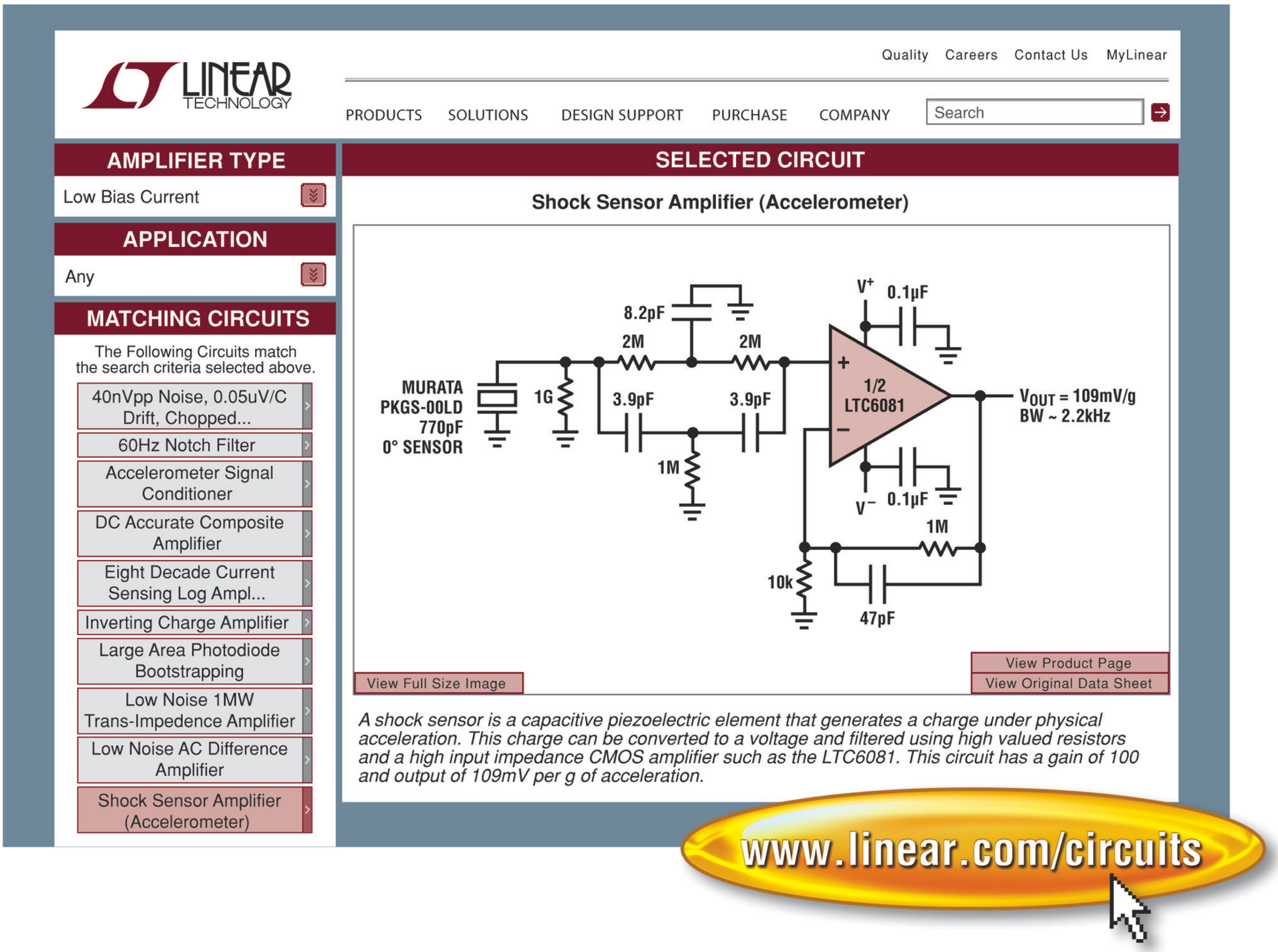

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LTC6087	1	750	14	1.2	2	General Purpose	MS-8, DFN-10
LTC6088	1	750	14	1.2	4	General Purpose	DFN-16, SSOP-16
LTC6078	0.2	25	0.75	0.072	2	TCV_{OS} = 0.7µV/°C Max.	MS-8, DFN-10
LTC6079	0.2	25	0.75	0.072	4	TCV_{OS} = 1.4µV/°C Max.	DFN-16, SSOP-16
LTC6240	0.2	175	18	2.4	1	Low Frequency Noise = 550nV$_{P-P}$	SOT-23-5, SO-8
LTC6241	0.2	125	18	2.2	2	Low Frequency Noise = 550nV$_{P-P}$	DFN-8, SO-8
LTC6242	0.2	150	18	2.2	4	Low Frequency Noise = 550nV$_{P-P}$	DFN-16, SSOP-16
LTC6244	1	100	50	5.8	2	Low Frequency Noise = 1.5µV$_{P-P}$	DFN-8, MS-8

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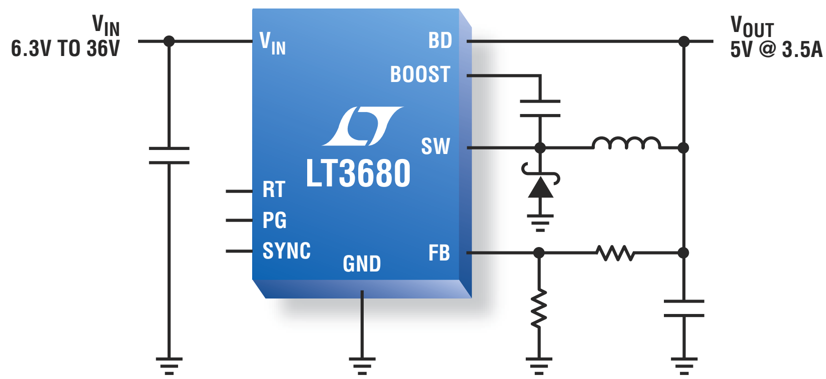
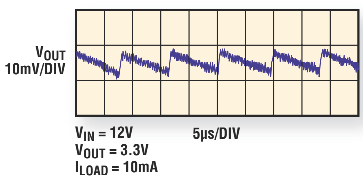
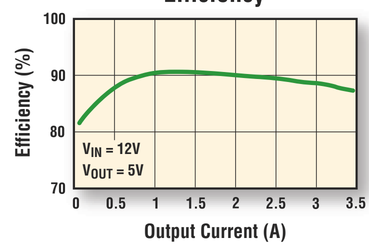


Burst Mode® Output Ripple



Efficiency



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LT3505	3.6V to 36V, 40V Max.	1.4	300kHz to 3MHz	2mA	2 x 3 DFN-8, MSOP-8E
LT3681	3.6V to 34V, 36V Max.	2.0	300kHz to 2.8MHz	50μA	3 x 4 DFN-14
LT3684	3.6V to 34V, 36V Max.	2.0	300kHz to 2.8MHz	0.85mA	3 x 3 DFN-10, MSOP-10E
LT3481	3.6V to 34V, 36V Max.	2.0	300kHz to 2.8MHz	50μA	3 x 3 DFN-10, MSOP-10E
LT3685	3.6V to 38V, 60V Max.	2.0	200kHz to 2.4MHz	0.85mA	3 x 3 DFN-10, MSOP-10E
LT3480	3.6V to 38V, 60V Max.	2.0	200kHz to 2.4MHz	70μA	3 x 3 DFN-10, MSOP-10E
LT3680	3.6V to 36V	3.5	200kHz to 2.4MHz	75μA	3 x 3 DFN-10, MSOP-10E
LT3508	3.7V to 36V, 40V Max.	1.4 x 2	250kHz to 2.5MHz	4.6mA	4 x 4 QFN-24, TSSOP-16E

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READERS SOLVE DESIGN PROBLEMS

Circuit and software provide accurate recalibration for baseline PIC microcontroller's internal oscillator

Noureddine Benabadji,
University of Sciences and Technology, Oran, Algeria

All of Microchip's (www.microchip.com) baseline PIC microcontrollers have internal 4-MHz oscillators, which are useful for freeing up one or two pins for I/O use and allowing you to build minimal-component-count designs using these devices. You must calibrate the internal oscillator by reading a factory-programmed calibration setting that resides at the last address in the user-program memory and then writing that setting into the microcontroller's oscillation-calibration register during the application software's initialization of the device. Because the calibration value is unique to each microcontroller, problems arise for time-sensitive applications if you erase or overwrite the last address.

The circuit in **Figure 1** recovers the calibration value by recalibrating against a reference clock, the 4-MHz crystal. The frequency looks for the best calibration value to ensure that the microcontroller's internal oscillator runs within 1% accuracy at 4 MHz. You can download the microcontroller's program and a flow chart

DIs Inside

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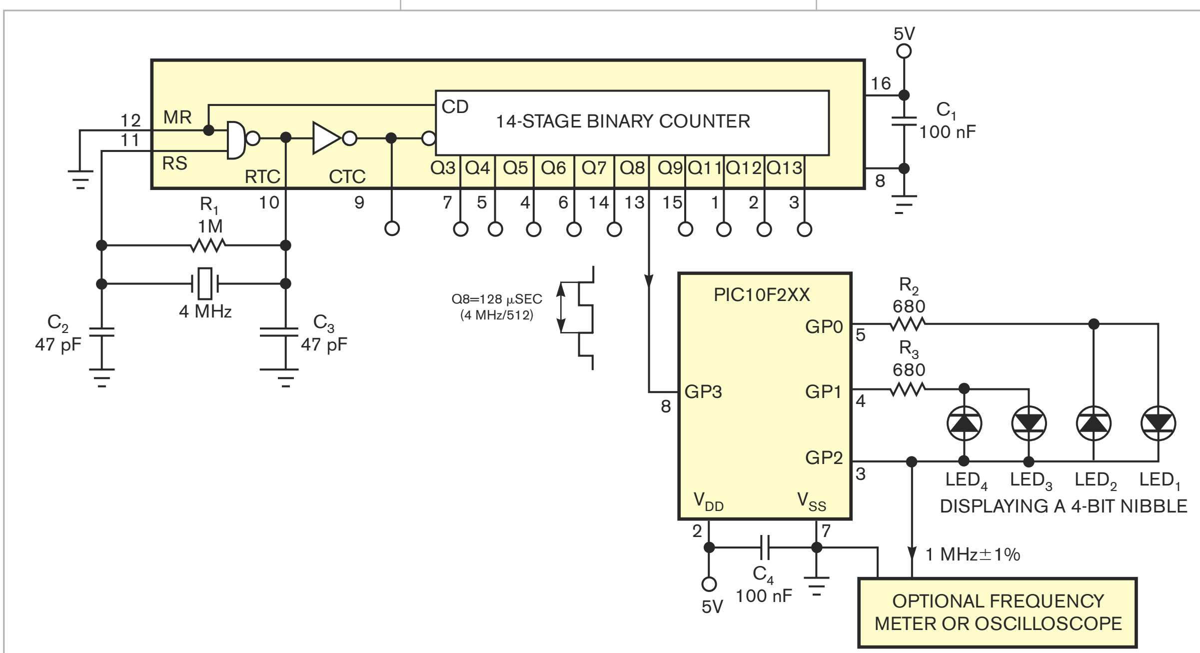

Figure 1 This circuit and an assembly-language program that occupies less than 250 bytes allow you to calibrate a PIC10F2xx microcontroller against a 4-MHz reference clock.

in a compressed zip file from www.edn.com/080501di1.

The baseline PIC microcontroller, which includes the PIC10F, PIC12C508/509/510, or PIC16F505/506 series, uses its internal timer, Timer 0, to count the number of instruction cycles that execute in one period from output Q8 of a Fairchild Semiconductor (www.fairchildsemi.com) CD4060 oscillator/divider to the only input, GP3, of the PIC microcontroller. The 4-MHz crystal drives the CD4060, which yields a period of 128 µsec from the output Q8.

The four LEDs display the two 4-bits nibbles of the 8-bit oscillation-calibration register's best value. Output GP2 acts as a multiplexing line to drive these LEDs for 8 to 10 sec and then as the oscillator output to yield a 1-MHz signal, which you can measure with a frequency meter or an oscilloscope.EDN

Microcontroller moving-dot display interface uses three I/O lines

Abel Raynus, Armatron International, Malden, MA

The moving-dot display has some benefits over the bar-graph display: It better indicates the location of a detected object in sonar and radar applications; it needs only one LED's current-limiting resistor instead of several; and it provides the same current for all LEDs, thus providing even brightness. When a new design required adding a seven-LED moving-dot display to an 8-bit, low-end microcontroller, a question arose about the corresponding interface. Of course, the most cost-effective approach is to directly connect the LEDs without any extra parts. But this approach needs seven vacant microcontroller-output pins, which microcontrollers with limited I/Os often cannot afford.

A previous Design Idea describes a one-wire interface that applies only to a bar-graph display, not to a dot display (**Reference 1**). Another tack would be interfacing using serial-to-parallel shift registers or a serial-input Johnson counter. But small microcontrollers often lack a SPI (serial-peripheral interface), and you must use firmware to re-create it (**Reference 2**). The method in this Design Idea needs three output lines—data, clock, and latch—and requires some firmware and hardware. Exploiting the fact that only one LED in a dot display should light at a time, you can use National Semiconductor's (www.national.com) CD4051 1-to-8 analog demultiplexer (**Figure 1**). This circuit needs three microcontroller outputs, and the firmware is simple and straightforward. The additional benefit is that the microcontroller now does not limit the LED current and voltage; you can choose them independently.

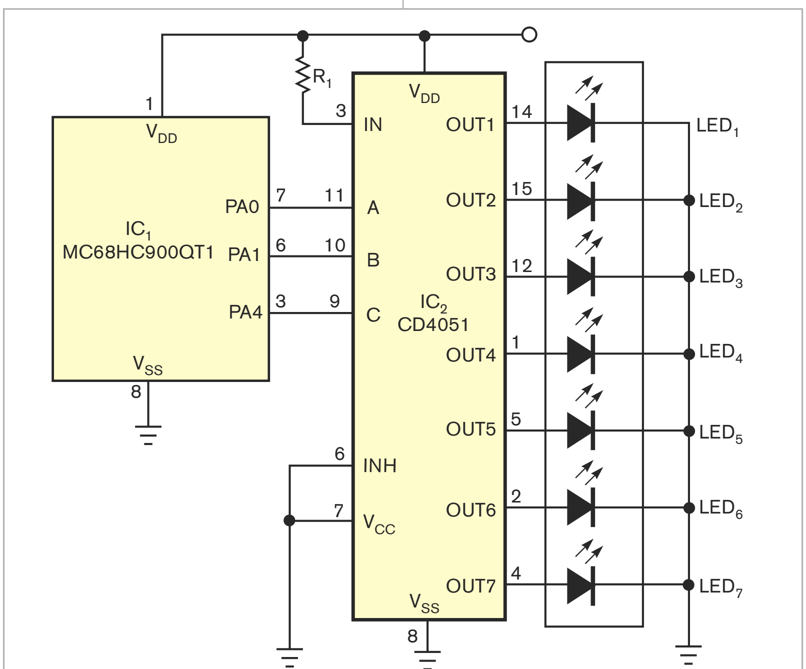

Figure 1 Using the 1-to-8 CD4051 analog demultiplexer you can interface a moving-dot LED display to a low-end microcontroller using just three outputs.

Listing 1, which you can download from the Web version of this Design Idea at www.edn.com/080501di2, provides demo firmware illustrating this design. The demo program automatically moves the lit dot back and forth by incrementing and decrementing a modulo-7 counter. Ideally, any three adjacent microcontroller outputs, such as pA0, pA1, and pA2, are available for the A, B, and C inputs of the CD4051. But, this scenario is not always possible. In this application of a low-end, eight-pin MC68HC908QT1 microcontroller, you can use pins pA2 and pA3 only as inputs. You can easily overcome this problem by programming, as **Listing 1** shows. This Design Idea applies to any small microcontroller because it uses only a standard instruction set.EDN

REFERENCES

1 Jayapal, R, "Microcontroller's single I/O-port line drives a bar-graph display, *EDN*, July 6, 2006, pg 90, www.edn.com/article/CA6347254.
2 Raynus, Abel, "Squeeze extra outputs from a pin-limited microcontroller, *EDN*, Aug 4, 2005, pg 96, www.edn.com/article/CA629311.

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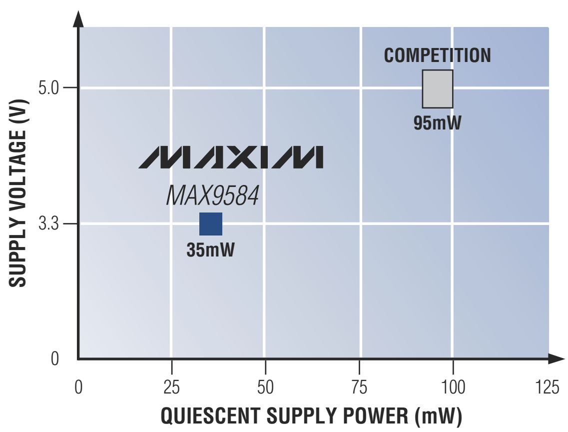

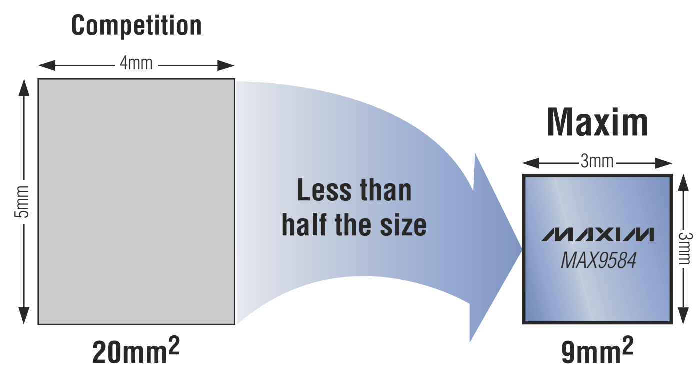

Features

- ±1dB, 7MHz passband (8.5MHz, -3dB bandwidth)
- 40dB attenuation at 27MHz
- AC- and DC-coupled input(s)
- Integrated dual SPST versions simplify signal routing

Applications

- Set-top boxes
- Televisions
- Notebook computers
- Cell phones
- DVD players
- General consumer electronics

Part	No. of Channels	Input Clamps	Shutdown	Switches	Package
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MAX9587/MAX9588/MAX9589	2/3/4	✓			6-SOT23/8-µMAX/10-µMAX
MAX9586	1	✓	✓		5-SOT23
MAX9517	1		✓	✓	12-TQFN
MAX9524	1	✓	✓	✓	12-TQFN

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Microcontroller displays multiple chart or oscilloscope timing ticks

William Grill, Honeywell, Lenexa, KS

While working with a 10-bit DI-184 module from Dataq to monitor and display vibration-sensor data, I found that, although the chart displays a time index, this time reference is not visible in the saved file. You can add time ticks, representing seconds or minutes, to a chart graphic by using a simple and inexpensive crystal-based microcontroller to generate a sequence of tags on a dedicated chart channel. **Figure 1** shows a small, eight-pin 12F508 microcontroller from Microchip Technology (www.microchip.com) that provides multiple timing ticks. **Listing 1**, the microcontroller's program is available in the Web version of this Design Idea at www.edn.com/080501di3. It offers four timing sequences. You can select a timing sequence by strapping pins 4 and 6 (**Table 1**, also at www.edn.com/080501di3).

The 4-MHz crystal maintains a solid instruction-timing reference, and equalized coded branches in the **listing** maintain accurate timing ticks. You can also configure the 12F508 with an internal, 4-MHz RC oscillator. You base the coded loops on a sequence of exactly 25 instructions, and they provide a fundamental, base-reference loop that is exactly 100 instructions. A 16-bit register counter serves as the multiplier to produce the base timing. For use with scopes, you can recode the **listing** with minor changes to use 50 instructions or a 50-µsec base-timing-tick minimum. The 8-bit registers in the equalized loop provide multipliers to produce the additionally tiered output. The microcontroller uses two output pins, 5 and 7, as a pseudo 2-bit DAC. This configuration generates one of four voltage levels for timing ticks that display continuously, and you can record them along with application data. **EDN**

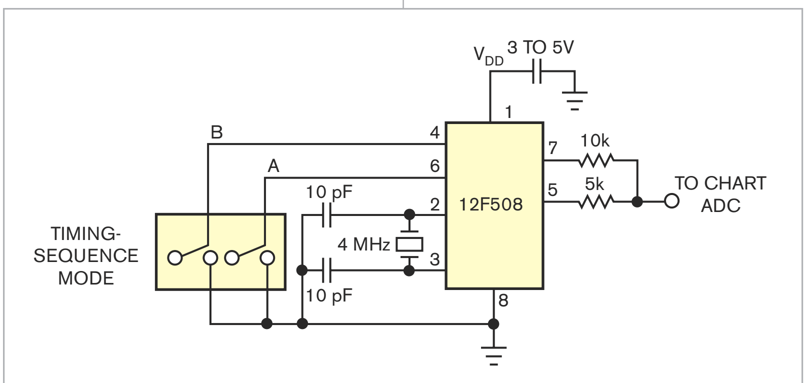


Figure 1 An 8-bit microcontroller with output pins 5 and 7 configured as a 2-bit DAC provides precise timing ticks to annotate captured data.

Fast-settling synchronous-PWM-DAC filter has almost no ripple

W Stephen Woodward,
Chapel Hill, NC

An inexpensive way to implement high-resolution digital-to-analog conversion is to combine microcontroller-PWM (pulse-width-modulated) outputs with precision analog-voltage references, CMOS switches, and analog filtering (**Reference 1**). However, PWM-DAC design presents a big design problem: How do you adequately suppress the large ac-ripple component inevitably present in the switch's outputs? The ripple problem becomes especially severe when you use typical 16-bit microcontroller-PWM peripherals for DAC control; such high-resolution PWM functions usually have long cycles because of the large 2^{16} countdown modulus of 16-bit

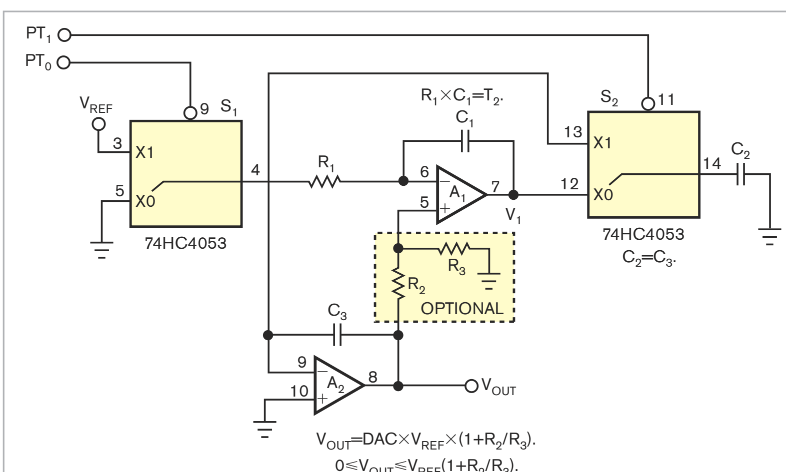


Figure 1 This DAC ripple filter combines a differential integrator, A_1, with a sample-and-hold amplifier, A_2, in a feedback loop operating synchronously with the PWM.

timers and comparators. This situation results in ac-frequency components as inconveniently slow as 100 or 200 Hz. With such low ripple frequencies, if you employ enough ordinary analog lowpass filtering to suppress ripple to 16-bit—that is, −96-dB—noise levels, DAC settling can become a full second or more.

The circuit in **Figure 1** avoids most of the problems of lowpass filtering by combining a differential integrator, A_1, with a sample-and-hold amplifier, A_2, in a feedback loop operating synchronously with the PWM cycle, T_2 in **Figure 2**. If you make the integrator time constant equal to the PWM cycle time—that is, $R_1 \times C_1 = T_2$—and, if the sample capacitor, C_2, is equal to the hold capacitor, C_3, then the filter can acquire and settle to a new DAC value in exactly one PWM-cycle time. Although this approach hardly makes the resulting DAC exactly "high speed," 0.01-sec settling is still 100 times better than 1-second settling. Just as important as speed, this improvement in settling time comes without compromising ripple attenuation. Ripple suppression of the synchronous filter is, in theory, infinite, and the only limit in practice is nonzero-charge injection from S_2 into C_3. The choice of a low-injected-charge switch for S_2 and an approximately 1-μF capacitance for C_3 can easily result in ripple amplitudes of microvolts.

Optional feedback-voltage divider R_2/R_3 provides flexibility in a DAC-output span with common voltage references. For example, if $R_2 = R_3$, then a 0 to 10V output span will result from a 5V reference. An additional advantage of this method of span adjustment is that output ripple remains independent of reference amplification. **EDN**

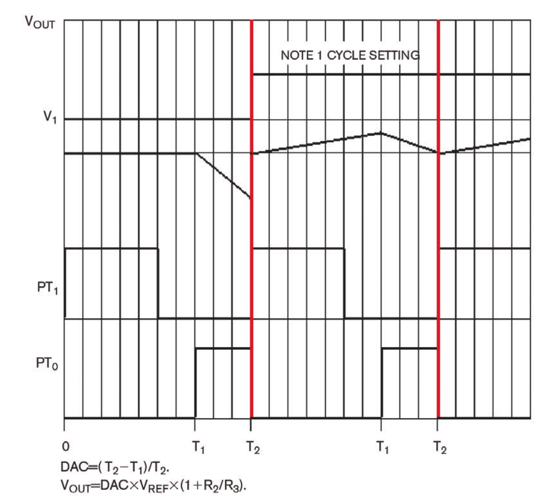


Figure 2 The DAC output settles within one cycle.

REFERENCE

1 Woodward, Steve, "Combine two 8-bit outputs to make one 16-bit DAC," *EDN*, Sept 30, 2004, pg 85, www.edn.com/article/CA454640.

Switched-gain op amp serves as phase detector or mixer

W Bruce Warren, Marietta, GA

Some op amps, such as the AD8041 from Analog Devices (www.analog.com) and the EL5100 from Intersil (www.intersil.com), provide a disable pin, which allows you to parallel the outputs of several op amps for video multiplexing. In addition to this multiplexing, you can also use the disable function to configure the op amp as a phase detector or a frequency mixer. **Figure 1** shows how the disable function can implement a low-frequency phase detector. You can switch the gain of this circuit's amplifier on and off at the rate of the phase-reference signal. Doing so produces a dc component at the output of the op amp. This component is proportional to the cosine of the phase difference between the phase of the input signal and the phase of the reference signal.

In the circuit, the output of the op amp is: $V_{OUT}(t) = V_{IN}(t) \times G(t)$, where $V_{IN}(t) = A\cos(\omega_{REF}t + \theta)$, and $G(t)$ is the time-varying gain of the op amp. $G(t)$ is a 50%-duty-cycle square wave that switches from zero to G_0 at the frequency of the phase-reference signal. G_0 is the gain of the op amp when the op amp is enabled. Because $G(t)$ is a time-varying periodic function expand it in a Fourier series: $G(t) = G_0[1/2 + 2/\pi\{\cos(\omega_{REF}t) - 1/3\cos(3\omega_{REF}t) + 1/5\cos(5\omega_{REF}t) + \ldots\}]$.

Multiplying $V_{IN}(t)$ by $G(t)$ and retaining only the dc terms, the dc component of the output is $V_{OUT}(dc) = (AG_0/\pi)\cos(\theta)$.

The EL5100 op amp in **Figure 1** has a 200-MHz unity-gain bandwidth, and you can turn its output on and off by applying a square wave of at least 0 to 4V to the output-disable terminal, Pin 8. Using the feedback resistances shown and with $G_0 = 3$, the peak output voltage of the phase detector is approximately equal to the peak value of the input signal. The EL5100 has a disable time of 180 nsec and an enable time of 650 nsec, which allows you to gain-switch the device to approximately 250 kHz. At higher frequencies, the gain of the phase detector falls off because the gain-switching no longer has a 50% duty cycle.

The lowpass filter following the op amp extracts the dc component of $V_{OUT}(t)$ and has a 3-dB point at 800 Hz. A 100Ω resistor in series with the 0.1-μF shunt capacitor limits the phase lag of the filter when the phase detector is inside a PLL (phase-locked loop). The values in **Figure 1** provide a maximum phase lag of approximately 65°. Using 5 and −5V power sup-

plies allows the output swing of the phase detector to be symmetric at approximately 0V. If your design doesn't require this symmetry, you can use a single 5V supply with 2.5V positive offset-biasing of the op amp. In this case, the output swing is symmetric with respect to 2.5V. As with all wide-bandwidth-op-amp circuits, you should take care to connect the power-supply bypass capacitors to ground with short connections and as close to the op amp's power-supply pins as possible to avoid instability.

This same gain-switching scheme also works as a frequency mixer. If the input signal is at frequency ω_S and the reference-square-wave input is at frequency ω_{lo}, the IF output signal is $(\omega_{lo}-\omega_S)$ or $(\omega_{lo}+\omega_S)$. You obtain the desired IF signal by replacing the output lowpass filter in **Figure 1** with a bandpass filter tuned to the desired IF frequency of $\omega_{lo}\pm\omega_S$. If the switching rate for the reference signal is higher than the disable function can provide, then you can use the harmonic mixing using the odd-order harmonics of the reference signal. This approach reduces the gain of the mixer by a factor of 1/N, where N is the number of the harmonic you are using. **EDN**

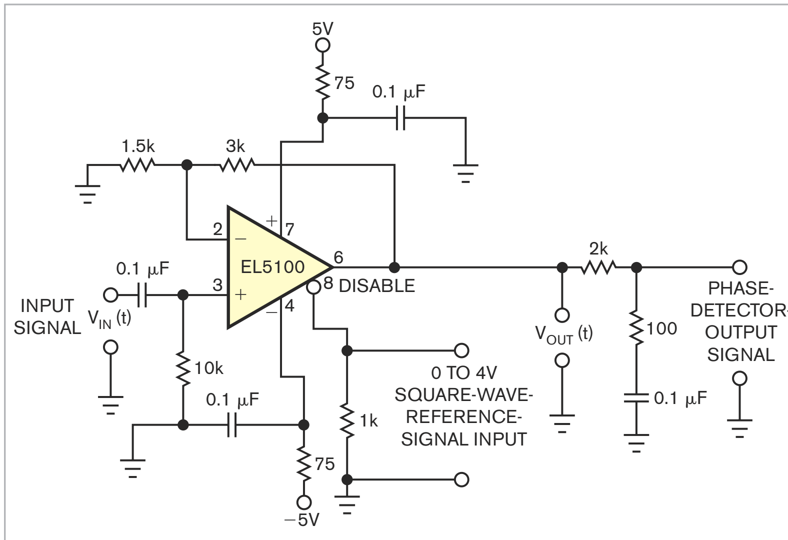


Figure 1 By switching the disable input of the op amp at a reference frequency and lowpass-filtering its output, you can obtain a dc voltage proportional to the phase difference of the switching frequency and the input frequency.

Counterfeiting still a top concern for distributors

It may not be the No. 1 issue for distributors, but counterfeit goods remain a top concern within the electronics supply chain, according to Robin Gray Jr (**photo**), executive vice president of NEDA (National Electronic Distributors Association, www.nedassoc.org), a trade association representing authorized distributors.

At the May 2007 EDS (Electronic Distribution Show and Conference), Gray called counterfeiting the "number one threat the industry faces." A year later, it's still a principal problem, Gray reports.

"It particularly affects manufacturers because it's their product that is being counterfeited," he says. Meanwhile, authorized distributors have an opportunity to benefit. As customers become increasingly concerned about the risk of buying from a nonauthorized source, Gray says, they are turning their purchasing power to authorized distributors.

"[Counterfeiting] is a big, looming issue for the industry. It's an issue that's going to be in the spotlight politically, as the government and law-enforcement officials take a more active role in stopping it," Gray says. "It means lost sales, [and] lost sales translate into lost jobs, less money spent on innovation and new technology, loss of IP [intellectual property], and damaged brands and reputations."

Indeed, the threat has become so great that the United States and the European Union partnered to seize more than 360,000 fake ICs and components in a joint operation at the end of 2007. The ICs and components included more than 40 trademarks from Intel, Philips, and others and were worth more than $1.3 billion. The US Patent and Trademark Office estimates that counterfeiting and piracy drain approximately $250 billion and some 750,000 jobs from the US economy each year.

Gray will present on industry trends at EDS 2008 on May 6.

GREEN UPDATE

GREENPEACE RAISES BAR WITH ENERGY CRITERIA

Greenpeace wants to see electronics companies clean up their acts and will soon be ranking OEMs such as Apple, Philips, and Nokia by stricter criteria.

The environmental organization currently ranks electronics companies in its *Greenpeace Guide to Greener Electronics* based on toxic-chemical use and e-waste (electronic-waste) regulations. In the future, Greenpeace plans to also rank brands against new energy criteria, to encourage the electronics industry to reduce its carbon footprint.

The new energy criteria include support for global mandatory reduction of GHG (greenhouse-gas) emissions, disclosure of GHG emissions plus emissions from two stages of the supply chain; commitment to reduce GHG emissions with time lines; proportional use of renewable energy in total electricity use of more than 25% operations; and energy efficiency of new end-product models based on the latest Energy Star standards.

"Most electronics brands are rising to the toxic-chemical and e-waste challenge issued by the Greenpeace guide," says Iza Kruszewska, a Greenpeace toxics campaigner. "It is now time to raise the bar and challenge the industry to take responsibility for the entire life cycle of products—from production through manufacture and to the very end of their products' lives."

You can find Greenpeace's current guide at www.greenpeace.org/greenerelectronics.

OUTLOOK

ANALOG DEMAND HOLDS STRONG

Recent interest from distributors, including Avnet Inc (www.avnet.com) and Arrow Electronics Inc (www.arrow.com), in the analog segment of the electronic supply chain should prove to be opportune as this year progresses.

Worldwide analog revenue is expected to increase to just more than $40 billion in 2008, and grow to more than $69 billion in 2013, for a five-year compound annual-growth rate of 11%, according to Databeans Inc (www.databeans.net).

The market-research company expects continued demand for wireless products, as well as healthy revenue growth for analog-power products, to drive the growth. The two segments combined to account for more than 40% of the entire $36.4 billion analog market in 2007, the company's data shows.

Demand for application-specific analog products and standard-linear products is expected to be positive this year, with a large projected increase in total analog shipments set to offset decreases in average selling prices of application-specific products, Databeans reports.

In 2007, Texas Instruments retained its lead in the analog market, followed by STMicroelectronics and Infineon Technologies, according to the market researcher.

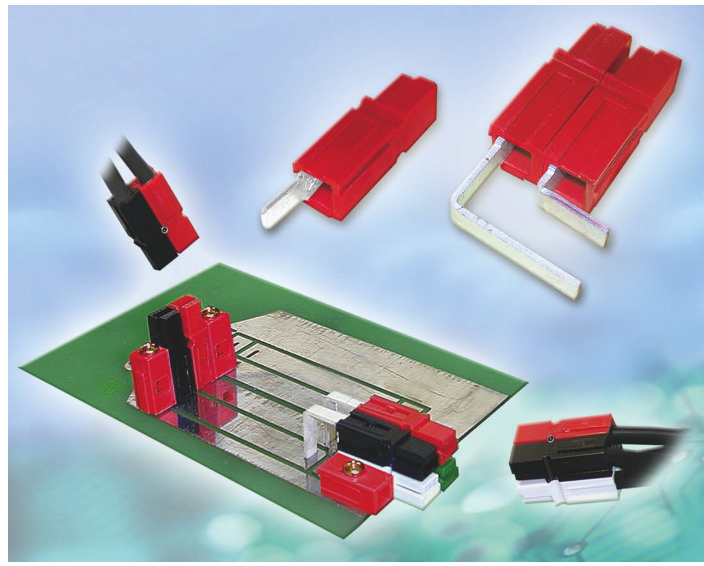
productroundup

CONNECTORS

PCB connector and contact series has a 45A UL rating

The high-power PCB (printed-circuit-board) connector and contact series, using copper-alloy and contacts with tin plating, complies with ROHS (restriction-of-hazardous-substances) directives. Designers can preassemble units in the series into one- or two-row configurations, reducing assembly costs and eliminating connector separation. The connectors and contacts are also available separately, allowing customization of connector configurations. The devices work with the vendor's Powerpole 15/45 Fingerproof connector housings and provide a 45A UL rating per circuit. Available in a variety of colors, the series also offers mounting wings, spacers, and board-mounting staples. The 1×2 vertical series costs $1.21 each, and the 2×3 R/A series costs $3.46 each (1000).

Anderson Power Products, www.andersonpower.com



Windows-based design tool improves wire-harness quality

The Windows-based E³.cable 2008-series design tool provides design requirements based on the nature of the end products, industry legislation, and safety mandates. The tool provides development of detailed wiring, cabling, and harness designs for the automotive, military, and aerospace industries. The wire-harness design, targeting cars, trucks, and specialized vehicles adds industry-specific functions, reducing the need for manual activities. For airplanes, helicopters, and military-application designs, the tool focuses on reducing effort, increasing design quality, and claiming 100% reliability. The E³.cable 2008 series costs $12,000.

Zuken, www.zuken.com

Connector family includes magnetic jacks

Targeting networking routers, switching hubs, set-top boxes, printers, and networking adapters, the vendor's RJ45 connectors portfolio now incorporates magnetic jacks. The devices suit use with 10/100 and 1000BaseT Ethernet connections. The connectors have a 1.5A and 150V-ac voltage rating with or without LEDs. Prices for the RJ45 connectors range from $1 to $2.10 per port for the 1000BaseT version and 60 to 90 cents per port for the 10/1000BaseT version.

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Watch those power leads!

In the Western Electric IC-manufacturing line of the early '70s, bipolar chips used "beam-lead" technology, which entailed a few back-end-wafer steps to add metallic beams onto each chip. Placing the die and then pressing the beams onto the lead frame would mechanically and electrically connect the die to the package leads. A three-amplifier biquad second-order-filter structure had become popular. To obtain higher order structures, a cascade of biquads would typically suffice.

The filter designers asked for a three-amplifier DIP so that each biquad would need only one DIP; the design would use thin-film resistors and capacitors rather than discrete components. Designers would customize resistors and capacitors for each biquad variant in the total filter. We used our yields and manufacturing costs to determine that, for the next few years, costs would be lower if we used three chips in one DIP. We designed a lead frame that would accept three dice and went to manufacturing.

Filters began rolling off the line. About a year later, someone in our filter-manufacturing plant reported that he was getting field failures for a product that employed several biquads per filter. These products were not simply out of spec; the filter was nonfunctional.

The filter team found that the op amp was the culprit. I asked for a quantity of the biquads along with the filter schematic, and, a few days later, 50 dead biquad modules arrived on my desk. After a detailed investigation of each filter, I observed that most had a defective DIP.

I removed and retested several triple-op-amp DIPs from the board. In every case, the center op amp was defective, and the failure signature suggested that it was disconnected from its positive-power supply. I opened a couple of the packages and tested the leads. The positive power to the lead was intact up to the beam lead, and the bonding appeared sound. Because the beam leads were on the active side of the die, after bonding, the die was face down. Using a knife, I cut the beam leads on three sides of the center die and flipped it over. I saw that the wide V_{DD} metal runner that connected to the output-driver transistor on the chip had blown open close to the beam lead.

I noticed that the V_{DD} and V_{SS} for the center op amp came to opposite sides of the module. So, if you powered up the module backward, V_{DD} would get the negative voltage, and V_{SS} would get the positive voltage, forward-biasing the substrate diode and allowing massive current flow. I took a "good" DIP, reversed the power supplies to the middle op amp, and slowly increased the compliance limit on the power supply. After destructive testing of several parts, I determined that, at 300 mA for 10 seconds, the V_{DD} blew.

But the packages took nine months to fail in the field. When the team leader for the filter design observed testing, he saw that the operator would sometimes accidentally insert a filter backward, and the power-supply current would spike. Upon rotating the module and retesting, the device passed. They sent me some, and I found that the center op amp was good, but the V_{DD} was badly damaged. In-field electromigration slowly ate away what little V_{DD} remained. Because changing the DIP would also require changing its motherboard, we found another option. I tested a few dice and found that I could run the supplies reversed for 24 hours at 250 mA with no visible damage. The filter test center reduced the current compliance limit to 200 mA, and field failures of this type never recurred.EDN

Since 2001, Doug Marsh has done part-time analog-design contract work. Like him, you can share your Tales from the Cube and receive $200. Contact edn.editor@reedbusiness.com.

DANIEL VASCONCELLOS

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