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Issue 5/2006
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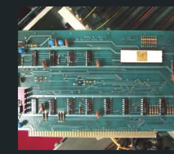

CHOOSE YOUR LASER

Subpar wars: high-resolution-disc formats fight each other, consumers push back

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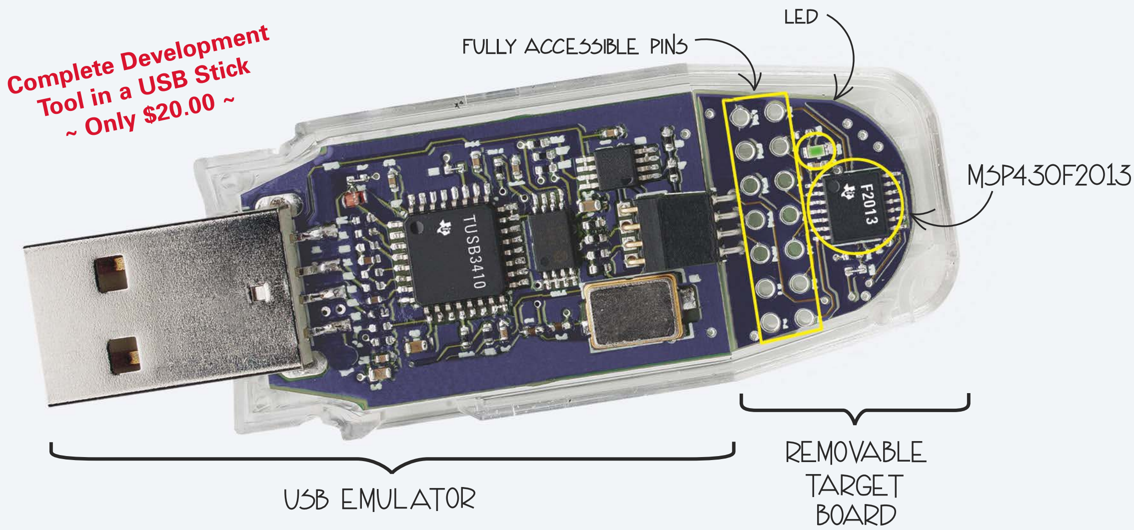
Easy.



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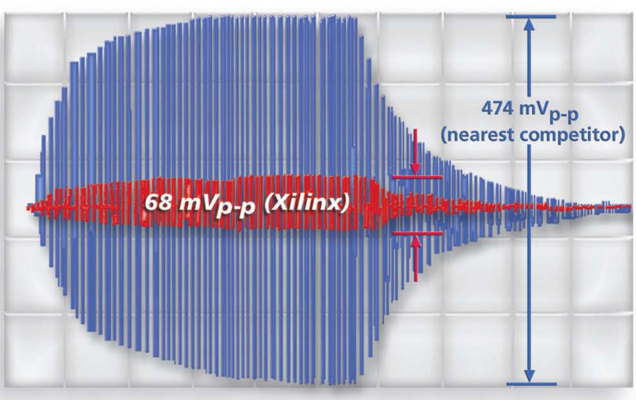

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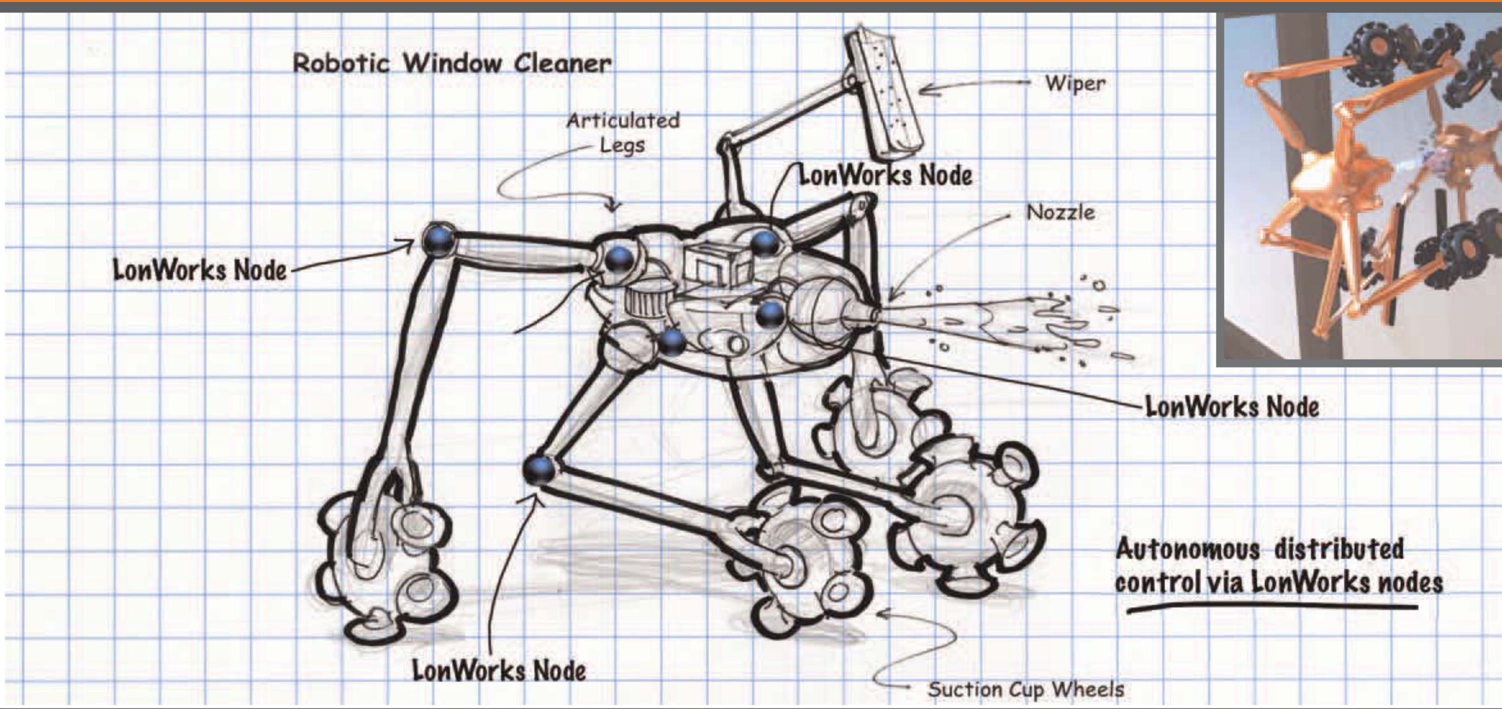

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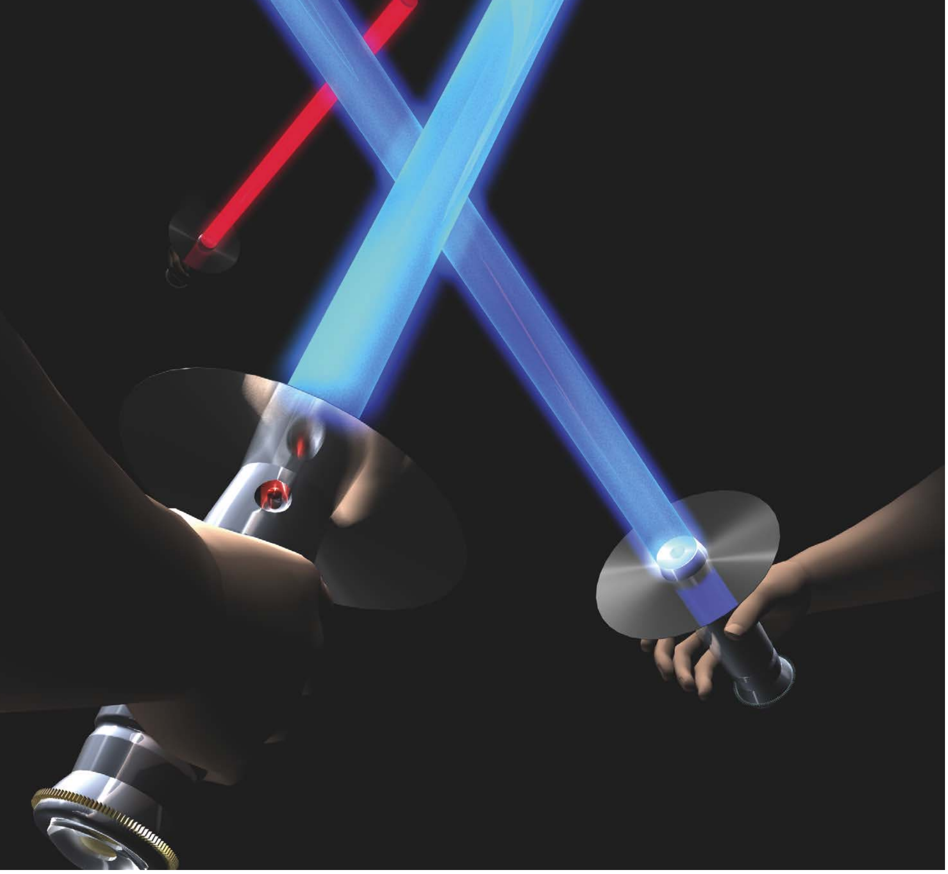

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50 years

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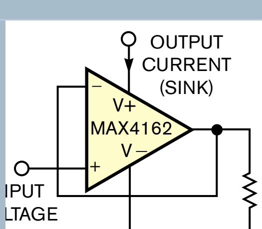

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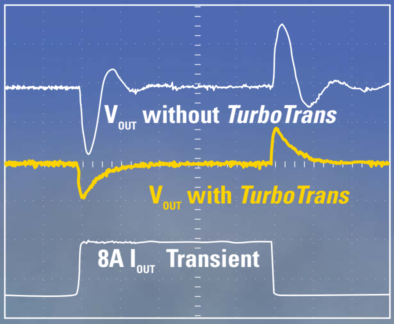

Technology for Innovators™

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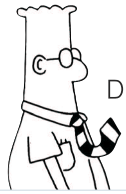

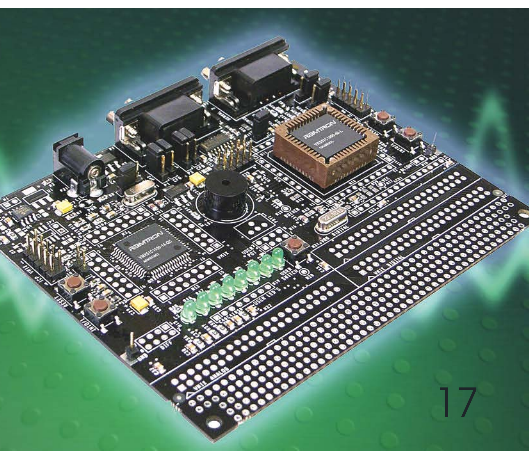

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DEPARTMENTS & COLUMNS

PRODUCT ROUNDUP

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Generating accurate jitter for SERDES-receiver-tolerance testing
By Gabriel Patulea, Cisco Systems
A simple method generates accurate jitter that is entirely sinusoidal and therefore deterministic.
→ www.edn.com/article/CA6305819

Lattice announces high-end and economy FPGAs
Apparently unafraid of going toe to toe with Xilinx and Altera in the high-end SRAM-based FPGA market, Lattice Semiconductor has announced a high-performance FPGA aimed squarely at the high-speed-communications and data-storage design spaces.
→ www.edn.com/article/CA6305011

Preventing bug escapes: Panel ponders verification
Having talented design and verification engineers is the No. 1 way to reduce the chances a fatal bug will escape detection, but having a comprehensive verification methodology is also important.
→ www.edn.com/article/CA6305660

Gigabit talk dominates DesignCon (again)
For at least the third consecutive year, 10-Gbps talk has dominated the DesignCon conference and exhibition.
→ www.edn.com/article/CA6305697

ISSCC offers divergent views of SOC future
Keynote addresses and papers at the 2006 International Solid State Circuits Conference showed that SOC (system-on-chip) integration is far from the simple march to a single chip that has often been portrayed.
→ www.edn.com/article/CA6305824

ESL is promising but still needs improvement, panelists say
ESL (electronic-system-level) tools, specifically for SystemC, still have a long way to go before system designers, let alone software and hardware engineers, will adopt them.
→ www.edn.com/article/CA6305884

Engineers still suffering from jitter jitters
As serial data rates climb past 2 Gbps and voltage falls in many consumer applications, more engineers are experiencing the challenge of trying to locate sources of timing jitter in their designs.
→ www.edn.com/article/CA6305400

BRIAN'S BRAIN
A blog by Brian Dipert, Senior Technical Editor
What's the deal with Brian's Brain?
It's overflowing with information and opinions. It encompasses an extraordinary range of technology topics, from network-attached-storage ICs to handheld games to satellite radio to graphics processors to semiconductor processes to home-networking schemes.

It's an interesting place to visit (though we're not sure we'd want to live there). It even allows you to make your own comments, and it has its own RSS feed.

Get into Brian's Brain:
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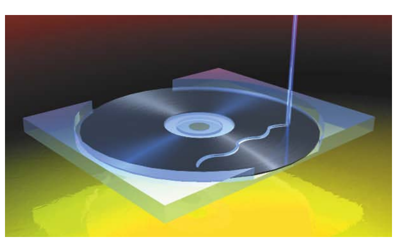
FROM THE VAULT

Items from the EDN *archives that relate to this issue's contents.*

SUBPAR WARS (pg 40):

Beating the blue-laser blues
→ www.edn.com/article/CA629326



CES stars: tough to find in mediocre year
→ www.edn.com/article/CA6301620

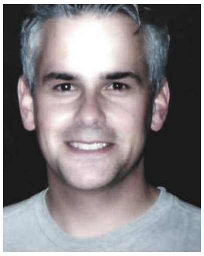
INTERFACING ELECTRONICS TO PEOPLE (pg 55):

Positive prognosis: Electronics transforms health care
→ www.edn.com/article/CA402151

RF-INTERFERENCE-DESIGN CONSIDERATIONS FOR PORTABLE-DEVICE BATTERIES (pg 33):

New battery technologies hold promise, peril for portable-system designers
→ www.edn.com/article/CA6288029

Battery-authentication ICs separate the good guys from the bad
→ www.edn.com/article/CA6301616



BY MICHAEL SANTARINI, SENIOR EDITOR

Stanley's Law: IC design follows pc-board design

Last year, on the last day of the last session of the DAC (Design Automation Conference), I attended a panel on IC-power management that Ron Wilson moderated. Then with *EE Times*, Wilson is now *EDN*'s executive editor. The power problem—in particular, leakage—reared its ugly head about three years ago and has since become a top concern for IC design. Three years ago, Apache jumped on the power problem before everyone else, and being early to market has given it an advantage over late entrants. Apache, known for its power tools, is one of only two privately held EDA companies that TSMC's (Taiwan Semiconductor Manufacturing Co's) 5.0 and 6.0 reference flows list.

On Wilson's DAC panel, all the power-tool vendors and users were saying that thermal would be the next big power-related issue to overcome, because heat causes leakage, and leakage increases heat—a nasty cyclical effect. Start-up Gradient Design is fielding a tool targeting thermal issues in ICs. The company anticipates that customers will soon need tools that identify thermal issues at the chip level.

When I was leaving Wilson's panel, I saw an old friend, press-relations maven Laurel Stanley. She used to be my point of contact when Joe Costello and Jack Harding were Cadence's chief executive officers. I harangued her for everything Cadence-related: mergers, criminal trials, civil trials, dismissals, and layoffs. I brought up the topic of the panel, and she made an observation: "Everything that happens in IC design, happened in pc-board design many years ago." Her observation seemed brilliant—and worthy of a "law." Indeed, pc-board design had run into a timing-speed crisis; signal-integrity, power, and thermal crises soon

> **An old friend made a brilliant observation: "Everything that happens in IC design, happened in pc-board design many years ago."**

followed—all years ahead of IC design.

According to Stanley's Law, will the next IC crisis after thermal be EMI? Mentor Chief Executive Officer Wally Rhines has a great knack for pinpointing these trends, and he may someday be able to pinpoint the exact lag time between pc-board and IC pains.

I remembered Stanley's Law at a panel I attended recently at DesignCon. Late onto the schedule, the panel didn't make it into the print program. So, it turns out, I was the only non-public-relations/panelist-handler attendee. The panel was on reuse in pc-board design. At a predominantly IC-design-methodology show, a pc-board panel wouldn't have attracted too many attendees, anyway. Even so, the panel simply turned into a roundtable question-and-answer session in which Wilson, design and EDA consultant Pallab Chatterjee, and I, fired off questions at panelists. It ended up being an interesting session, and we talked about everything in pc-board design, except reuse. At one point, Mentor Graphics Vice President John Isaac brought up ODB++, which I'd forgotten all about for many years.

Why is ODB++ important? When you apply Stanley's Law to it, it becomes a well-lit runway for the semiconductor-design world. ODB++ is the format that the entire design and pc-board-manufacturing chain finally picked over IPC's GenCAM as the official format for CAD-to-CAM transfer to replace Gerber files. The format includes features for transferring sensitive manufacturing data to design tools.

Today, a similar problem is stalling the IC-design-for-manufacturing flow: Foundries are reluctant to share sensitive process data with EDA companies, especially start-ups, and are calling for a secure way to do it. The EDA, semiconductor, and equipment industries now have to formulate a model and transfer method.

I hope Stanley's Law applies here, too, and shows that if the pc-board guys can pull it together, albeit after a bloody, drawn-out fight, the IC-design and -manufacturing industry can do it, too. Perhaps I should call IPC's director of technology transfer, Dieter Bergman, and Valor's director, Chuck Feingold, and tell them to dust off their boxing gloves. **EDN**

Contact me at michael.santarini@reedbusiness.com.

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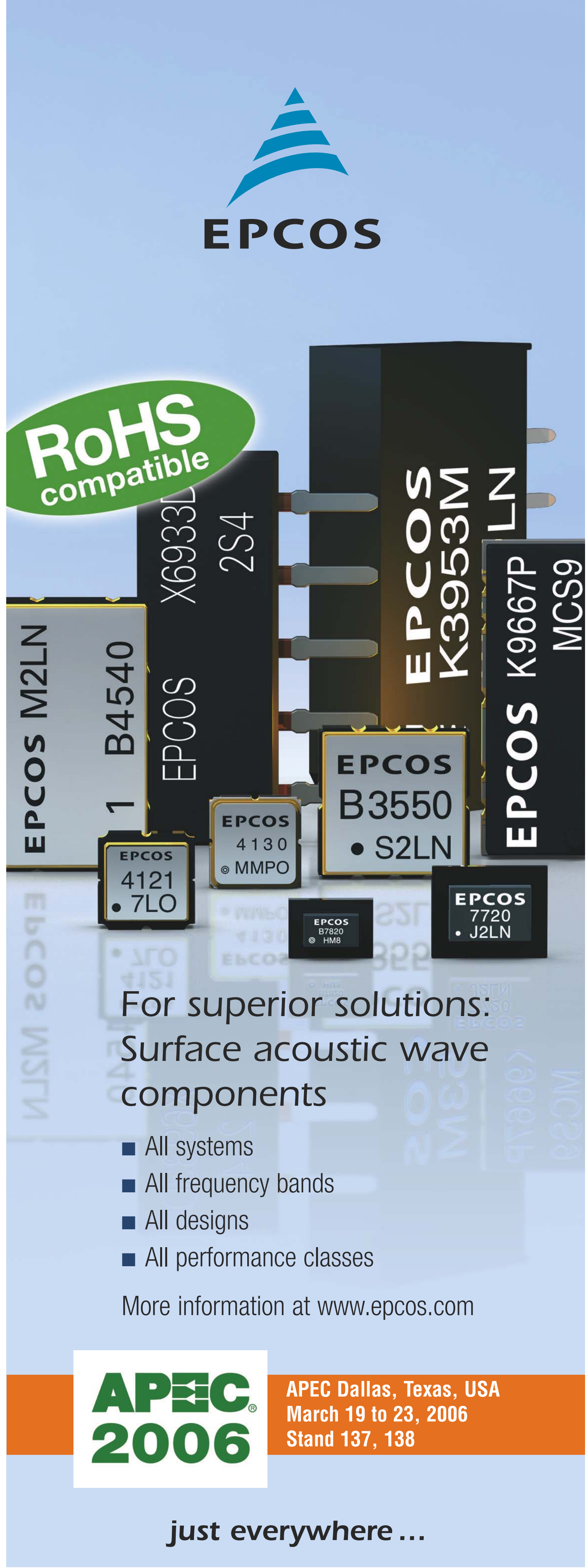

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AD8531/AD8532/ AD8534	250 mA, output, R-R I/O	✓	✓		✓	2.7	6	3	25	45	0.75	SC70	0.20
AD8541/AD8542/ AD8544	Micropower, R-R I/O	✓	✓		✓	2.7	6	1	6	42	0.038	SC70	0.20
AD8631/AD8632	1.8 V, low power, R-R I/O	✓	✓			1.8	6	5	4	23	0.3	SOT-23	0.20
AD8591/AD8592/ AD8594	250 mA output with shutdown	✓	✓		✓	2.7	6	3	25	45	0.75	SOT-23	0.21
AD8691/AD8692/ AD8694	Low noise, R-R output	✓	✓		✓	2.7	6	10	2	8	0.85	SC70	0.21
AD8517/AD8527	1.8 V, low noise, R-R I/O	✓	✓			1.8	6	7	3.5	15	0.9	SOT-23	0.27
AD8613/AD8617/ AD8619	1.8 V, micropower, low noise, R-R I/O	✓	✓		✓	1.8	6	0.4	2.2	25	0.038	SC70	0.29
OP07D	Ultralow offset voltage	✓				10	36	0.6	0.15	11	2.7	SOIC-8	0.30
AD8565/AD8566/ AD8567	Single-supply, R-R I/O	✓	✓		✓	4.5	18	5	10	26	0.7	SC70	0.34
AD8648	20 MHz, quad, R-R I/O				✓	2.7	6	20	2.5	8	2	TSSOP	0.58[2]
Video Amplifiers													
ADA4860-1	High speed, current feedback	✓				5	12	730	13	3.8	5.3	SOT-23	0.39
ADA4851-1/ADA4851-2/ ADA4851-4	Voltage feedback, R-R output	✓	✓		✓	3	12	130	3.3	10	2.4	SOT-23	0.39
ADA4850-1/ ADA4850-2	Ultralow power-down	✓	✓			2.7	12	175	4.1	10	2.4	LFCSP	0.45
ADA4853-1	Ultralow power, high speed, R-R output	✓				2.65	5	80	2	20	1	SC70	0.45
ADA4861-3	High speed, current feedback			✓		5	12	730	13	3.8	5.3	SOIC-14	0.67[3]
ADA4862-3	High speed, internally fixed G = +2			✓		5	12	300	25	10.6	5.3	SOIC	0.67[3]
ADD8710	10-channel Gamma buffer + V_{COM} driver					4.5	18	5	12	—	0.8	TSSOP	0.85[4]
Instrumentation Amplifiers													
AD8553	Auto-zero with shutdown	✓				1.8	6	1	0.02	30	1.1	MSOP	0.88
Audio Power Amplifiers													
SSM2211	Low distortion, 1.5 watt	✓				2.7	6	4	25	85	4.2	LFCSP	0.27
SSM2167	Low voltage, microphone preamp	✓				2.7	6	1	—	20	2.3	MSOP	0.35

[1] Single amplifier price listed unless noted.
[2] Quad amplifier price listed.
[3] Triple amplifier price listed.
[4] AD8710 is a 10 amplifier part.
See website for additional model pricing and packages available.

MEDICAL ELECTRONICS

Volume 6, Issue 2

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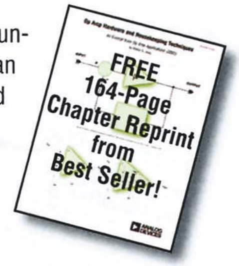
FEATURED ARTICLES

New Advancements in Integrated Circuit Technology Expand the Capabilities of Modern Medical Equipment for Healthcare Professionals and Consumers Alike



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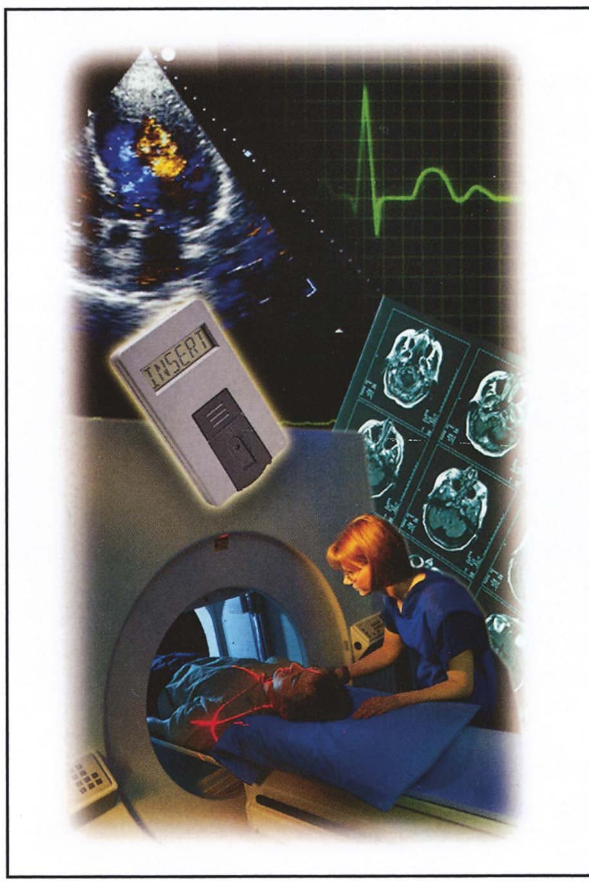

For a comprehensive listing of ADI products specifically designed for medical equipment applications, please turn to Pages 6, 7, and 8.

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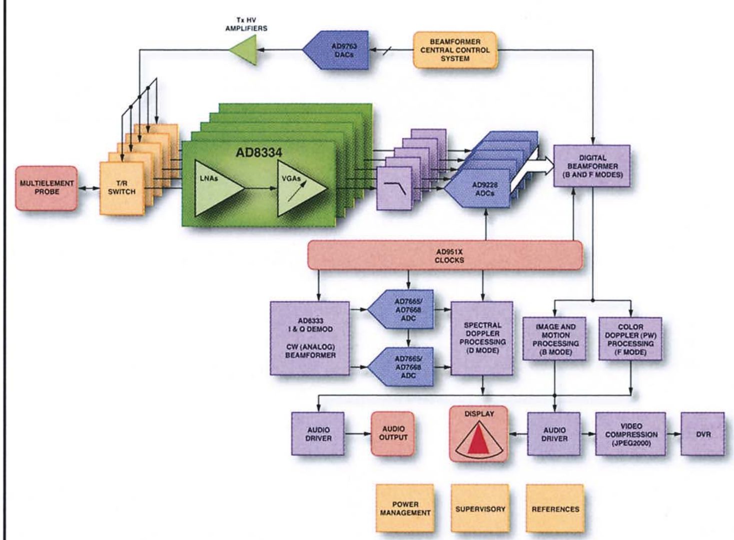
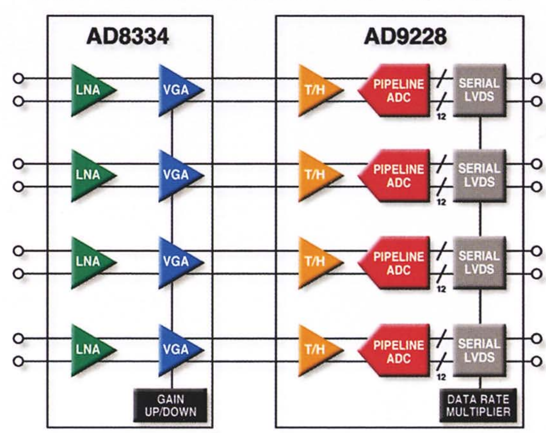


New Family of Low Power, Quad, High Speed ADCs, and Quad VGA Optimized for Portable Medical Applications

Analog Devices offers a new family of low power, quad, high speed ADCs and a new quad variable gain amplifier (VGA) suited for low power, multichannel system designs such as ultrasound. By providing serial, low voltage differential signaling (LVDS) data outputs, this new family of ADCs simplifies board layout and enables more data conversion paths to be routed within a given printed circuit board (PCB) area. The VGA is optimized to drive inputs to 10-bit and 12-bit ADCs. The AD9219 and AD9228, low power extensions of the previously released AD9229 quad ADC, offer 100 mW per channel power in quad ADCs. This is less than half of the 270 mW per channel in the AD9229. With supporting sample rates as high as 65 MSPS, these low power, 1.8 V, 10-bit and 12-bit ADCs deliver the kind of performance needed for multichannel systems. Performance features like 70 dB SNR to Nyquist, internal data rate multipliers that generate the serial LVDS data output rate, and a framing bit and output data clock make these quad ADCs a compelling solution. The AD9219 and AD9228 also offer improved flexibility in the output data with programmable clock and data alignment, and digital test pattern generation using a serial port interface (SPI®). The AD8334 VGA is a quad version of the released AD8332 dual VGA and is designed primarily for ultrasound systems as the quad ADC driver. With its ultralow noise preamplifier, the AD8334's referred input noise voltage is 0.74 nV/√Hz. Its selectable output clamping provides overload protection to the ADC inputs.

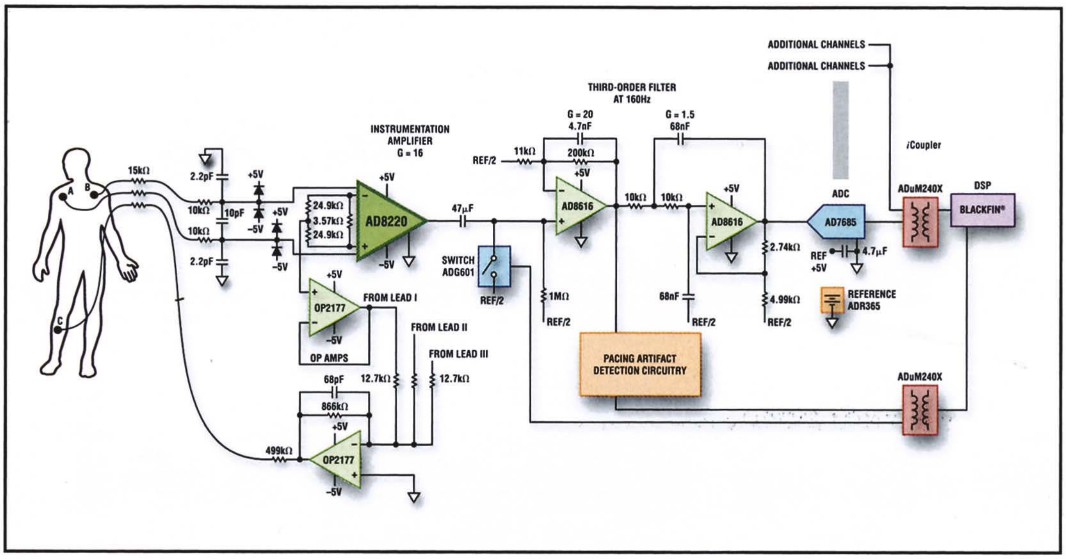
LOW POWER, QUAD VGA, AND ADC ICs REDUCE BOARD SPACE IN PORTABLE APPLICATIONS



View our on demand technical seminars: "Optimizing System Performance Using Multichannel ADCs with Serial LVDS Outputs" and "Designing with Differential Amplifiers" at *www.analog.com/onlineseminars.*

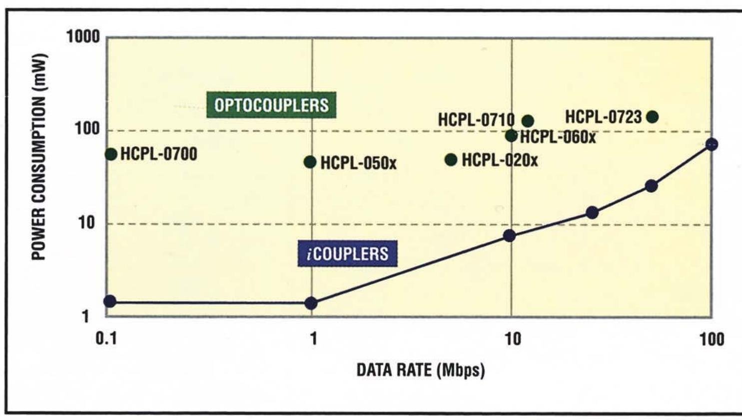
*i*Coupler Technology Enables Precise ECG/EKG Patient Monitoring

An ECG/EKG measures the electrical activity of a patient's heart. Treated as a vector quantity, the cardiac signal, typically 1 mV, is measured differentially. The first stage provides low gain to amplify the magnitude of the cardiac vector. Initial gain is limited by the 500 mV dc offset that develops between leads. A band-pass filter of 0.05 Hz to 150 Hz is employed. After the ADC, the signal is passed through a galvanic isolation barrier such as the *i*Coupler family of digital isolation products.



*i*Coupler Quad-Channel Isolators Double Isolation Rating to 5 kV

Analog Devices' new family of quad-channel digital isolators extends the benefits of the *i*Coupler technology to the realm of applications requiring increased isolation levels. Offering the same industry-leading performance specifications as the existing 2.5 kV ADuM140x quad-channel family, the ADuM240x family provides a 5 kV isolation rating, a variety of channel configurations, supporting applications such as medical equipment, power supplies, and other high voltage equipment.



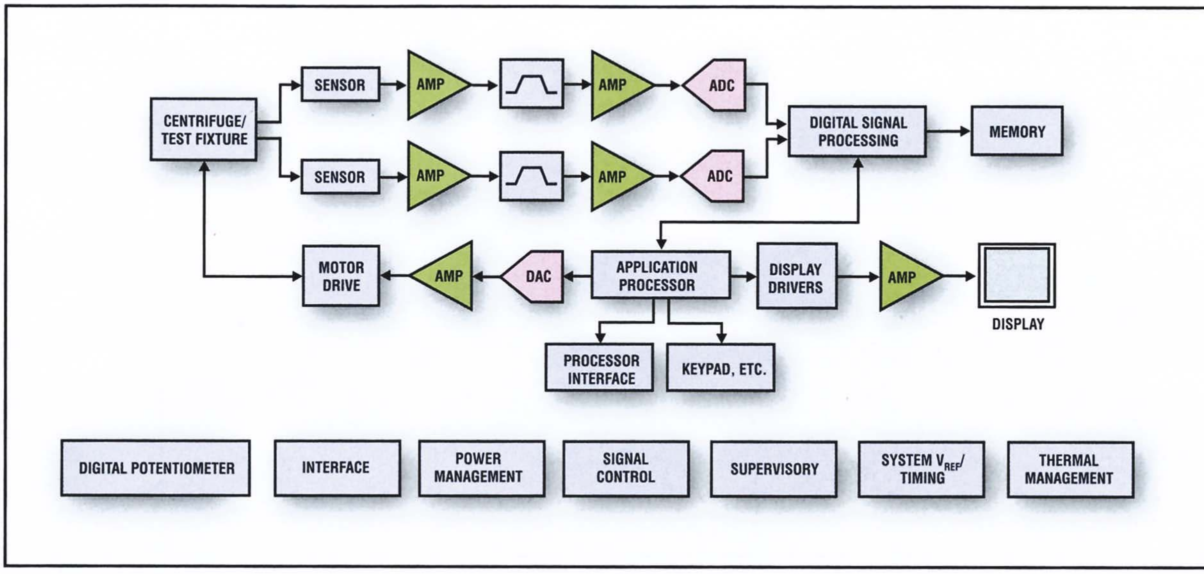
In the past, equipment designers requiring elevated isolation ratings have had limited options in choosing an isolation solution. Various high isolation optocouplers were available, but limited in data rate, timing accuracy, power consumption, and area efficiency. Improved performance and power consumption were achieved using transformers and other discrete components, but at the cost of increased design effort, complexity, and board space. Now, the ADuM240x family eliminates all these difficulties. It combines the high performance characteristics of all *i*Coupler products with a 5 kV isolation rating in a footprint per channel 80% less than optocoupler solutions. Furthermore, as a component having the most common isolation regulatory approvals, the ADuM240x simplifies the user's end product certification process.

Online Seminar Series

View our on demand technical seminar: "*i*Coupler Isolation Technology: Eliminate Those Optocoupler Headaches" at *www.analog.com/onlineseminars.*

Impedance-to-Digital Conversion Improves Blood Sample Analysis Accuracy

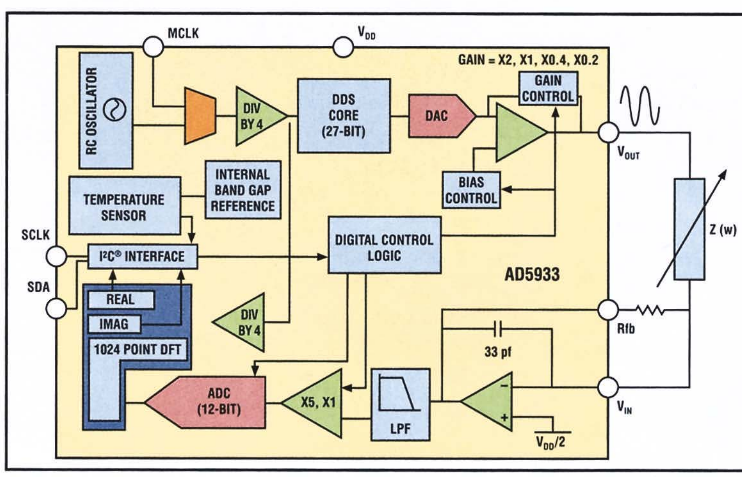
Blood analysis signal chains consist of a stimulus generator, data acquisition system, and DSP. When virus strain enters the blood, a chemical reaction occurs, altering its impedance at certain frequencies. Characterizing across frequency bands by injecting a stimulus via a low impedance probe, analyzing the response signal, and using a DSP algorithm to calculate the effective impedance allows specific virus strains to be detected.



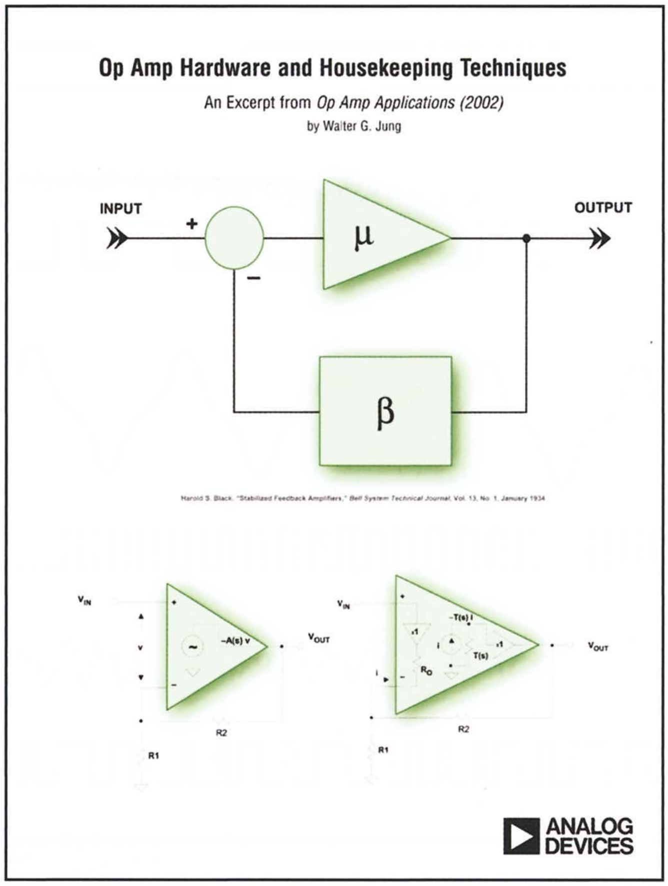
Integrated Impedance Converters Simplify the Challenges of Complex Measurements

The problem with measuring a complex impedance using discrete components can be numerous: frequency profiles need to be generated and subsequently digitized, error budgets calculated, and temperature effects taken into account across multicomponent selections. In total, the multichip solution is time consuming and space inefficient.

The AD5933 and AD5934 are the world's first integrated impedance converters, combining a precision on-board frequency generator with 12-bit, 1 MSPS (AD5933) and 250 kSPS (AD5934) ADCs. The frequency generator allows an external complex impedance (range 100 Ω to 10 MΩ) to be excited with a known frequency of up to approximately 100 kHz. The response signal from the impedance is sampled by the on-board ADC and DFT processed by an on-board DSP engine. The DFT algorithm returns a real (R) and imaginary (I) data-word at each frequency point (in the case of a sweep), allowing impedance to be conveniently calculated based on an initial system calibration.




Amplifiers
Power Management
Processors
DSP
RF
MEMS
Converters


Op Amp Hardware and Housekeeping Techniques
An Excerpt from *Op Amp Applications (2002)*
by Walter G. Jung
INPUT
OUTPUT
+
−
μ
β
Harold S. Black, "Stabilized Feedback Amplifiers," *Bell System Technical Journal*, Vol. 13, No. 1, January 1934
V_IN
V_OUT
R1
R2
ANALOG DEVICES

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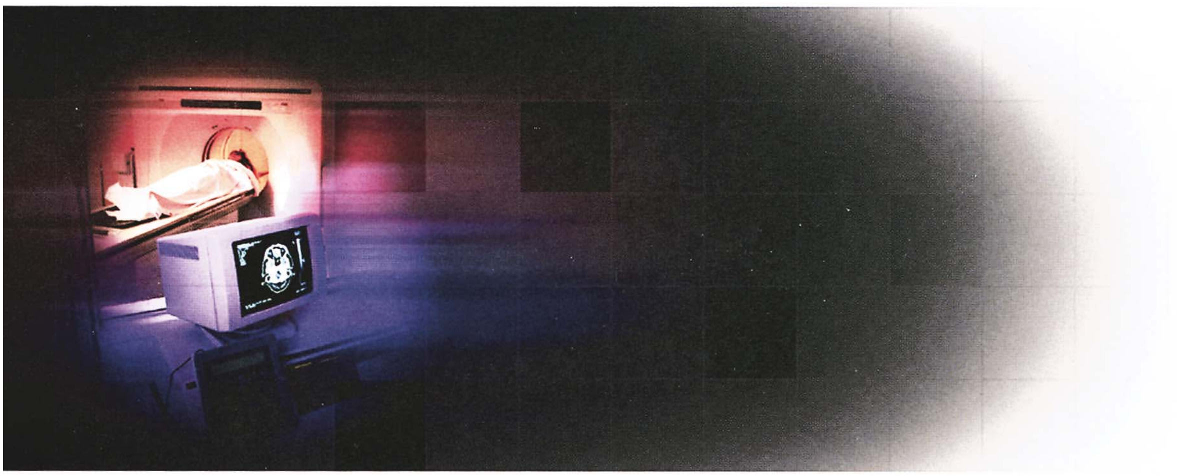
Sample Kits Optimized for Medical Applications Now Available



Avnet Electronics Marketing is currently sampling an Analog Devices' solutions kit, featuring an array of components ideal for use in medical applications.

Kit Contents:

Part Number	Description
AD8616	Precision dual-operational amplifier
AD7685	16-bit PulSAR® ADC
ADuM2400	Quad channel *i*Coupler®
AD5445	12-bit multiplying DAC
AD8335	Quad VGA
AD9248	14-bit, dual, high speed ADC
ADR360	Voltage reference
AD5933	12-bit impedance converter
ADM1062	Super Sequencer™
AD8553	Auto-zero in-amp

Visit the Avnet website for a sample kit, data sheets, and additional product information at *www.em.avnet.com/adimedicalsamplekit.*

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164-Page Chapter Reprint—FREE to First 300 Respondents

Please answer the following questions:

1. Which category best describes your job? (select one)
- ☐ Engineering Management
- ☐ Engineering
- ☐ Management Other than Engineering
- ☐ Purchasing/Procurement
- ☐ Marketing/Sales
- ☐ Consulting
- ☐ Professor/Instructor/Research/Scientist
- ☐ Editor/Industry Analyst
- ☐ Other__________

2. Which of the following best describes your business? (select one)
- ☐ Computer Systems and Peripherals
- ☐ Communications Systems
- ☐ Controls, Test, and Medical Equipment
- ☐ Consumer Electronics
- ☐ Automotive
- ☐ Military/Aerospace
- ☐ Other__________

3. Is your request in support of an active design? (select one)
- ☐ Yes
- ☐ No (Do you anticipate a new design in the next 12 months?)
  ☐ Yes ☐ No
- ☐ Unknown

4. Which of the following best describes your design stage? (select one)
- ☐ Component Identification
- ☐ Production
- ☐ Prototyping
- ☐ Redesign
- ☐ Requirements Definition
- ☐ Research for Future Project
- ☐ Unknown

5. When do you plan to make your component decision?
- ☐ 0–3 Months
- ☐ 3–6 Months
- ☐ 6–12 Months
- ☐ More than 12 Months
- ☐ Already in Production
- ☐ Unknown

6. What is your best estimate of the number of components your company would be using for this (design) project on an annual basis?
- ☐ 1–999
- ☐ 1,000–4,999
- ☐ 5,000–9,999
- ☐ 10,000–49,999
- ☐ 50,000–99,999
- ☐ 100,000+
- ☐ Unknown

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Medical Electronics Solutions Bulletin

Please send me the following materials:

(Offer expires 5.31.06. Please limit sample and data sheet requests to any six.)

Part Number	Data Sheet	Sample	Part Number	Data Sheet	Sample
1. AD5933	☐	☐	21. AD8553	☐	☐
2. AD7468	☐	☐	22. AD8607	☐	☐
3. AD7621	☐	☐	23. AD8617	☐	☐
4. AD7641	☐		24. AD8618	☐	☐
5. AD7665	☐	☐	25. AD8655	☐	☐
6. AD7683	☐	☐	26. AD8656	☐	☐
7. AD7685	☐	☐	27. AD9228[2]	☐	
8. AD8220	☐	☐	28. AD9229	☐	☐
9. AD8317	☐		29. AD9510	☐	☐
10. AD8318	☐	☐	30. AD9707	☐	☐
11. AD8319	☐	☐	31. AD9763	☐	☐
12. AD8333[1]	☐		32. ADL5306	☐	
13. AD8334	☐	☐	33. ADL5330	☐	☐
14. AD8342	☐	☐	34. ADL5350	☐	
15. AD8352	☐	☐	35. ADR121	☐	☐
16. AD8361	☐	☐	36. ADR365	☐	☐
17. AD8362	☐	☐	37. ADR391	☐	☐
18. AD8367	☐	☐	38. ADuC7020	☐	☐
19. AD8368	☐		39. ADuM2401	☐	☐
20. AD8370	☐	☐			

[1] For more information about AD8333 product, please email *AD8333.samples@analog.com.*

[2] For more information about our AD9228 product, please email *Highspeed.converters@analog.com.*

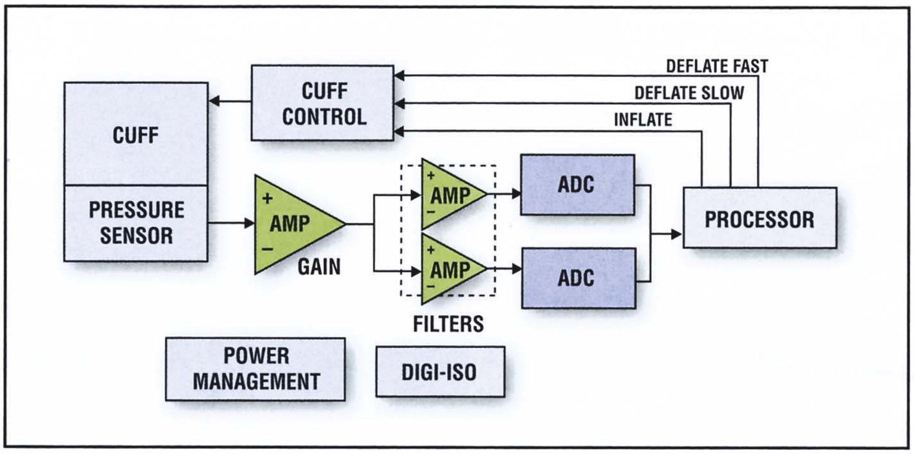
This is only a partial listing of the products available for sampling from this solutions bulletin. If you are interested in sampling a part that isn't listed here, please visit *www.analog.com/V6Medical* and click the link. Or, complete this enclosed card and mail or fax it to Analog Devices at 508.378.8440.

ANALOG DEVICES

9672

Precision ADCs that Enhance Portable Patient Monitoring Applications

Blood pressure can be measured using a variety of different methods. One method is to measure overall cuff pressure and amplitude of oscillations. As the pressure in the cuff is reduced, small oscillations in pressure are measured due to blood flow through the arm changing in volume. This system requires only one sensor to measure pressure. This is accomplished using a gain block followed by active filters and precision ADCs controlled by a processor.



Improve Accuracy, Speed, and Extend Battery Life of Portable Medical Devices with Tiny, 16-Bit SAR ADCs

Analog Devices' recent addition of the AD7683 and AD7694 to the 16-bit PulSAR® ADC family extends the available solutions to meet designers' small package, low power needs. Both parts are available in 8-lead MSOP and operate from a single power supply, V_{DD} between 2.7 V and 5.5 V. The AD7683 features a throughput rate of 100 kSPS and utilizes an advanced design technique to achieve a low power dissipation rate (4 mW at 5 V/100 kSPS). The performance has not been compromised in achieving this low power consumption. Typical INL is ±3 LSB and 16-bits with no missing codes guaranteed over temperature. It contains a low noise, wide bandwidth, very short aperture delay track-and-hold circuit, and a versatile serial interface port. The AD7694 is a 16-bit no missing code ADC with 250 kSPS throughput rate and ±4 LSB typical INL. The combination of precision, low power, and small footprint, enables developers of portable battery-powered medical or data acquisition systems to achieve greater functionality at high resolution and longer battery life.

View our on demand technical seminar: "Driving Precision Converters: How to Select the Best Reference and Amplifier for Your ADC Application" at *www.analog.com/onlineseminars.*

Analog-to-Digital Converters

Part Number	Resolution (Bits)	Sample Rate	Interface	Supply Range (V)	Medical Application	Package Type	Price ($U.S.)
AD7690	18	400 kSPS	SPI	5	Imaging	10-lead MSOP	19.50
AD7683	16	100 kSPS	SPI	3/5	Imaging	8-lead MSOP	5.75
AD7466	12	200 kSPS	SPI	1.8 /2.5/3/3.3	Patient monitoring	6-lead SOT-23	2.35
AD7468	8	320 kSPS	SPI	1.8/2.5/3/3.3	Patient monitoring	6-lead SOT-23	1.15
AD7621	16	3 MSPS	SPI, parallel	2.5	Imaging	48-lead LFCSP	29.95
AD7641	18	2 MSPS	Byte, parallel, SPI	2.5	Imaging	48-lead LFCSP	32.95
AD7665	16	570 kSPS	SPI, parallel	5	Imaging	48-lead LFCSP	19.00
AD7671	16	1 MSPS	SPI, parallel	5	Imaging	48-lead LFCSP	21.95
AD7674	18	800 kSPS	Byte, parallel, SPI	5	Imaging	48-lead LFCSP	27.95
AD7678	18	100 kSPS	Byte, parallel, SPI	5	Imaging	48-lead LFCSP	19.20
AD7685	16	250 kSPS	SPI	2.7 to 5	Patient monitoring	10-lead MSOP	6.50
AD7686	16	500 kSPS	SPI	2.7 to 5	Patient monitoring	10-lead MSOP	12.00
AD9228	12 × 4	40 kSPS, 65 kSPS	Quad LVDS	1.8	Ultrasound	48-lead LFSCP	23.50, 32.50
AD9219	10 × 4	40 kSPS, 65 kSPS	Quad LVDS	1.8	Ultrasound	48-lead LFSCP	15.98, 19.98
AD9229	12 × 4	50 kSPS, 65 kSPS	Quad LVDS	3	Ultrasound	48-lead LFSCP	24.99, 32.51
AD9446	16	80 kSPS, 100 kSPS	Quad LVDS	3.3/5	MRI	100-lead TQFP	48.33, 56.77

Amplifiers

Part Number	Component Description	Medical Application	Supply Voltage (V)	Package	Price ($U.S.)
AD8205/ AD8206	High common-mode difference amps	Patient monitoring, portable and consumer medical	4.5 to 5.5	8-lead SOIC, bare die	1.35
AD8220	R-R output, JFET input in-amp	Instrumentation, EEG, ECG	±4.6 to ±36	8-lead MSOP	2.29
AD8333	50 MHz, dual I/Q demod and phase shifter	Ultrasound	±4.5 to ±6.0	32-lead LFCSP	8.95
AD8334	Ultralow preamp and programmable R_{IN} quad VGA	Ultrasound	4.5 to 5.5	64-lead LFCSP	14.49
AD8337	280 MHz, dc-coupled VGA	PET scan	4.5 to 10	LFCSP, chip scale	2.49
AD8538	Precision, low power in-amp	Portable instrumentation	2.7 to 5.5	5-lead TSOT	0.89
AD8553	Auto-zero in-amp with shutdown	Portable instrumentation	1.8 to 6	10-lead MSOP	1.30
AD8607	Precision, low noise, micropower, R-R I/O	Portable instrumentation, patient monitoring	1.8 to 6	14-lead MSOP	1.01
AD8616	24 MHz CMOS, R-R, dual	Instrumentation, EEG, ECG	2.7 to 6	8-lead SOIC	1.15
AD8617	Micropower, low noise, R-R I/O	Patient monitoring, IR thermometers, consumer medical	1.8 to 6	8-lead MSOP	0.7
AD8655	Precision, low noise CMOS, single	AFE, low noise physiological measurements	2.7 to 5.5	8-lead MSOP	0.70
ADA4841-1	Low distortion, low noise	Portable instrumentation	2.7 to 12	6-lead SOT-23	1.59
ADA4899	Unity gain stable, ultralow distortion and voltage noise	Ultrasound, CAT scan, MRI, instrumentation	5 to 12	8-lead LFCSP	1.89
ADA4922-1	Differential 18-bit ADC driver	Instrumentation	5 to 26	8-lead LFCSP	3.59
ADA4941-1	Differential 18-bit ADC driver	Portable instrumentation	2.7 to 12	8-lead LFCSP	2.39

Digital-to-Analog Converters

Part Number	Resolution	Sample Rate (MSPS)	INL (LSB)	SFDR (dB)	Medical Application	Package Type	Price ($U.S.)
AD5443	12	2.47	±1.0	87	Patient monitoring	10-lead MSOP	3.71
AD5445	12	20.4	±1.0	82	Patient monitoring	20-lead TSSOP, 20-lead LFCSP	3.38
AD9707	14	175	±0.8	83	Ultrasound	32-lead LFCSP, 28-lead TSSOP	8.00
AD9706	12	175	±0.8	83	Ultrasound	32-lead LFCSP, 28-lead TSSOP	6.48

RF Products

Part Number	Component Description	Medical Application	Package Type	Price ($U.S.)
AD8318	1 MHz to 8 GHz, logarithmic detector/controller	Detection of RF power in MRI, PET, and other instruments	16-lead LFCSP	4.99
AD8317	1 MHz to 10 GHz, logarithmic detector/controller	Detection of RF power in MRI, PET, and other instruments	8-lead LFCSP	3.93
AD8319	1 MHz to 10 GHz, 40 dB logarithmic detector/controller	Detection of RF power in MRI, PET, and other instruments	8-lead LFCSP	2.99
ADL5306	60 dB range (100 nA to 100 μA), low cost logarithmic converter	Optical power detection in blood glucose monitors, cameras, etc.	16-lead LFCSP	4.69
AD8362	50 Hz to 2.7 GHz, 60 dB TruPwr™ detector	Detection of true RF power in MRI, PET, and other instruments	16-lead TSSOP	6.25
AD8361	2.5 GHz TruPwr detector	Detection of true RF power in MRI, PET, and other instruments	6-lead SOT-23	3.75
ADL5330	1 MHz to 3 GHz VGA with 60 dB gain control range	Gain control of RF signal in ultrasounds, MRI, PET scanner	24-lead LFCSP	4.98
AD8367	500 MHz, 45 dB linear-in-dB variable gain amplifier	Gain control of RF signal in ultrasounds, MRI, PET scanner	14-lead TSSOP	4.55
AD8370	750 MHz, digitally controlled, variable gain amplifier	Digital gain control of RF signal in ultrasounds, MRI, PET scanner	16-lead TSSOP	4.20
AD8352	2 GHz, ultralow distortion, differential RF/IF amplifier	High speed ADC driving	16-lead LFCSP	3.49
AD8342	LF to 500 MHz active receive mixer	Downconversion to lower IF in X-ray, MRI, and other scanners	16-lead LFCSP	4.20
ADL5350	LF to 4 GHz high linearity Y-mixer/answer	Downconversion to lower IF in X-ray, MRI, and other scanners	8-lead LFCSP	2.36

Precision Clocks

Part Number	Clock Distribution	Outputs/Logic Family	Core Signal Generator	Medical Application	Package Type	Price ($U.S.)
AD9510*	1.2 GHz	4 LVPECL, 4 LVDS/CMOS	PLL	Ultrasound	64-lead LFCSP	11.95
AD9513	800 MHz	3 LVDS/CMOS	PLL	Ultrasound	32-lead LFCSP	5.95
AD9515*	1.6 GHz	1 LVPECL, 1 LVDS/CMOS	PLL	Ultrasound	32-lead LFCSP	4.75
AD9540	655 MHz	1 CML, PECL compliant	DDS	Ultrasound	48-lead LFCSP	9.95

*Other output and package configurations are available for the 1.2 GHz and 1.6 GHz-rated clock products.

Digital Signal Isolators (*i*Couplers)

Part Number	Number of Channels	Isolation Rating (V rms)	Maximum Data Rate	Medical Application	Package Type	Price ($U.S.)
ADuM140x	4	2500	90 Mbps	Patient monitoring	16-lead SOIC	2.43
ADuM240x	4	5000	90 Mbps	Patient monitoring	16-lead SOIC	3.16

Temperature Sensors

Part Number	Interface	Maximum Error (°C)	Temperature Range	Medical Application	Package Type	Price ($U.S.)
ADT7301	Serial SPI/DSP	±0.5	–40°C to +150°C	Patient monitoring	6-lead SOT-23, 8-lead MSOP	1.20
TMP05	Analog	±0.5	–40°C to +150°C	Patient monitoring	5-lead SC70, 5-lead SOT-23	0.95
TMP36	Analog	±1.0	–40°C to +150°C	Patient monitoring	8-lead SOIC, 5-lead SOT-23	0.40

Power Management

Part Number	Power Consumption (μA)	Manual Reset Capabilities	Output Stage	Medical Application	Package Type	Price ($U.S.)
ADM809	17	No	Push-pull	Portable instrumentation	3-lead SC70, 3-lead SOT-23	0.61
ADM6711	12	Yes	Push-pull	Portable instrumentation	4-lead SC70	0.28
ADM6713	12	Yes	Open-drain	Portable instrumentation	4-lead SC70	0.28
ADM8616	3	No	Push-pull	Portable instrumentation	4-lead SC70	0.85
ADM8617	3	No	Open-drain	Portable instrumentation	4-lead SC70	0.85

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INNOVATIONS & INNOVATORS

Agency-approved power supply cuts cost, leadtimes

Applications requiring nonstandard power-supply voltages, especially for industrial, IT, or medical markets, usually require a custom power supply, with the attendant added expense and delivery time. Targeting that problem, XP Power has introduced an ac/dc switching power supply that enables system designers to specify any voltage level up to the maximum rating of each output and still maintain full agency approvals. The RCL175 power supply is available with one to four outputs: 3 to 60V, 5 to 60V, and 5 to 30V on the two remaining outputs. The isolated 5 to 30V outputs allow parallel or series connection for further flexibility. Users can adjust the 3 to 60V output by ±10%, and the other outputs track this output by ±10%. The compact power supply targets use in industrial, IT, and medical applications and suits both Class I, which includes supplies with a ground connection, and Class II, covering those with no ground connection.

The supply uses a silicon-carbide diode to maximize efficiency and minimize component count in the power-factor-correction boost converter. The fractional-turn transformer allows combinations of outputs, such as 3.3 and 5V, without postregulation. The product sells for $155 (100).

—by Margery Conner

▷**XP Power**, www.xppower.com.

These ac/dc switching power supplies enable designers to specify any voltage level up to the maximum rating of each output and still maintain full agency approvals.

$99 development kit supports 8051 microcontrollers

Ramtron International recently launched the UniVersaKit, a development and evaluation system that supports Ramtron Versa product families, as well as most industry-standard 8051 microcontrollers. The board includes 3.3 and 5V voltage regulators; an RS-232 transceiver; DB9 connectors; reset and interrupt switches; user LEDs; a serial, two-wire flash RAM; a buzzer; and prototyping space. Ramtron ships the UniVersaKit with the development board, an in-circuit programmer, a serial cable, a power supply, and a CD-ROM. The kit also provides user guides, an integrated development environment, a C compiler, and an assembler. The kit costs $99.

—by Warren Webb

▷**Ramtron International**, www.ramtron.com.

A new, low-cost evaluation kit from Ramtron offers a hardware- and software-design environment for 8051-microcontroller projects

FROM THE VAULT

EDN VOICE OF THE ENGINEER 50 years

By 2006, electronic devices will be self-diagnostic and probably self-repairing to some extent. In many ways, they will be like a cat—with at least nine lives—and you'll be able to tell how many lives remain at any given time. Terminally electronic circuits will be replaced and discarded, not remanufactured or otherwise fixed.

John M Fluke, founder, John Fluke Mfg Co, *EDN*, Oct 14, 1981

DSOs boast low noise, automatic search for long-waveform records

Many purchasers don't want to pay now for scope bandwidth that they won't use for several years, so Agilent's new Infiniium 80000B series brings back upgradable bandwidth, a feature that disappeared from oscilloscopes in the days of analog instruments. A couple of mouse clicks or taps on the touch-sensitive screen of most high-performance digital scopes, including Agilent's, can invoke variable-bandwidth lowpass filtering that mitigates the wider-bandwidth scopes' higher noise, but filters can't address the higher cost of the wider bandwidth.

In addition, the new way of upgrading is less convenient than the plug-in architecture of old. With one exception—increasing the −3-dB frequency from 12 to 13 GHz, which you do by unlocking bandwidth-enhancing DSP software inside the scope—upgrading an 80000B scope's bandwidth requires returning the unit to the manufacturer for hardware installation and recalibration.

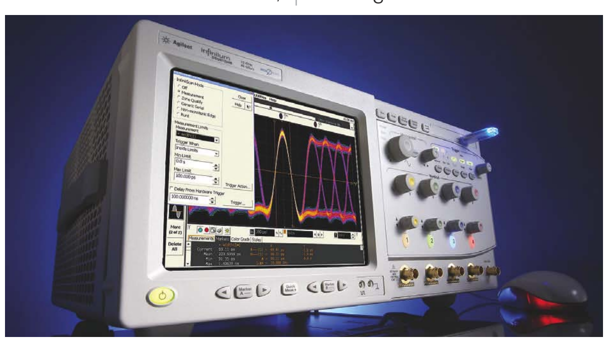
At a bandwidth of 1 GHz, a 12-GHz 80000B scope that Agilent tested exhibited noise of 153 µV rms and 1.6 mV p-p. At the full 12-GHz bandwidth, the scope's noise increased to 406 µV rms and 4.3 mV p-p, less than the theoretical factor of the square root of the high bandwidth divided by the low bandwidth. Agilent says that the 80000B scopes have the lowest noise in their class, an attribute that makes them ideal for jitter measurement because a scope's jitter-noise floor depends on its internal noise.

The scopes' new Infiniiscan feature automates finding anomalous waveforms. At sampling rates of 4G samples/sec and slower with half of the channels active, the scopes offer memory as deep as 64M samples/channel. (At higher sampling rates, maximum memory depth is 2M samples/channel.) Finding infrequent anomalies in long-waveform records is tedious at best, and the record length makes visually catching every anomaly virtually impossible. Among Infiniiscan's impressive capabilities is finding glitches as brief as 65 psec. Infiniiscan can also combine hardware triggering and software analysis to find waveforms that pass or fail combinations of criteria that you can specify.

The 80000B series' touch-sensitive color LCDs offer improved resolution of 1024×768 pixels. In addition, the intensity-grading feature distinguishes among 256 intensity levels to make visual waveform analysis more intuitive. Prices for the four-channel, 2-, 3-, 4-, 6-, 8-, 10-, 12-, and 13-GHz units range from $30,000 to $115,000. Prices for upgrades to increase from any bandwidth to the next higher one range from $9000 to $19,500.

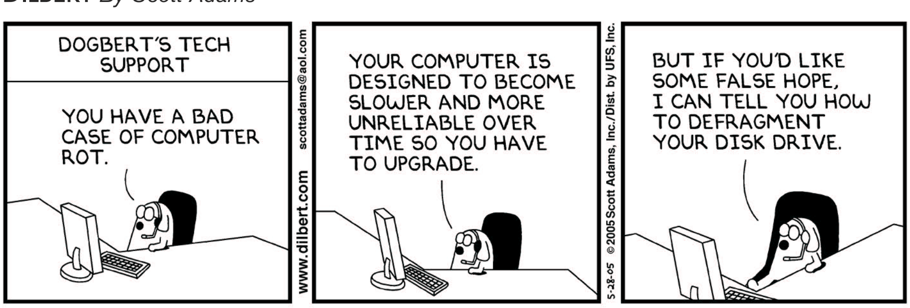
—by Dan Strassberg

▷**Agilent Technologies**, www.agilent.com.



Scopes in the 80000B series allow you to buy only the bandwidth you need now and upgrade later. The Infiniiscan feature automates and greatly simplifies finding anomalous waveforms in records that can be as long as 64M samples.

DILBERT *By Scott Adams*



GPIB card simplifies configuration

The new PXI-3488 from Adlink Technology provides the interface between GPIB instruments and PXI (PCI Extensions for Instrumentation)-equipped test-and-measurement systems, and it simplifies the required hardware/software configuration. The module's 1-kbyte onboard FIFO and high-speed bus, which the onboard CPLD accelerates, give the interface a 1.5-Mbyte/sec maximum data-transfer rate to satisfy high-volume data-transfer requirements.

The board supports Windows 98/NT/2000/XP, and its driver library is compatible with industry-standard VISA (Virtual Instrument Software Architecture) and instrumentation protocols.

The PXI-3488 interface-controller card offers test-and-measurement-equipment designers a high-speed option for PXI modular-instrumentation systems.

The PXI-3488 card complies with IEEE 488.1 and 488.2 standards and supports popular application-development environments, such as VB, VC++, Delphi, LabView, and TestExec. The PXI-3488 sells for $345 (volume discounts available).

—by Warren Webb

▶**Adlink Technology**, www. adlinktech.com.

Instruments characterize single-lane and multilane, multigigabit/sec bus components

A new jitter-tolerance-compliance-test suite for Agilent's N4903A high-performance, 7- and 12.5-Gbps serial BERTs (bit-error-ratio testers) provides quick and accurate testing with an extensive library of standard and custom curves, adjustable margins, automated parameter sweeps, and a graphical pass/fail-result display and print/save function for easy documentation of test results. Built-in, calibrated, automated, and compliant jitter-tolerance testing uses sources of periodic and random jitter, bounded uncorrelated jitter, and both intersymbol and sinusoidal interference.

All N4903As provide immediate eye analysis with one-screen eye diagrams, eye-contour lines, and eye-mask and pulse-parameter measurements. This feature eliminates the need to use an oscilloscope to check for a valid signal before testing. A new pattern-capture capability simplifies analysis of complex devices. The N4903A platform's upgradability protects your investment. Prices for the 7- and 12.5-Gbps versions start at $120,000 and $160,000, respectively. The new N4903A-J12 jitter-tolerance-compliance-test software suite costs $9975. A newly revised version of the vendor's Quick eye- and pattern-capture software is free to owners of N4903A systems.

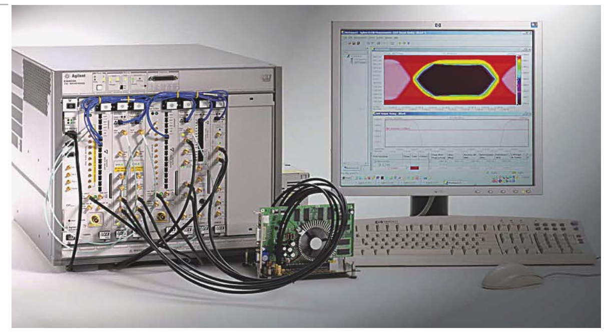
Both development- and compliance-test engineers will benefit from using the new Agilent N5991A PCI Express receiver-compliance-test and characterization software's features. One-button compliance-test capability greatly simplifies the test procedure. Compliance sweeps using the correct stimulus signal and carrying the proper amounts of calibrated stress minimize measurement time. Both printed and electronic versions of compliance-test data ensure easy and accurate documentation of results. And precise characterization of the physical-signal performance allows margin analysis for further improvement in device-specific technology and manufacturing processes.

The Agilent PCI Express receiver-compliance-test suite runs on standard PCs and requires the new Agilent N5990A transmitter-and-receiver test-automation-software platform for the 81250 ParBERT (parallel BERT). The platform provides a flexible test sequencer; a configurable database interface; a Web interface; and interfaces for the full integration of sources of periodic jitter, random jitter, and bounded, uncorrelated jitter-stress generation. These items enable you to conduct compliant and calibrated jitter-tolerance measurements.

You can further combine the 81250 ParBERT with the N5990A test-automation software platform, the N5991A PCI Express compliance-test software, and the N5393A PCI Express electrical-performance validation-and-compliance software for the Agilent Infiniium series of oscilloscopes to form a complete PCI Express compliance-test station. The price for the 7-Gbps version of the multilane 81250 starts at $250,000. The N5990A test-software platform costs $49,975, and the N5991A PCIe-compliance software costs $15,997.

—by Dan Strassberg

▷**Agilent Technologies**, www.agilent.com.



The 81250 series parallel bit-error-ratio tester is an accurate, automated tool for PCI Express-receiver tolerance-compliance testing and characterization.

AdvancedMC module boasts 2-GHz processor

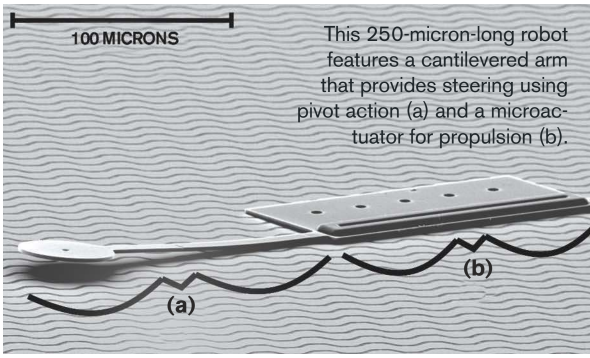
Concurrent Technologies recently announced a new, lead-free AdvancedMC (Advanced Mezzanine Card) processor module targeting wireless-base-station, security, test-and-measurement-system, voice-over-Internet Protocol, and server applications. The single-width, full-height PR AMC/33x module suits AdvancedTCA, MicroTCA, and proprietary platforms. It features the 2-GHz Intel Pentium M processor 760 and the E7520-server chip set. The E7520 interfaces as much as 2 Gbytes of soldered DDR2-400 ECC memory, providing a peak memory bandwidth of 3.2 Gbytes/sec.

The PR AMC/33x provides full hot swap, IPMI (Intelligent Platform Management Interface), PCI Express, Gigabit Ethernet, and serial ATA150 ports. The module also features two USB 2.0 ports, two RS-232 ports, and 1 Mbyte of application flash. The module supports Linux, Windows 2000, Windows Server 2003, Windows XP, Windows XP Embedded, QNX, and VxWorks operating systems. Prices for the PR AMC/33x start at $1735 (OEM volumes).**—by Warren Webb**

▶**Concurrent Technologies**, www.gocct.com.

Concurrent Technologies' single-width, full-height AdvancedMC processor module incorporates Intel's 2-GHz Pentium M processor.

03.02.06



This 250-micron-long robot features a cantilevered arm that provides steering using pivot action (a) and a microactuator for propulsion (b).

RESEARCH UPDATE

BY MATTHEW MILLER

Microrobot crawls under remote control

Engineers and computer scientists at Dartmouth College (Hanover, NH) have developed what they claim is the world's smallest steerable, untethered robot. The machine, which measures approximately 250×60×10 microns, integrates a wireless power and control-signal receiver, two actuators, and on-board state memory. Moving forward with an inchwormlike gait, the robot turns by pressing down its cantilevered steering arm and then pivoting around it. The average step measures just 12 nm, but the robot takes more than 10,000 steps per second and can cover more than a foot of distance in about 30 minutes, the team reports. (Go to www.edn.com/060302ru for a link to a site that offers video clips of the robot in action.)

For now, the robot operates only on a special surface: an electrode array that generates the power and control signals. However, the researchers foresee versions that could operate on a variety of surfaces. Potential uses include exploring hazardous environments, manipulating tissues in biotech applications, and repairing ICs, according to the researchers. For more information, go to http://engineering.dartmouth.edu/~microeng/robot05.html.

▷**Dartmouth College**, www.dartmouth.edu.

LED there be white

Researchers at Vanderbilt University have discovered a formula for a quantum-dot coating that transforms the light emitted by a blue LED into a broad-spectrum white light with a slightly yellow cast—similar to that of incandescent bulbs. The dots, which are crystals of cadmium and selenium that contain either 33 or 34 pairs of atoms, spontaneously emit the white light. This approach stands in contrast to other techniques, such as one developed at Sandia National Laboratories (www.sandia.gov), which involve doping quantum dots with additional compounds that interact with the crystals to produce white light. In addition, the Vanderbilt team says that its process takes about an hour to produce a batch of the dots, as opposed to as much as a month for the other processes.

The discovery of the "magic" formula happened by accident, according to the group. A researcher asked a colleague to make a batch of small quantum dots because he wanted to study the way they grow, but he got a surprise when laser illumination resulted in the warm, white glow.

▷**Vanderbilt University**, www.vanderbilt.edu.

03.02.06

Doppler effect enables portable vein finder

Despite all the expensive technology at their disposal, doctors find that treatment often grinds to a halt due to difficulty inserting an intravenous line—a task that can be especially tricky when the patient is dehydrated, obese, or a young child. Researchers at the Georgia Institute of Technology (Atlanta) are developing a portable device that will help medical personnel quickly and accurately locate veins, eliminating repeated needle sticks and speeding the delivery of needed medicines.

As a medic moves the device along a patient's arm or leg, a transducer emits a pencil-lead-thin ultrasound beam, which a reflector directs into the skin. Signal-processing circuits then use the Doppler effect to distinguish arteries from veins based on the direction of blood flow. The device emits an alert when it locates a vein, and a needle guide ensures accurate insertion. Supported by a medical-device manufacturer, the rsearchers are concentrating on delivering a low-cost design and expect that miniaturization will eventually lead to a unit the size of a large fountain pen. For more information, go to http://gtresearchnews.gatech.edu/newsrelease/vein-finder.htm

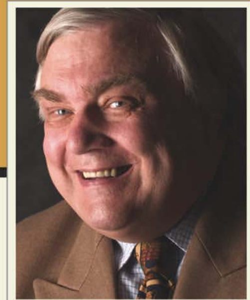
▶**Georgia Institute of Technology**, www.gatech.edu.

A Georgia Tech researcher displays a prototype of a scanner that uses ultrasound to help medical personnel locate veins.

RAQ's

Rarely Asked Questions

Strange but true stories from the call logs of Analog Devices



Contributing Writer James Bryant has been a European Applications Manager with Analog Devices since 1982. He holds a degree in Physics and Philosophy from the University of Leeds. He is also C.Eng., Eur.Eng., MIEE, and an FBIS. In addition to his passion for engineering, James is a radio ham and holds the call sign G4CLF.

Ground Noise and Groundhogs — Folklore for EEs

Q. *Happy Groundhog Day! Why do I have an output when my analog input is grounded?*

A. The most common reason is ground noise*. A superstition among EEs says that "ground" is the place where good signals go when they die — a sort of zero-impedance, zero-potential panacea wherever you find the triangle ⏚ or the dangling worms ⏚. A real-life ground has finite impedance, so a current flowing between two "ground" points will cause a potential difference (PD) between them. This PD often causes errors in precision (and even non-precision) circuitry. The current may be the return from the circuit's input or output connections, or it may be a current from some nearby system that just happens to flow through the circuit's ground conductor.

The three main strategies for minimizing the effects of ground noise are 1) minimize ground impedance, 2) isolate the grounds of sensitive circuitry from large or noisy currents, and 3) use differential signal transmission to isolate signals from ground noise.

1) It seems that some designers assume room-temperature superconductors have already been invented — and that copper is one of them. Some PCB designs have ground traces only a few mils wide, and the resulting voltage drops are humongous. Ground impedance is minimized by using the widest possible PC traces for ground and, preferably, having a whole uninterrupted layer of copper, known as a ground plane.

2) It is also valuable to have separate grounds for sensitive circuitry and for circuits drawing high currents. These separated circuits will need to communicate, so there is usually a single point, known as a "star point" and located near the power supplies, where these two grounds are joined to give a common reference potential. Most mixed-signal systems have analog and digital grounds separated in this way; when this is done the AGND and DGND pins of all ADCs and DACs should be grounded to the analog system ground.

3) If signals are transmitted differentially on two ungrounded "signal" and "return" wires, then ground noise is much less likely to affect their integrity, although common-mode noise may still cause some ill-effects.

It is not widely known that ground noise is what awakens Punxsutawney Phil on Groundhog Day. Ice is a better insulator than liquid water and when the ice around Phil's hole starts to melt, ground currents start to flow, ringing a little bell to alert him.

* Device noise or offset is also quite a common cause.

To learn more about ground noise, Go to: http://rbi.ims.ca/4915-501

GLOBAL DESIGNER

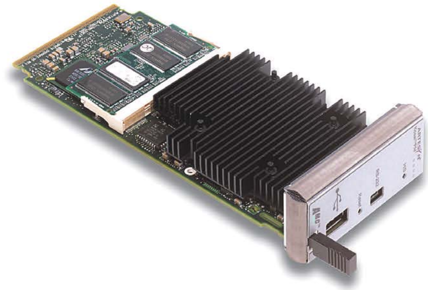
Handset-technology advances dominate Barcelona confab

The mobile handset continues to drive the global high-tech industry, and the adoption and enabling of new features, such as multimedia, typically happen first outside North America. The industry gathered Feb 13 through 16 at the 3GSM World Congress (www.3gsmworldcongress.com) in Barcelona, Spain, where the latest handset features debuted. The theme of the handset as an extensible computing platform was front and center. Companies are layering on features ranging from GPS (global positioning system), to video, to additional wireless-communication schemes.

STMicroelectronics (www.st.com), for instance, made announcements in multimedia, ancillary wireless, and components. The company launched the STw5095 stereo codec with integrated amplifiers; it targets battery-powered portable products, including handsets and media players. STM touts 20-bit resolution and 93-dB dynamic range for quality, but its 23-mW power consumption during playback and 1 μW during standby suit it for the intended application.

STM also announced a pair of digital encoders, the STw8009 and STw8019, that enable video output in portable devices ranging from handsets to media players and digital cameras. The company claims that the design optimizes cost and pc-board real estate by partitioning image-processing functions to the host processor and performing encoding and data-conversion functions on-chip. The company also announced at 3GSM that its STLC4370 802.11 chip for handsets is in production, and several manufacturers are now shipping handsets that incorporate the technology. Adding 802.11 to a cellular handset allows enhanced corporate-e-mail capabilities and, eventually, seamless roaming between cellular and local networks.

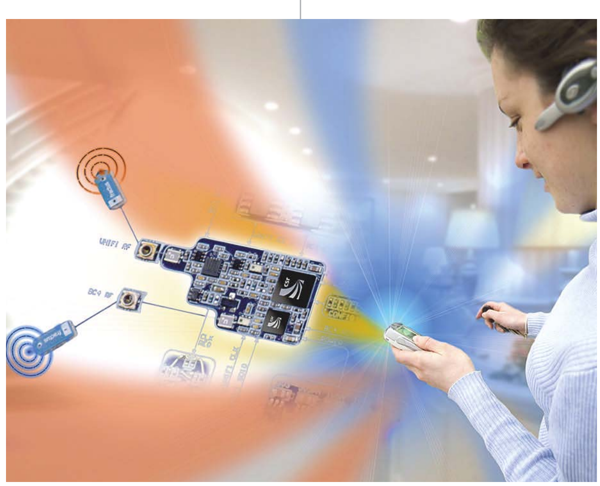
Cambridge Silicon Radio (www.csr.com) and PortalPlayer (www.portalplayer.com), meanwhile, partnered at the show to demonstrate support for both 802.11 and Bluetooth in portable devices. The demo relied on PortalPlayer's PP5022 application processor and CSR's UniFi Wi-Fi chip and BlueCore Bluetooth chip. The demo illustrated the broadening of 3GSM to focus on other portable products, such as media players, although the wireless-enhanced design could masquerade as a mobile phone, as well.



Targeting 3G and WiMax base stations, Artesyn's KosaiPM Pentium-based module powers the company's microTCA communication platform.

CSR also partnered with Fractus (www.fractus.com), which specializes in fractal-antenna technology, to demonstrate simultaneous Bluetooth and Wi-Fi operations on a prototype combo card. The card, which is tiny enough for deployment as a handset, can support a VOIP (voice over Internet Protocol) call over Wi-Fi while a normal call uses the Bluetooth radio.

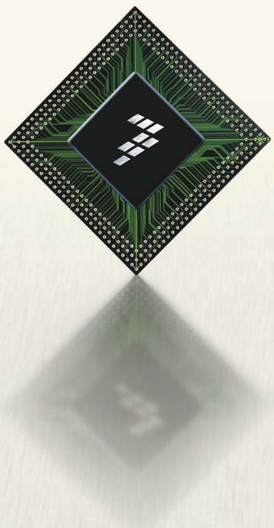
The 3GSM crowd also continued the migration toward faster, more capable cellular technologies. On the GSM side of cellular, the next step is a move from EDGE to W-CDMA (wideband CDMA) that's already under way in parts of Europe. Analog Devices (www.analog.com) showed its first W-CDMA/EDGE (enhanced-data-for-GSM-evolution) chip set at the exhibition. The company based its SoftFone-W chip set on the Blackfin embedded-processor technology. The software-centric design is adaptable; Analog Devices recently used the same building blocks to deliver a TD-SCDMA (time-division synchronous-CDMA) design for the Chinese market.



Wi-Fi/Bluetooth cards from CSR employ Fractus antennas.

Design wins and partnerships are always hot themes at 3GSM, and this year was no exception. For instance, Ceva (www.ceva-dsp.com), a licensee of DSP, GPS, and multimedia cores, announced handset wins in Korea, China, and France. EoNex (www.eonex.com), a Korean CDMA-chip supplier, will use the Ceva-TeakLits DSP core in a CDMA-2000 design. Spreadtrum Communication (www.spreadtrum.com), a Chinese baseband-chip supplier, will use Ceva technology in a TD-SCDMA design, and VMTS (www.vmts.com), a French company, will also use the Ceva DSP core.

In addition, SIRF Technology (www.sirf.com) announced the GSCi-5000 combo GPS and Bluetooth product. Artesyn (www.artesyn.com) demonstrated its new microTCA platform for 3G and WiMax base stations, and Aeroflex (www.aeroflex.com) announced a software-trace capability for wireless-network testing using its SystemAT testers. The company claims that it can slash the diagnostic time for operators rolling out new software or performing field trials.**—by Maury Wright**



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BY HOWARD JOHNSON, PhD

Terminator

My friend Lloyd builds timing analyzers for high-energy physics experiments. In these experiments, an array comprising hundreds of detectors senses the times of arrival for the spray of particles emanating from a cascading sequence of atomic interactions.

Each detector connects through a length-matched coaxial cable to Lloyd's analyzer. The analyzer records the times-of-arrival data and triangulates the location of each atomic event. When calibrated, the accuracy of the system is truly awe-inspiring.

The detectors are mounted in a high-radiation zone 3 ft from the analyzer. At that distance, the RG-58A/U 50Ω coaxial cable may slightly degrade the 400-psec rise time of the detector outputs. However, that situation does not matter as long as the cable affects each detector the same way and as long as the step response of the cable itself adds no significant jitter. (It doesn't.)

The reflections that may occur between the detector outputs and the analyzer inputs *do* matter.

The reflections that may occur between the detector outputs and the analyzer inputs *do* matter. If any late reflections occur, the reflected signals may perturb the rising edges from subsequent events, shifting their apparent times of arrival. You cannot postprocess out of the system the jitter that this mechanism induces.

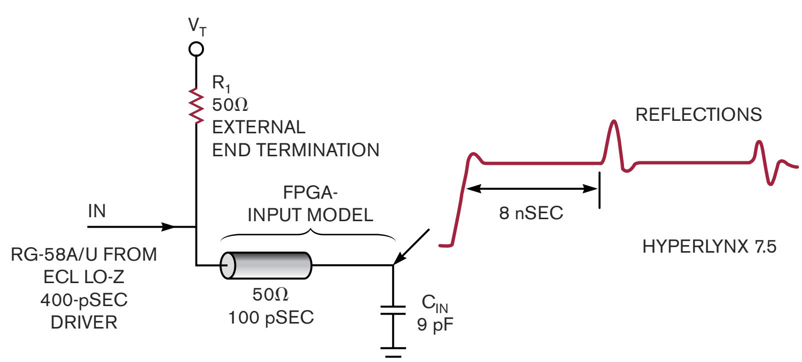

Figure 1 The FPGA-input capacitance creates massive reflections.

If you can limit the magnitude of the reflections to, say, *X*% of the signal swing, then the worst-case time-domain jitter that those errant reflected blips induce will amount to only *X*% of the signal rise time.

At this point, you are probably thinking about termination at both ends. That scenario is an excellent way to mitigate reflection. However, just for fun, imagine that a government contractor built the detectors and that they provide low-impedance ECL outputs. You cannot change them. Consequently, the analyzer must provide near-perfect end terminations.

Next, stipulate that, for cost reasons, you must use an off-the-shelf FPGA to receive the detected signals. The FPGA incorporates switchable internal resistors, but they are insufficiently accurate for this application. Your contract mandates external terminating resistors, 50Ω±1%, for each signal.

Unfortunately, even with a perfect external termination, the 9-pF capacitance of the FPGA input creates massive reflections (**Figure 1**). The reflections return every 8 nsec, commensurate with the round-trip delay of the coaxial cables. The person who wrote the system specification failed to consider that fact.

In any system in which the time constant, $\frac{1}{2}Z_0C_{IN}$, approaches the rise time of your source, you can expect these types of big reflections.

Given these specifications, can Lloyd's system possibly work? Stay tuned for my next column, when we will work on the answer together. EDN

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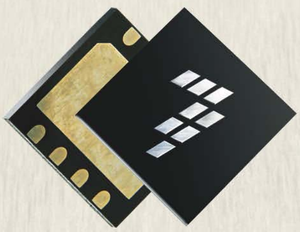
Go to www.edn.com/060302hj and click on Feedback Loop to post a comment on this column.

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.



BY ROBERT CRAVOTTA • TECHNICAL EDITOR

Version inquiry

DANIEL VASCONCELLOS

I was supporting the system-build and -integration effort, in the field, of an R&D flight system. The system was an iterative evolution of a quick and dirty proof-of-concept vehicle that the team had demonstrated several months previously. Most of the boards, harnesses, and assemblies were handcrafted one- or two-offs (prototype quantities). The use of so many custom boards complicated the system-integration effort because anomalous behaviors encountered during the integration effort could reasonably be the result of flaws in the hardware or software design, build errors introduced during the hardware fabrication, or flaws in the test-setup configuration. In any case, it was critical for us to explicitly determine the cause of each anomalous behavior because the prototype system would be able to support only a single shot at the final test run.

To support parallel development of the software with the hardware build, we built a few of each of the electronics-control boards. At a minimum, we were developing the system on partially built systems—one in the lab and one in the field. Although this approach allowed us to perform more of the development effort in parallel, it increased the complexity of managing the configurations as we discovered and corrected flaws in the design or building of the system. In general, practicing version control of the boards and components minimized out-of-sync problems.

On one occasion, though, the version-control effort for the multiple development systems failed and cost the development team considerable time to troubleshoot. The design team predominantly comprised hardware designers, and the team considered replacing a physical PROM chip on the controller board as sufficient to manage the version of the software loaded in the system. The flight-control software had no user interface; it could control the flight vehicle and talk to the ground-control system through a serial link. Because the PROM sported a handwritten label that identified the software version loaded in it, the design team had not felt it necessary for the system software to include the ability to tell the ground-system controller what version of the software was loaded and executing on the flight system.

In this situation, the field system was exhibiting an intermittent anomalous behavior. The successful operation of the system in the lab suggested that we had a problem in the test-setup configuration. After many failed attempts to discover the problem in the test configuration, the design team tried to convince the team in the lab that the problem was not the test configuration. At some point in the troubleshooting effort, I asked whether the software loaded in the PROM could be an earlier version than that loaded in the lab. The label on the PROM indicated otherwise, but the intermittent-failure behavior suggested that we had a previous version of the software loaded. After we shipped the field board to the lab, we were able to duplicate the problem in the lab setup. It turned out that we had loaded the PROM with an earlier version of the software but had incorrectly labeled it.

At this point, we added a query function to the flight-system software so that the ground system could confirm what version of the software was loaded. One thing that contributed to the prolonged effort to correct this problem was that none of the system people who worked on the first iteration of the system were present in the field during the building of the second system. The system people on the second system were new to the project. The people with the experience to recognize the earlier version of the software were too far removed from the integration effort to recognize that a version mis-synchronization had occurred. This situation exacerbated an otherwise-simple-to-solve problem because of a break in the field-integration team's experience with the system. **EDN**

Microsoft

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The developers at Fujitsu know that the hundreds of peripheral drivers included in the Windows® CE operating system provide the solutions they need to easily integrate multiple device functions.

Needing to incorporate drivers for an infrared receiver, 802.11g WiFi card, and touch screen, the Fujitsu U-Scan Shopper development team chose Windows CE. Because Windows CE offers familiar, yet easily customized components and tools, they were able to develop the device in only five months. With the power of Windows CE, the Fujitsu U-Scan Shopper offers users coupons on demand, infrared scanners for product promotions, and in-store order placement, all from the convenience of the produce section, or wherever your shopping cart takes you.

We considered Linux, but couldn't have achieved the same results, so we chose the Windows CE operating system."

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Windows Embedded

BY MACWIEN KRISHNAMURTHI AND AHMAD KAMAL SHAMSURI • MOTOROLA

RF-interference-design considerations for portable-device batteries

TODAY'S USE OF EVER SMALLER YET MORE COMPLEX BATTERIES IN MOBILE-COMMUNICATIONS APPLICATIONS REQUIRES DESIGNERS TO USE ADVANCED DESIGN TECHNIQUES TO PROTECT BATTERIES FROM RFI. USERS MUST CONSIDER A NUMBER OF PHENOMENA AND DESIGN ISSUES TO ENSURE THAT THEIR DESIGNS CONFORM TO BOTH RF AND BATTERY-MANAGEMENT-SYSTEM PARAMETERS.

Designers face increasing challenges from RFI (radio-frequency interference) when integrating batteries and protection circuitry into systems. At a basic level, a battery pack is an energy-storage device comprising cells and support-circuit assemblies that maximize a host device's performance. Batteries serve as power sources for portable electronics, such as mobile phones, two-way radios, PDAs (personal digital assistants), MP3 players, notebook computers, and wireless scanners. Currently, many portable electronics use Li-ion (lithium-ion)-cell technology (**Figure 1**). Li-ion battery packs generally have complex protection circuitry, especially if an application requires multiple cells. Typical two-way-radio Li-ion battery packs use two cells in series, and their protection circuitry is more complex than that for a typical single-cell Li-ion battery pack in a mobile phone, for example (**Figure 2**). Applications requiring many cells in a series, such as those in notebook computers, are even more complex (**Figure 3**).

Li-ion battery packs need protection circuitry to curb them from overcharging, thereby exceeding their volatility-voltage and -current curves. The circuitry also limits the cells from excessive discharge beyond the undervoltage limit of the cell, which could damage the cell. In addition to the protection circuitry, Li-ion battery packs may also require other circuitry, such as a voltage- or charge-based fuel gauge and electronics, for regulatory-agency approval.

With the growing need for smaller and lighter mobile-communication devices, battery packs usually reside close to their hosts and play major roles in the overall communication systems' size and weight. As a result, compliance with the many RF and battery-management-system parameters becomes increasingly challenging at the system level.

Two-way-radio battery packs normally have two cells in series. Depending on the radio tier, the battery circuit may comprise protection ICs for voltage monitoring and control, voltage- or coulomb-based fuel-gauge circuitry, charge- and discharge-termination circuitry, and circuitry for agency approvals. In a typical notebook battery pack, the circuit can monitor voltage and control multiple cell configurations, charge and discharge terminations, and coulomb-fuel-gauge-based circuitry. Although host applications that require multiple cells may be more susceptible to RFI-design issues due to the volume of electronic circuitry they use, even single-cell-system applications require battery designers to be conscious of the potential for RFI in their designs.

RFI is any undesirable RF signal that interferes with the integrity of electronics and electrical systems. Any electronic system with an interference-signal source and a transmission medium for that source can suffer performance degradation due to RFI. Transmitters, such as mobile phones, two-way radios, commercial radio transmitters, system providers, and other devices, can generate RFI. Conducted transmission of RFI signals occurs through wires, circuit components, and pc boards, for example, and radiated RFI generally implies transmission through space.

RFI ISSUES IN PORTABLE WIRELESS SYSTEMS

Designers must consider a number of RFI-related issues, including SAR (specific absorption rate), BER (bit-error rate), SINAD (signal-noise-and-distortion) degradation, radiated transmitter power, transmitter instability, system reset and shut-

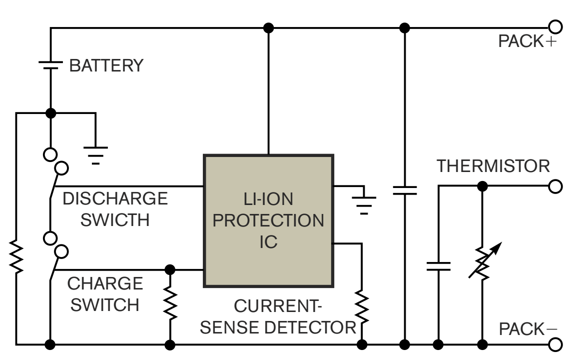

Figure 1 A typical mobile-phone-battery-pack circuit uses one lithium-ion cell.

down, transmitter-frequency pull, receiver hum and noise, transmitter conducted and radiated spurious emissions, RF desensitivity, and discomfort.

SAR quantifies how much RF energy the tissue of a mobile-phone user absorbs. Currently, many mobile-phone designs, including most clamshell designs, use an internal antenna for transmission and reception of RF signals instead of an external antenna due to challenges in miniaturization and the product's industrial design. Designers can use the battery pack as a module to control and manipulate some of the phone's RF-radiated parameters. In the case of minimizing the SAR, a designer could optimize the transmitted-radiated-power level and redistribute and lower the intensity of the localized electromagnetic field. It can be challenging to maximize the transmitted-radiated power while minimizing the SAR performance of mobile phones. Some manufacturers develop their mobile-phone systems to comply with the SAR performance of 1.6 mW/g, which is the FCC (Federal Communications Commission)-compliance limit (**Reference 1**).

BER is a measure of the phone receiver's sensitivity. Typical radiated receiver sensitivity of phones is approximately −102 dBm at the phone-antenna input, and BER does not exceed 2.44%, whereas higher performance phones have more stringent BER goals (**Reference 2**). The electronics in pc-board assemblies for batteries can demodulate the RF energy that the phone transmits and can generate noise that could corrupt the voltage supply and data traces to the phone. This conducted noise can then couple or feed into the phone's power-management system and eventually find its way into the phone's receiver system, thereby degrading the receiver-sensitivity performance. Positive-cell batteries use aluminum material, which contributes to the overall lighter weight of the battery pack, but it can be a medium to couple RF-radiated signals to the phone receiver, thereby bypassing the battery electronics. Metal distribution inside the battery pack is another concern that could lead to the degradation of the receiver's antenna efficiency.

Similar to BER, SINAD is a figure of merit of receiver sensitivity for analog-receiver designs. Designers must give the highest consideration to the mechanical assembly and construction of the battery and the layout of the pc board to keep radiated-RF energy from the charging system away from the electrical circuit of the battery, especially the supply lines. Noisy charger power supplies may desensitize the analog-receiver system and cause poor SINAD performance when the battery is charging.

Transmitter-radiated power is a measure of the radiated-RF power of a phone or two-way-radio device. Designers measure this factor to study the ability of a communications device to transmit radiated power through 360°. The total radiated power should typically be 33 dBm for the GSM (global-system-for-mobile-communication) band. PC-board layouts, along with the internal battery assemblies and metal compositions in the enclosure's plastics and labels, can contribute to the transmitter-radiated-power performances. Designers should use decoupling and isolation techniques between the host-transmitter system and the battery; otherwise, the communication device's antenna response could vary.

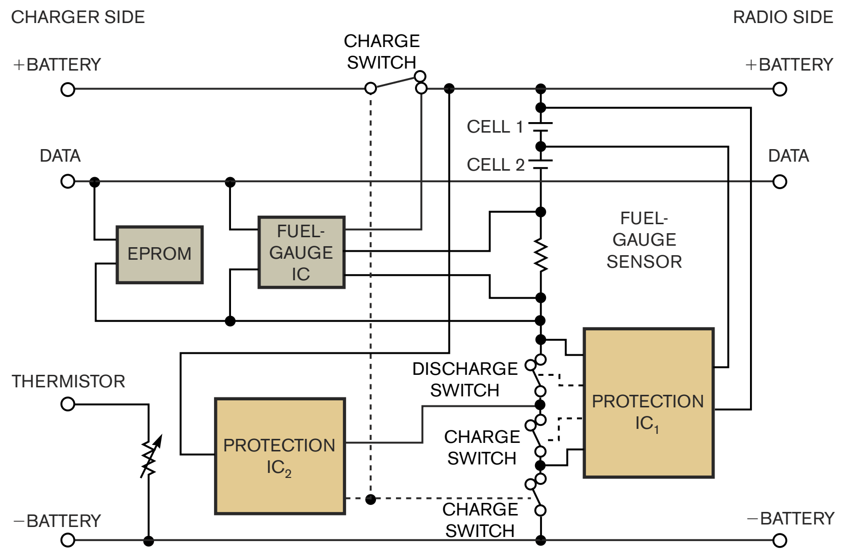

Figure 2 A typical two-way-radio battery-pack circuit uses two lithium-ion cells.

TRANSMITTER INSTABILITY

Transmitter instability is a measure of the spurious signals a transmitter generates. It can be in the form of spurious signals close to or tens or hundreds of megahertz away from the carrier. If the amplitude of these spurious signals is outside agency-reference-recommendation value, they could cause undue disturbances to other users by entering the receiver systems of other RF bands (**Reference 3**). The generation of spurious signals from a transmitter could be the result of imposed varying antenna loads, noisy voltage-supply lines to the stages of the transmitter, or noncontinuous battery-voltage supply to RF energy from the host. Parts of the battery assembly may receive and demodulate this energy, creating noise, and then conduct it through the supply lines to the host transmitter.

Designers need to plan for system resets and communication-device shutdowns early in the design process. System resets and shutdowns cause loss of functions and data flow to the host device, which could have an impact in a user emergency. Protection circuitry in Li-ion batteries are more prone to desensitivity due to their lack of immunity to RF energy. If you overlook battery-circuit RF immunity and susceptibility, protective ICs and passive support circuitry may operate at undesired voltage references, altering dynamic and hysteresis limits. This situation could lead to noncompliance of functional voltage- and current-protection parameters. Low-frequency noise, which gen-

erates from demodulation of imposed RF energy on the battery's internal electronics, may couple to the reset- and supply-voltage circuitry of the host's microprocessor. This situation leads to a system reset or improper host-control and -monitoring activities.

Transmitting-frequency pull is the instantaneous frequency drift from the nominal transmission frequency. In the absence of a modulating signal, the transmitting carrier in two-way radios should not deviate or drift from the frequency of interest. The interaction of dangling wrist chains near the host system, for example, is an external interference that could induce frequency pull. Typical transmitting-frequency pull could be tens of kilohertz. In battery packs, large copper fills in pc boards that do not properly correspond with the host reference points and that lack isolation from the host could lead to the formation of electromagnetic currents, which can also induce frequency pull.

Receiver-hum and -noise figures measure the receiver-quieting level in the presence of a strong carrier. (You can obtain the recommended hum and noise values from the agency-reference document.) For a portable battery, the charger circuit, which typically attaches to the battery during charging, can affect hum and noise. Thus, during charging, the battery must reliably prevent charger-switching noise from coupling into the host.

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CONDUCTED AND RADIATED EMISSIONS

Spurious emissions are critical RF-system-performance considerations. Poor spurious-emission performance can disturb nearby electronic devices. Designers must eliminate conducted or radiated spectral impurities. Conducted and radiated spurious emissions must meet certain regulatory requirements. The higher order harmonics of the carrier cause unwanted signals to couple into the battery assembly, such as the cell or the pc board. Transmitted harmonics should be within −36 dBm for frequencies lower than 1 GHz and −30 dBm for frequencies of 1 to 4 GHz (**Reference 4**). Thus, designers must properly bypass the spurious signals and carefully lay out the pc board to prevent undesired signal coupling. The close proximity of the battery to the RF circuit on mobile phones makes it even more difficult to prevent RF-signal coupling.

RF discomfort normally occurs when a high concentration of RF energy accumulates on metallic parts. RF discomfort causes a tingling, or "ant-bite," sensation that some users feel on their skin when in contact with the exposed metal parts and when the host device is in transmitting mode. This sensation may be challenging to reproduce in low-band to VHF two-way radios in which the transmitter power is normally higher than in other portable radio bandsplits. A typical portable battery uses metal parts for the battery-supply contacts and thus could possibly cause RF discomfort when a user touches the metallic parts. Designers must carefully place common-mode-current paths and the impedance to unwanted RF energy in battery and pc-board layouts.

The use and management of battery data are crucial in most portable communication devices. Designers must accurately characterize battery life and other smart features and ensure that the specs do not breach protection limits. Battery data can be

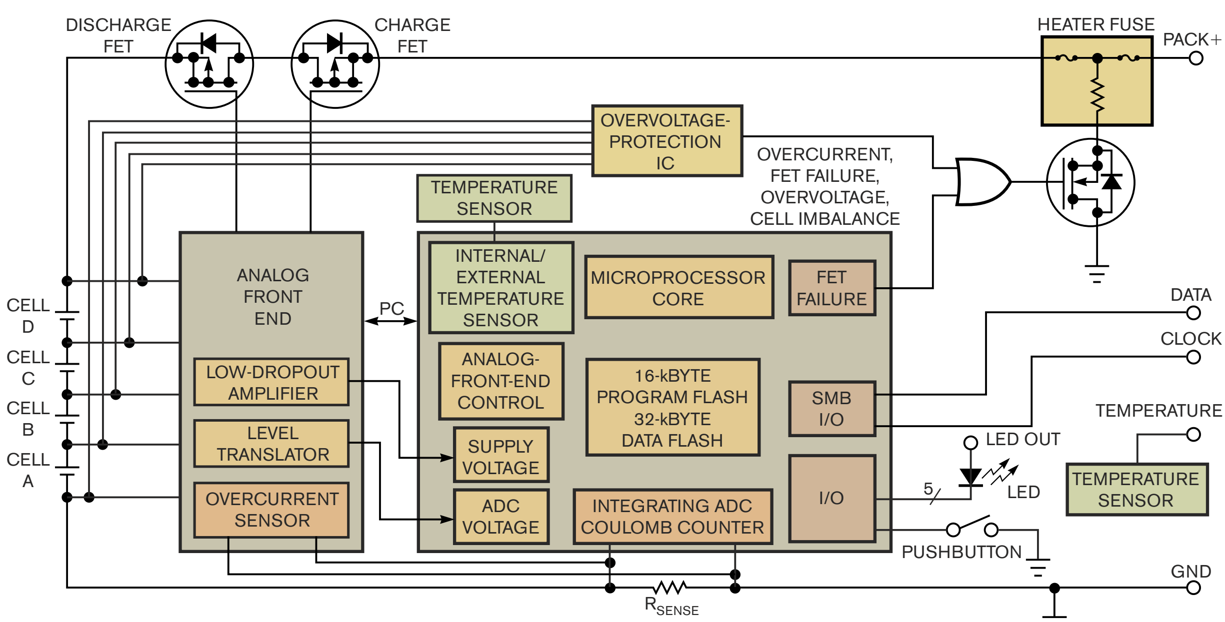

Figure 3 A typical notebook-computer battery-pack circuit uses multiple cells.

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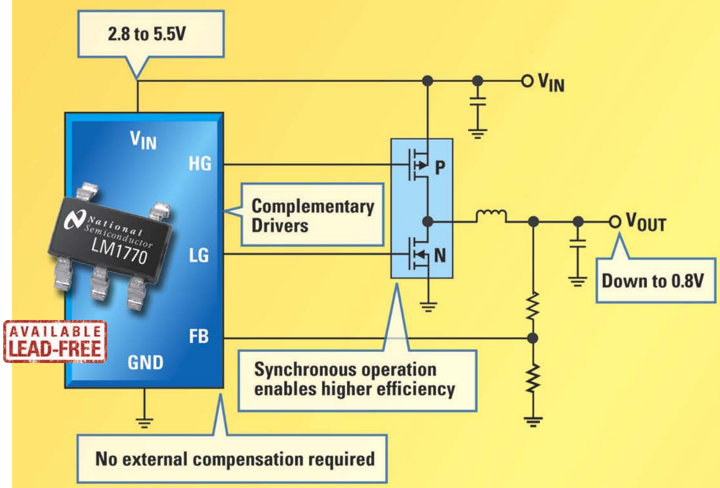
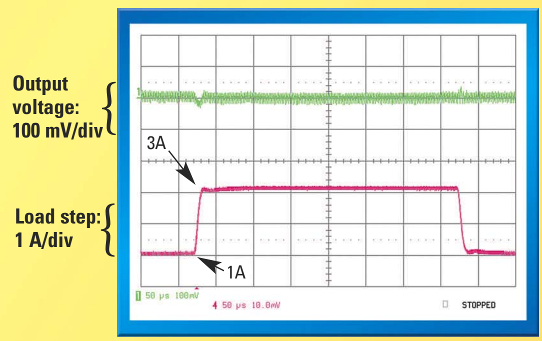
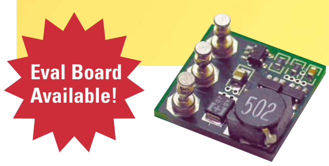
Application Circuit



Transient Response



V_{IN}= 5V, V_{OUT}= 3.3V



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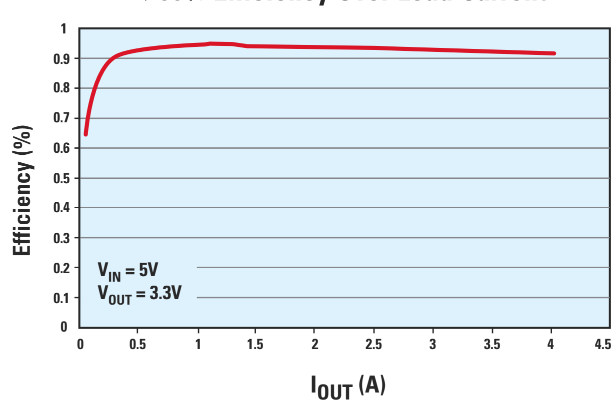

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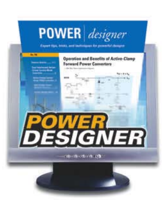

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static or dynamic, depending on the extent and complexity of the host's requirements. Static battery data, such as chemistry, charge terminations, voltage approximation, and gauge, are less prone to RFI, because these variables involve hard-coded information. However, loss of battery information may result from the battery EPROM's lack of immunity to RFI. Dynamic battery data relates to real-time fuel gauging, monitoring of charge and discharge cycles, monitoring usage of aftermarket chargers, more accurate battery-capacity estimation, and estimation of battery-pack usage. These variables are more prone to RFI and low-frequency-noise interference.

Batteries are integral parts of the overall host system, but designers integrating them into systems face increasingly challenging obstacles in developing approaches that minimize RFI. Maintaining differential-mode-current cancellation, curbing common-mode RF currents, decoupling functional circuitry, maintaining uniform ground references, and minimizing the host's RFI susceptibility are challenging goals that designers should focus on early in the design cycle. A poor layout could result in a waste of time and resources on "Band-Aid" fixes. Because little isolation lies between the host and the battery-pack assembly, mobile-communication batteries must include good RF-design techniques and guidelines to meet the host system's performance goals. Understanding the host's critical radiation blocks and reference points is crucial, so that designers can plan proper layout and bypass techniques to minimize or eliminate the effects of RFI. EDN

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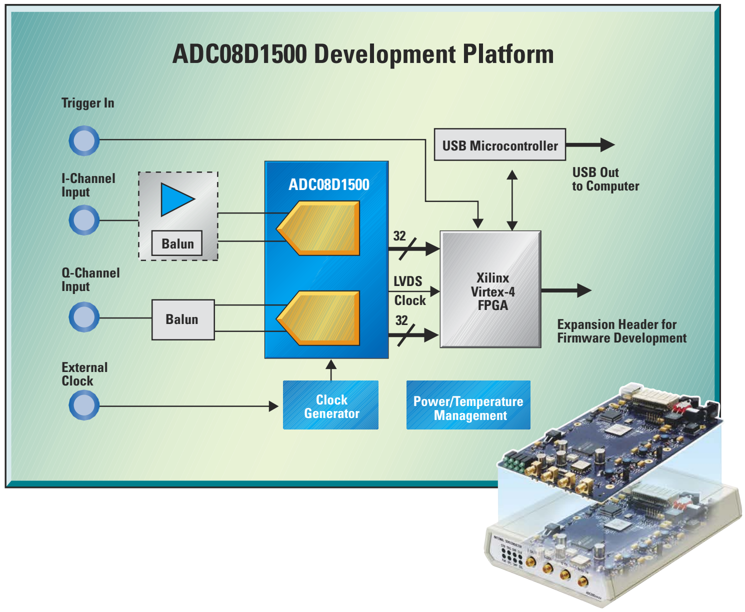

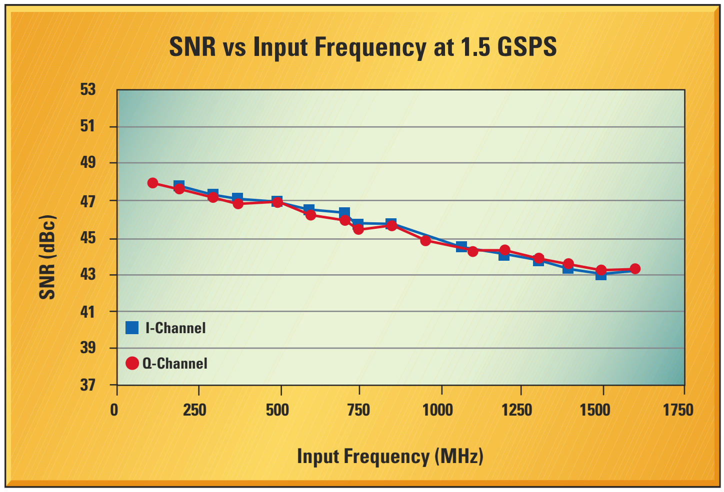

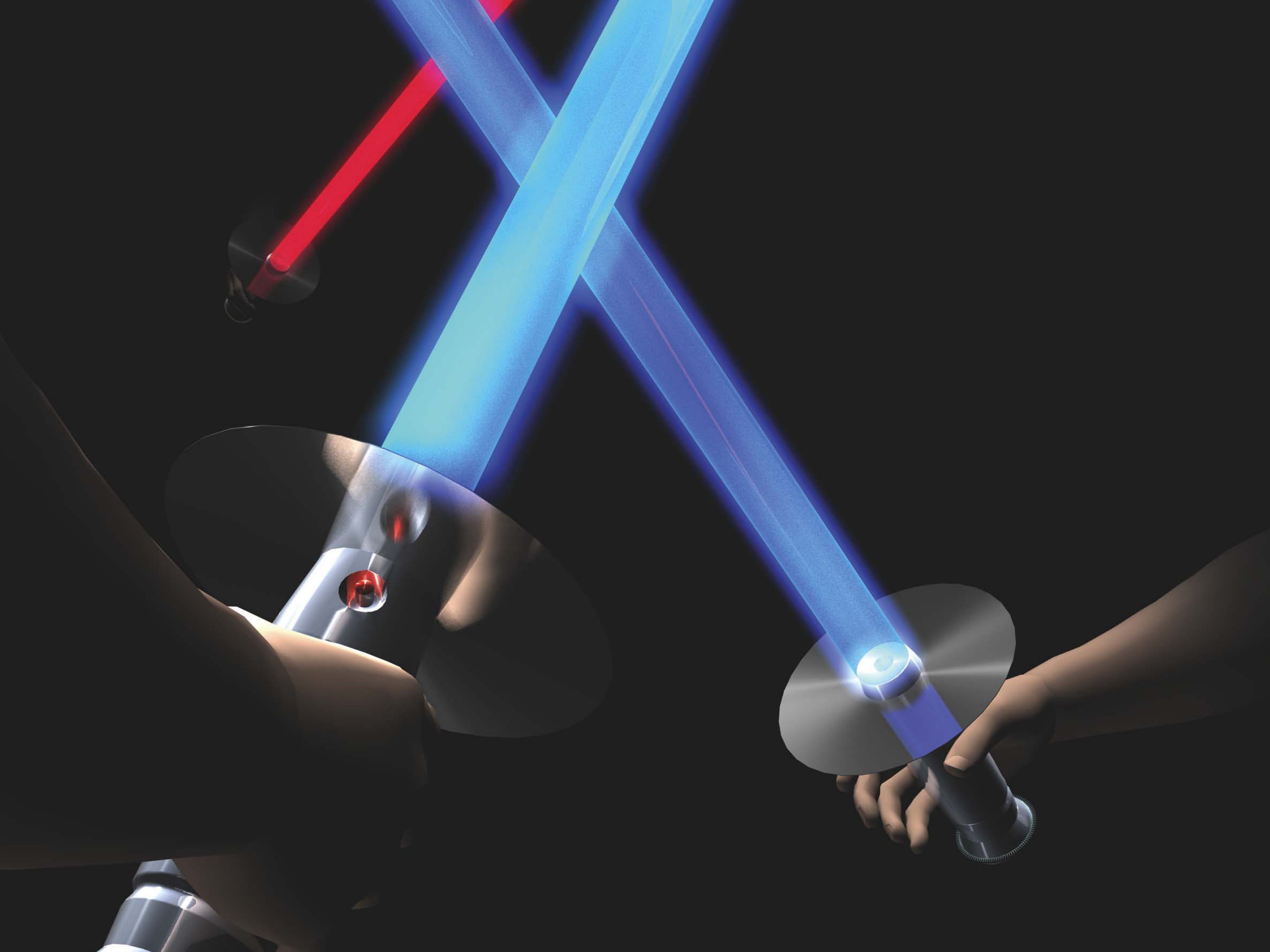

HIGH-RESOLUTION-DISC FORMATS FIGHT EACH OTHER, CONSUMERS PUSH BACK

SUBPAR WARS

BY BRIAN DIPERT • SENIOR TECHNICAL EDITOR

WITH BLUE-LASER COMPETITORS BLU-RAY AND HD DVD BOTH GEARING UP FOR HIGH-VOLUME PRODUCTION, A CLEAR PICTURE OF THE FORMAT WINNER HASN'T YET EMERGED. RED-LASER FORMATS REMAIN CREDIBLE ALTERNATIVES IN SOME APPLICATIONS, BUT BOTH USAGE-RIGHTS RESTRICTIONS AND DISPLAY-AND-VISION LIMITATIONS PUT *ALL* THEIR FUTURES IN DOUBT.

Notable progress and pending production plans of the vigorously competing Blu-ray Disc and HD DVD camps were, in many observers' eyes, *the* key story of January's CES (Consumer Electronics Show) and therefore warranted an update of a topic *EDN* covered less than a year ago (**references 1** and **2**). By mid-January, Toshiba and its partners were gearing up to begin shipping HD DVD PC drives, living-room players, and media in March, with the earliest planned Blu-ray drives and players at significantly higher prices following shortly thereafter. Meanwhile, although the Blu-ray-inclusive PlayStation 3 made no meaningful appearance at CES, a press event, rumored to be taking place just before this article's publication date, may clear up at least some of the lingering format questions (**Figure 1** and **Reference 3**).

Prerecorded video constitutes a dominant percentage of the total market opportunity for today's red-laser-based DVDs. Presumably, therefore, it will have a similar influence on next-generation blue-laser media; the Blu-ray and HD DVD camps' intensive courting of movie studios' mind share and endorsement reflects this supposition. Other applications, such as user-archived video, game consoles, and PC-file storage and backup, have a tangible role to play, too. They will help define which, if any, of the next-generation optical-disc formats will break out of the low-volume niches that perpetually plagued their underperforming audio predecessors, SACD (Super Audio Compact Disc) and DVD-Audio (**Reference 4**). But the format that wins in the home-movie-viewing room stands a solid chance of also winning elsewhere.

Unfortunately for next-generation-format promoters, this battleground pits Blu-ray and HD DVD not only against each other, but also against more modest, evolutionary, high-definition red-laser-DVD alternatives. And, most important, it pits them *all* against consumers' market-stalling potential none-of-the-above vote, if they don't discern a benefit from *any* of the contenders. The consumers' backlash, if it happens, doesn't necessarily mean that, by 2010, they'll all still be buying the same MPEG-2-based red-laser DVD movies they're watching now. After all, consumers' regular upgrades of their possessions ensure the continued viability of the tech industry. However, without another compelling reason for replacement, suppliers' only motivating weapon is cutting prices, a scenario that would be fiscally unpalatable to all stages of the optical-disc food chain.

THE PHANTOM MENACE?

The fundamental tenet of Blu-ray backers' arguments for their preferred format is the medium's higher per-layer capacity of 25 Gbytes, versus 15 Gbytes for HD DVD and 4.7 Gbytes for DVD. At January's Storage Visions conference, for example, Pioneer Electronics' Sandra Benedetto positioned Blu-ray's five-times-greater per-layer capacity over DVD as the logical next step in the optical-disc progression that began with the six-times-greater-capacity jump from CD to single-layer DVD. The futureproofing more-bits-is-better pitch is perhaps most relevant for users that are employing optical discs as backup media for their computer hard drives, thereby in part explaining Dell's strong support for the format. The capacities of modern hard-disk drives dwarf those of single-layer, 4.7-Gbyte DVDs or, for that matter, even the much more expensive, 9-Gbyte, dual-layer variants. Dell's Web site reveals that even the lowest priced desktop PC in the company's suite of product offerings contains a 40-Gbyte hard-disk

AT A GLANCE

- Blu-ray's fortunes hinge on capacity needs, studio enthusiasm, and the PlayStation 3.
- HD DVD needs to secure more extensive hardware support to sustain its momentum.
- Red-laser alternatives make blue laser's success uncertain.
- Consumer backlash and downloadable-media-delivery alternatives may doom all format options.

drive; multiple suppliers are now shipping 500-Gbyte, 3.5-in. hard disks, with even larger capacities soon to arrive, courtesy of perpendicular-magnetic-recording technology. However, hard-disk-drive backup to an external hard-disk drive or network-attached storage is in many scenarios a compelling alternative to optical-disc backup for cost, performance, and other reasons.

The more-bits-is-better pitch is also compelling when you're considering archiving HDTV material to optical storage. Over-the-air HDTV's 19.39-Mbps peak bit rate corresponds to roughly 17 Mbps of audio-plus-video information, which translates to approximately 8 Gbytes per hour of required storage capacity. Recently announced high-definition PVR (personal-video-recorder) chip sets from companies such as LSI Logic and Magnum Semiconductor store the incoming, unaltered Dolby Digital audio and MPEG-2 video bit streams on the system's hard-disk drive (**Reference 5**). However, to ensure that they can archive a consumer-acceptable amount of content to DVD—that is, more than a half hour's worth per layer—they must downscale the video to standard-definition resolution, and some of them also transcode the video to a more efficient format, such as an MPEG-4 variant. Blue-laser media would obviate the need for downscaling and transcoding; each layer of a Blu-ray disc, for example, could hold roughly three hours' worth of MPEG-2-formatted HDTV.

A NEW HOPE

How low an average bit rate can you losslessly compress a high-resolution video stream down to, and with what video codec, and still retain a high-quality result on red-laser-DVD media? I'll spend the next few months attempting to answer these questions with a suite of test clips; a plethora of software on Macs and PCs; an I-O Data player; and CRTs, LCDs, and plasma displays. Watch for the answers, both in the Brian's Brain blog (www.edn.com/briansbrain) and in future print write-ups.

PlayStation 3 promoters claim that a single dual-layer DVD's 9-Gbyte capacity is insufficient to house the ornate high-resolution games that modern consoles can render and that consumers expect. Microsoft disputes that contention, and a recently published independent analysis backs the company's stance (**Reference 6**). The Xbox 360 team points to mechanisms that extend the relevance of low-cost, "pressed," dual-layer DVD media (**Reference 7**). These mechanisms include a robust game-development environment, which ensures the elimination of textures and other content that designers create during development but don't use in the final title. Another mechanism, the use of advanced techniques for dynamic-content rendering, includes procedural synthesis, which more efficiently uses the available disc capacity. A third mechanism relies on Xbox Live online to deliver demos; bit-gobbling, cut-scene cinematics; and additional material that might otherwise need to reside on the disc.

Despite abundant rumors to the contrary, no shipped or announced Xbox 360 title so far requires more than one DVD-9 disc. Skeptics point out that, with less than six months' worth of titles from which to draw data, it's too early to come to a definitive conclusion. However, although second- and subsequent-generation titles will be more elaborate than their launch-targeted predecessors, the successors' less intense development cycles will combine with developers' increased experience on the console and its tool sets and lead to more efficient use of disc capacity.

Will blue-laser-based media be necessary for high-resolution prerecorded-movie content on pressed discs, and, if so, will Blu-ray's per-layer capacity edge over HD DVD be advantageous in this application? The answer to both questions is "it depends on the codec." Sony Pictures recently announced that it will master its Blu-ray titles using the more-than-10-year-old MPEG-2 video codec (**Reference 8**). This decision enables Sony to employ mature encoding tools and to avoid paying incremental royalties to companies holding patents on the more bit-efficient MPEG-4 AVC and VC-1 codecs that Blu-ray also supports. At least one more motivation probably exists: If you have the extra capacity and if you're trying to justify it, why not employ a video codec that best fills up that capacity?

Last fall, Warner Brothers Studios announced its nonexclusive backing of Blu-ray. A historically staunch DVD Forum and Toshiba ally, Warner Brothers insisted on the addition of a relaxed-pitch variant of Blu-ray in the standard as a condition of its endorsement. In effect, Warner Brothers successfully lobbied for the inclusion of low-cost, red-laser-compatible media in a Blu-ray form factor. This media would employ a more advanced video codec, such as VC-1, reflecting the company's long-standing relationship with Microsoft, to deliver a single-disc full version of a high-resolution title. Multiple industry insiders intimate, off the record, that Warner Brothers is currently devoting all of its development energy to HD DVD and backed Blu-ray only as a hedge. Another notable endorsement oddity is the fact that, although Apple is a member of the Blu-ray Disc Association, the currently shipping version of Apple's DVD Studio Pro media-development application supports HD DVD. Finally, Fox Studios successfully lobbied for Blu-ray to recognize additional DRM (digital-rights-management) mecha-

nisms beyond AACS (advanced access-content system) as a condition of its endorsement (**Reference 9**).

> **ALTHOUGH TOSHIBA CAN CARRY ITS CHAMPIONED FORMAT FORWARD TO A POINT, THE DVD FORUM NEEDS BROADER INDUSTRY BACKING TO LEAD HD DVD TO THE FINISH LINE.**

THE EMPIRE STRIKES BACK

Don't prematurely conclude that Blu-ray's on the ropes and HD DVD is the pending champion. Granted, Toshiba announced at CES that it would begin shipping its entry-level HD-A1 HD DVD player at $499 in March (**Figure 2**). The least expensive Blu-ray player, Samsung's BD-P1000, will enter the market in April at $1000, according to the company. Depending on which company's CES quote you prefer, Pioneer's BDP-HD1 will enter production in April, May, or June, with a target price of $1800. However, it is unclear whether Blu-ray drives' higher prices reflect increased bill-of-materials costs or an attempt to extract high profits from overenthusiastic early adopters of the technology. In December, Pioneer also announced that shipments of its first-generation PC-targeted BDR-101A drive would begin in the first quarter of this year. The full-sized unit supports only single-layer Blu-ray media and can't read or write CDs.

HD DVD's hardware presence at this year's CES was understated compared with that of Blu-ray. Although leading computer and consumer-electronics supplier Toshiba can carry its championed format forward to a point, the DVD Forum needs broader and deeper industry backing to lead HD DVD to the finish line. The organization has, however, picked up several key endorsements in recent months. Intel and Microsoft late last year both threw their substantial weight behind HD DVD, citing the format's support for MMC (Mandatory Managed Copy), a DRM mechanism that allows consumers to make legal copies of discs they purchase. Microsoft followed up its endorsement with the CES unveiling of an Xbox 360 HD DVD drive, likely in a slim notebook-PC-like form factor, that will enter production later this year. The company points out that it intends the drive only for movie playback, not for games.

Hewlett-Packard, formerly a staunch Blu-ray advocate, also backpedaled late last year and announced that it would bless both formats. The company's reversal of position occurred after the Blu-ray Disc Association indicated that, although it intended to eventually support MMC, HP's request for inclusion of the Microsoft-developed iHD (interactive-high-definition) layer was still under review. According to Blu-ray spokesman Andy Parsons, although the association is considering HP's request for interactivity, the group is still leaning toward the use of Java. "We are taking their request seriously but are not willing to delay the launch. I'm not saying we would not implement what they've requested, but it's not going to stop the format at this time," he told Reuters (**Reference 10**). Pragmatically, although Microsoft didn't indicate a preference for iHD when it backed HD DVD, the company's longtime anti-Java bias was probably also a factor in its decision. Dependence on Sun's Java runs counter both to Microsoft's ambitions for the PC-in-the-living-room Windows XP Media Center Edition and to partner Intel's VIIV efforts.

Although the press has paid much attention to Blu-ray's exclusive endorsement by movie studios Lions Gate, Sony Pictures, and Fox Studios, HD DVD also has an "exclusive" feather in its cap: Universal Studios. More generally, at CES, HD DVD-format backers claimed that

Figure 1 The PlayStation 3 may look like a game console, and it is, but it's also a key platform by which Blu-ray supporters plan to advance their media ambitions (a). Stand-alone players, for the moment at premium prices, will also play a key role in the format's prospects for success (b).

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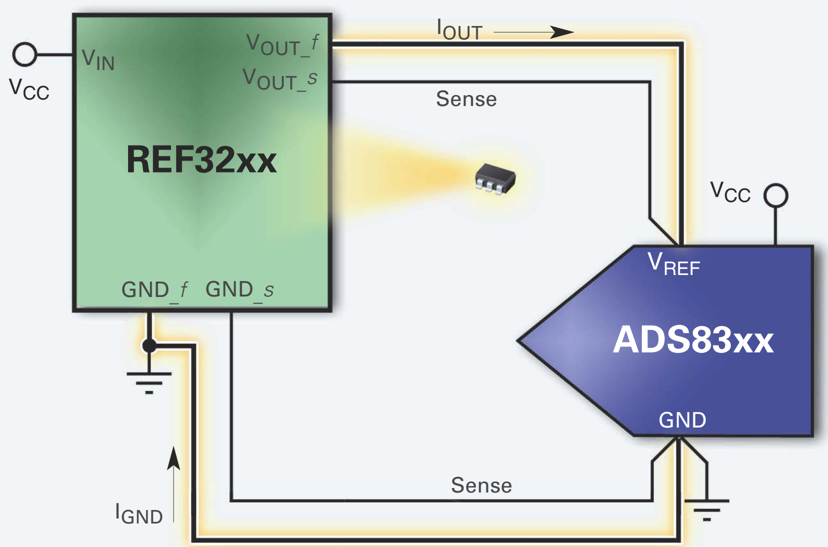

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REF1004x	1.235, 2.5	0.3	20	23	20	18	Shunt	0.01-20	SOIC-8	$1.30
REF29xx	1.25, 2.048, 2.5, 3, 3.3, 4.096	2	35	100	24	20 - 45	Bandgap	50	SOT23-3	$0.49
REF1112	1.25	0.2	10	30	60	25	Shunt	0.001-5	SOT23-3	$0.85
REF30xx	1.25, 2.048, 2.5, 3, 3.3, 4.096	0.2	20	50	24	14 - 45	Bandgap	50	SOT23-3	$0.60
REF31xx	1.25, 2.048, 2.5, 3, 3.3, 4.096	0.2	5	15	70	17 - 53	Bandgap	115	SOT23-3	$1.10
REF32xx	1.25, 2.048, 2.5, 3, 3.3, 4.096	0.2	4	7	55	17 - 53	Bandgap	1/135	SOT23-6	$1.70

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Figure 2 Toshiba and other HD DVD promoters plan to begin shipping players (a), full-sized computer drives (b), slim-sized computer drives (c), and drive-inclusive computers (d) near press time (a, c, and d: courtesy Toshiba; b courtesy NEC).

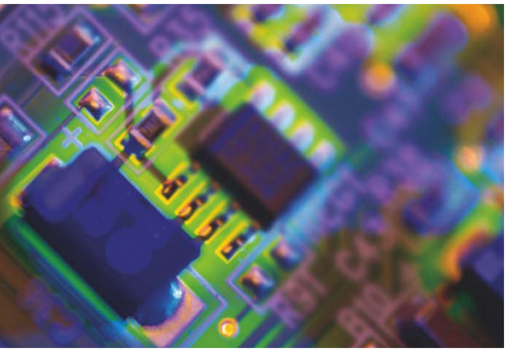
they would release nearly 200 titles by the year-end, with close to 50 of those available by May. The studios at the CES event represented more than half of the movies ever made. However, besides Warner Brothers, two other HD DVD advocates are also hedging their format bets. Last November, HD DVD-promoter NEC merged its PC-optical-disc-drive operations with Blu-ray developer Sony, following in the footsteps of HD DVD-backer Toshiba and Blu-ray-backer Samsung, which had in September 2003 combined their optical-disc-drive programs.

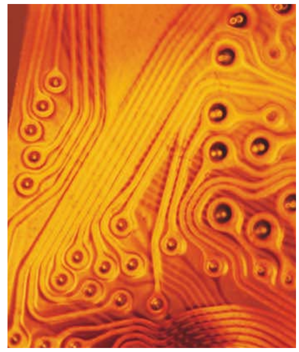
ATTACK OF THE NEAR-CLONES

The development of players that handled both DVD-Audio and SACD provided the resolution to that format war. However, only a small percentage of DVD players today support either format, probably at least partially because of the format standoff. Meanwhile, no PC optical drives can play back SACD. Could a dual-format, high-resolution DVD player effect a similar détente on the Blu-ray-versus-HD DVD battle, and at what cost for adoption? The recent unveiling of dual-format-controller ICs from companies such as Atmel and Broadcom may indicate that such a player could emerge. But, unlike past multiformat challenges, the situation is more complex this time around; its closest parallel is the mid-1990s appearance of drives supporting both CD and DVD media.

Those drives needed to handle both infrared, 780-nm, CD- and red, 650-nm, DVD-laser wavelengths and to focus that laser at both the 1.2-mm-CD and 0.6-mm-DVD levels within the optical media. Expand that format plethora to comprehend HD DVD, and you need to encompass the 405-nm, blue-violet-laser wavelength. However, HD DVD retains a common disc structure with DVD, enabling the use of a single-lens optical head for both. Further expanding the format list to include Blu-ray or substituting Blu-ray for HD DVD, however, complicates the lens arrangement, because you now also need to focus the laser at a 0.1-mm level.

HD DVD's evolutionary affiliation with DVD has long been the fundamental tenet of its advocates' arguments, much as Blu-ray's promoters have stayed "on message" with their preferred format's higher per-layer capacity. The DVD/HD DVD similarity is a plus for drive and media manufacturers, which would prefer to leverage investments they've already made into the DVD infrastructure. Media-content rights-holders, on the other hand, don't necessarily view this similarity as a benefit, thereby partially





8-Channel Analog Volume Control IC—Delivers Superior Sound Quality for High-End Surround-Sound and Pro-Audio Systems

CS3318 Offers Benchmark Audio Performance and Flexible Controls While Reducing System Cost

Designers of high-end multichannel audio systems have a new industry standard analog volume control integrated circuit: the CS3318 from Cirrus Logic. The flagship CS3318 is an eight-channel, high-voltage, digitally controlled analog volume control IC that is the benchmark for audio quality, showcasing 127 dB dynamic range.

The CS3318 operates from a ±9 V power supply, with 118 dB adjustable gain ranging from +22 dB to –96 dB, negligible distortion, and excellent inter-channel isolation. Plus, a 0.25 dB step size with zero-crossing detection and programmable time out ensures remarkably smooth control of volume adjustment. The CS3308 is a pin-compatible ±5 V version with a very high dynamic range of 123 dB.

Both the CS3318 and CS3308 reduce external component count and printed circuit board space, helping OEMs achieve more compact products at a lower cost. Patent-pending technologies, such as dynamic address assignment and simultaneous master volume controls across multiple devices over a single serial control bus, simplify designs and further reduce costs.

Features

- 8 independent controllable channels
  - 3 configurable master volume and muting controls
- 127 dB dynamic range (CS3318)
- 123 dB dynamic range (CS3308)
- –110 dB THD+N
- –96 dB to +22 dB in ¼ dB steps
- Noise-free level transitions
  - Zero-crossing detection and programmable time out
- Low channel-to-channel crosstalk
  - 120 dB inter-channel isolation
- Supports I^2C® and SPI™ communication
  - Independent control of up to 128 devices on a shared 2-wire I^2C or 3-wire SPI control bus
  - Supports individual and grouped control of all CS3308/18 devices on the I^2C or SPI control bus
- ±9 V analog supply (CS3318)
- ±5 V analog supply (CS3308)
- +3.3 V digital supply

Applications

- A/V receivers
- Home theater systems
- Digital mixing consoles
- Outboard audio converters
- PC soundcards
- External audio interfaces
- DSP amplifiers and in-car entertainment systems

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explaining the strong studio backing of Blu-ray. The widespread piracy of both CDs and DVDs has stung these rights-holders, who don't relish the thought of those mass-production lines quickly and cheaply migrating to pirated HD DVDs.

With neither Blu-ray nor HD DVD an obvious winner at this point, and with the standoff showing no signs of a near-term resolution, might another high-resolution video format seize the spotlight? In fact, a third contender *already* exists. Using a more modern video-codec alternative to MPEG-2, such as MPEG-4 AVC, also known as MPEG-4 Part 10 and as H.264, or VC-1, also known as WMV9, you can shoehorn a high-quality, high-resolution, long-playing movie onto a conventional single- or dual-layer red-laser DVD. For example, you can buy WMV9-encoded DVDs, such as *Standing in the Shadows of Motown*, *Step Into Liquid*, *Terminator 2: Judgment Day*, and a series of films from Imax. DRM issues currently restrict their playback to PCs, including living-room-based units, but manufacturers could add appropriate DRM support to the next generation of DVD players.

WMV9 is the codec choice of HDNet, which has begun offering its high-resolution, DRM-free content for sale on red-laser DVDs. Disc players based on the Taiwanese, red-DVD-based FVD (forward-versatile-disc) format are now ramping into initial production, and the porn industry is reportedly also beginning to ship high-resolution video content on red-laser DVDs. Pornography (no matter what you might think of its morality) has had a significant effect on driving the development and direction of technology over the years. Examples include its influence on the VHS-versus-Beta-format wars of the early 1980s, on DVD's multiangle feature, and on the streaming-media industry. Meanwhile, the China-based EVD (Enhanced Versatile Disc) Consortium soldiers on with the development of its formerly VP6-based, now high-resolution MPEG-2-based red-laser DVD format, with increased capacity courtesy of VMD (versatile-multilayer-disc) technology.

Buffalo Technology bases its LinkTheater DVD player on Sigma Designs' EM8620L decoder chip, and I-O Data's AVLP2/DVDLA and SRDVD-100U also employ this video processor (**Figure 3**). These players support DRM-free high-definition WMV9 and DivX playback, both from red-laser DVDs and over a network connection; DivX is a "kissing cousin" of MPEG-4 Advanced Simple Profile. Equator Technologies, now part of Pixelworks, has also for several years demonstrated prototype DVD players that support high-definition WMV and MPEG-4 content. A much larger group of DVD players today supports standard-definition DivX, primarily to serve people who download movies from file-sharing services and other Internet sites and people who rip and transcode dual-layer, pressed DVDs, in both cases burning the resultant material onto single-layer, recordable DVDs. And manufacturers are now shipping the next generation of chips supporting MPEG-4 AVC in decoding, encoding, and decoding-plus-encoding flavors. Ambarella, for example, claims that MPEG-4 AVC generally has higher quality than WMV9 at equivalent bit rates and that MPEG-4 AVC has 2.5 times the coding efficiency of MPEG-2 at equivalent resolutions, frame rates, and delivered quality.

Figure 3 I-O Data's SRDVD-100U is a pivotal piece of my video-codec-testing suite.

A DISTURBANCE IN THE FORCE

Or maybe *none* of the high-resolution-disc alternatives will achieve widespread prominence, due to alternative delivery mechanisms, consumer backlash, or a combination of these two factors. Microsoft Chairman Bill Gates, during an interview with Princeton University's student newspaper last October, in which he explained Microsoft's backing of HD DVD over Blu-ray, said: "For us, it's not the physical format. Understand that this is the last physical format there will ever be. Everything's going to be streamed directly or on a hard disk. So, in this way, it's even unclear how much this one counts" (**Reference 11**). Reflecting his forecast, you can now rent and download high-definition Hollywood movies over the Internet from vendors such as CinemaNow and Movielink. Judging from announcements and rumors at CES, the list of sources will markedly expand in the near future, following in the footsteps of the exploding digital-audio-download market (**Reference 12**).

Consumer backlash could occur for any number of reasons. Several recent studies, among them one that the BBC (British Broadcasting Corp) published in September 2004, have attempted to measure just how much resolution an average viewer can discern with various display technologies, screen sizes, aspect ratios, and viewing distances. The BBC study concluded, for example, that a 720-line video presentation suffices for a viewing distance of 9 feet with a 50-in.-diagonal


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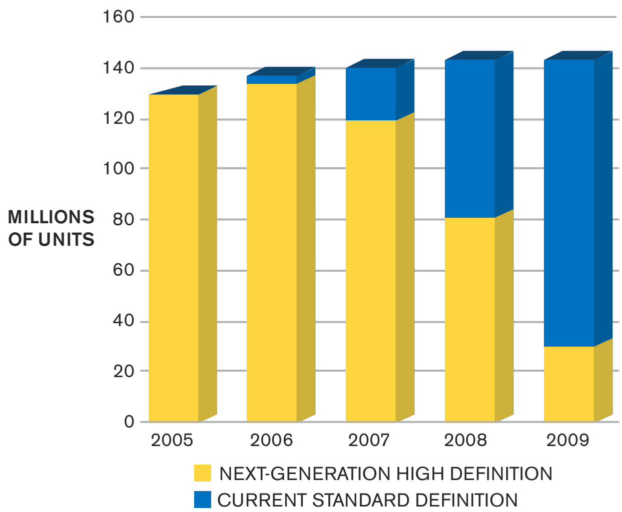

Figure 4 This forecast shows minimal total market growth, and it doesn't comprehend standard-definition DVD recorders and DVD-playback-capable game consoles (courtesy iSuppli).

display (**Reference 13**). As *Sound & Vision* magazine's Technical Editor David Ranada said in his summary of the BBC report, "Change either the viewing distance or the screen size, and the resolution requirement changes. Sit closer or use a bigger screen, and you need greater screen/signal resolution. Sitting at 9 feet, you start needing 1080 lines to avoid seeing the pixel structure once the screen size reaches around 56 inches" (**Reference 14**).

However, consider the flip side of Ranada's observation. If a consumer's screen is *smaller* than 50 in. or if he sits *farther* than 9 feet away from it, the added resolution potential of a 720-line, high-definition image will go to waste. It will be indistinguishable from today's 480-line DVDs. How many consumers own 50-in. or larger TVs, and how many of them view their TVs from closer than 9 feet, except perhaps on a consumer-electronics store's showroom floor? Not many. Therefore, how many of them will be willing to replace their DVD player with a significantly more expensive, high-definition version and all of their movies with even more expensive, high-definition versions? Again, probably not many.

One of the differentiating points the Blu-ray camp tried to make at CES, in positioning itself versus HD DVD, was that some of the announced Blu-ray players support 1080p single-link HDMI (high-definition-multimedia-interface) outputs, whereas the first crop of HD DVD players supports single-link resolutions only as high as 1080i. The term "1080i" refers to a 1080-line, 1920×1080-pixel, 60-*field*/sec, interlaced-scan video presentation, and "1080p" refers to 1080-line, 60-*frame*/sec, progressive-scan video. This difference doesn't reflect a fundamental format limitation; both Blu-ray and HD DVD can store 1080p video. It's also not a fundamental HDMI limitation; the interconnection's 165-MHz peak frame rate supports 1080p.

Although the HDMI specification supports frame rates as high as 165 MHz, that peak rate isn't a requirement for certification. HDMI transmitters and receivers synchronize up at a compatible speed when you first connect them, based on the receiver's EDID (extended-display-identification data). If a receiver supports rates only as high as 100 MHz, for example, the HDMI certification lab confirms that rate as the upper limit. TVs from many suppliers can't currently handle 1080p HDMI inputs, so a 1080p-capable Blu-ray player would need to down-throttle to 1080i to work with them. And, even if a display accepts 1080p, the video processor might immediately discard half of the information to simplify its job, effectively transforming the signal into 1080i. Future HD DVD players will likely be 1080p-capable; the fact that they're not now is negligible.

Consumers will likely be able to experience high-resolution video from a Blu-ray or HD DVD player only if it connects to a display over a content-protected HDMI link. The AACS standards body publicly admitted in mid-January that its specifications include a flag that, if content providers set it, downscales video to 540-line resolution before outputting it over analog outputs, such as RGB or component video (**Reference 15**). This "feature" means that anyone who owns a non-HDMI-equipped display is out of luck when it comes to viewing high-resolution flag-set material.

Consumer backlash may also come from the new AACS content-protection scheme that both Blu-ray and HD DVD have embraced. A small but tangible percentage of the DVD-viewing public currently employs CSS (content-scrambling-system)-circumventing software, to back up DVDs they've legally acquired, to copy them to a laptop-computer hard-disk drive, or to illegally duplicate DVDs from friends, family, or rental services. The developers of AACS claim that the technology will put a stop to such shenanigans. Consider, though, the following quote from Jon Johansen (also known as "DVD Jon"), who developed the initial De-CSS (decryption-of-CSS) algorithm (**Reference 16**). "AACS, like CSS, will be a success—not at preventing piracy. That's not the primary objective of any DRM system. Anyone who has read the CSS license agreement knows that the primary objective is to control the market for players. Don't you just love when your DVD player tells you 'this operation is prohibited' when you try to skip the intro?"

Fox successfully lobbied the Blu-ray group for additional content-protection mechanisms, whose details are not yet public, beyond AACS. Also, HD DVD supporters complained off the record at CES about the fact that Blu-ray advocates on the AACS board had, by repeatedly postponing the finalization of the specification, consumed much of the production-schedule lead that HD DVD otherwise would have had over Blu-ray. Turnabout is fair play, however: The Blu-ray content-protection enhancements that Fox demanded are reportedly among the key reasons that the PlayStation 3 is late to market.

AACS, unlike its CSS predecessor, implements three key aspects necessary for any robust DRM scheme: authentication, revocation, and renewal/upgrade (**Reference 17**). But under what monitoring and delivery scheme will manufacturers implement this content protec-

tion? AACS promoters repeatedly have stated that it will be unnecessary, either occasionally or constantly, to connect a Blu-ray or HD DVD player to the Internet. An executive of a major semiconductor supplier, however, paints a different picture. Players *will* need to regularly "dial in" to confirm their conformance and to adjust their features, he says off the record. Additionally, movie studios are reportedly, for example, considering releasing a single pressing of a high-resolution DVD worldwide as a cost-savings move. In this scenario, language-specific soundtracks, titles, and other viewer-tailored content would dynamically stream down to the player over the Internet, rather than reside on disc. Reflecting this vision, Toshiba's ad for its first-generation HD DVD players touts their "Internet connectivity for downloading soundtracks and bonus content."

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Blu-ray- and HD DVD-specific media could end up being dead on arrival, as was their D-VHS high-resolution video predecessor. Eventually, in this worst-case scenario, studios will release double-sided discs with high-resolution video on one side and standard-definition DVD content on the other, much as music labels are migrating from CDs to DualDisc at little to no price premium over CDs; this strategy is probably a far less lucrative one than the music labels originally envisioned. And consumers will most likely underwhelmingly embrace Blu-ray and HD DVD players. Consumers will probably buy them only when their DVD players break down, and then only when the price difference between them and a less-than-$100 replacement DVD player is minimal to nonexistent. This forecast is admittedly gloomy, and, for the continued vibrancy of the semiconductor industry, I hope it's too skeptical (**Figure 4**). But I find it difficult to conclude otherwise, particularly without detailed information on PlayStation 3 and Xbox 360 HD DVD drive costs, prices, production schedules, and volume ramps.**EDN**

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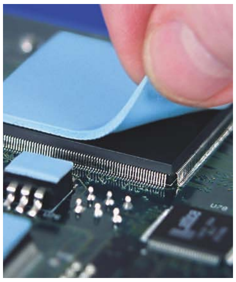

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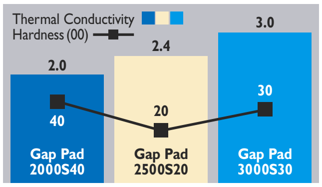

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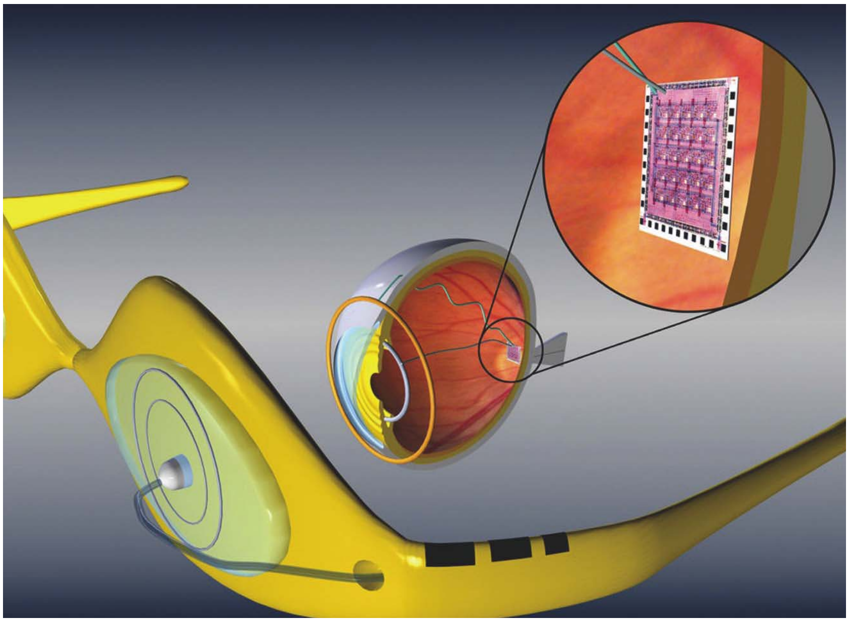

Figure 1 The artificial eye performs digital processing on data that a digital camera captures and passes the processed results to the patient through an electrode implanted directly on the patient's retina (courtesy Biomimetic Micro-Electronic Systems at the University of Southern California).

BY ROBERT CRAVOTTA • TECHNICAL EDITOR

INTERFACING electronics to people

ELECTRONIC EMBEDDED SYSTEMS CONTINUE TO FIND THEIR WAY INTO MORE MEDICAL SYSTEMS.

As electronic embedded systems are finding their way into and replacing more mechanical-control systems, it might reasonable to expect to see them finding their way into organic systems, such as the human body. Indeed, electronic embedded systems are interfacing with the human body in more ways each day to perform a variety of functions ranging from health monitoring, managing and maintaining the function of systems such as the heart, replacing failed organs by controlling the insertion of drugs or enzymes into the body, and even restoring the use of limbs and senses. In some cases, these capabilities have been around for decades, and the evolution of the electronics is reducing the cost of these systems as well as improving the reliability and life-cycle replacement of these systems. In other cases, these capabilities are emerging as possibilities in the lab but requiring more refinement to become practical in the real world.

In each of these cases, the electronic systems more intimately interface with the patient's body than they did previously. Some of the ways to interface with the body are intrusive, such as implantable devices, which spend their entire operational life within the body of the patient. The heart pacemaker is a common example of an implantable device. Devices that patients can swallow are emerging platforms for diagnostics and therapeutic procedures. Insulin- and drug-delivery pumps are intrusive systems that often comprise components that reside internally and externally to the patient; these systems can deliver precise amounts of insulin or drugs. A growing market is emerging for implantable neurostimulation, or spinal-cord-stimulation, devices with control units outside the patient's body for the treatment of chronic pain or for managing epileptic seizures.

In addition to intrusive systems with implantable components, electronics subsystems are also enabling medical practitioners and some devices to perform their functions less intrusively than previously. Laparoscopic surgery is an area in which electronics are enabling surgeons to perform procedures in a minimally invasive fashion that results in less stress on a patient's body (**Reference 1**). A number of companies are working on noninvasive glucometers that would enable continuous monitoring of blood-glucose levels; this emerging type of device allows patients to measure their

AT A GLANCE

- Medical-equipment designs are incorporating electronic subsystems into more devices.
- Interfacing electronics with the human body presents higher technical hurdles for designers to overcome.
- Advances in medical equipment are enabling more autonomous or semiautonomous systems.
- The human body may represent the next focus and challenge of network standards.

blood-glucose levels without pricking their fingers to extract blood for testing. The noninvasive glucometers in development are attempting to use a variety of approaches to measure blood-glucose levels, such as by shining light on the skin and detecting the infrared absorption, using radio-wave impedance to measure the absorption of electromagnetic waves through the skin and blood, or using reverse iontophoresis to draw interstitial fluid through virtually intact skin.

A HIGHER HURDLE

Embedded systems for use in medical and health-care applications are subject to a set of regulatory oversights that industrial and commercial applications need not contend with. The extent that these systems must satisfy regulatory requirements correlates with the roles these systems take on. Life-sustaining systems face more rigorous control, whereas diagnostic and monitoring systems undergo less stringent requirements to reach the market. According to Mir Imran, chairman of several companies, including InCube Laboratories and Guidant, "Many electronic medical systems are under development that the public is not aware of because they still need to complete the regulatory process."

The regulatory requirements for electronic medical systems do not currently directly flow down to the semiconductor providers; rather, the burden falls squarely on the shoulders of the end-product integrator. According to a number of semiconductor providers, teams developing medical systems, especially implantable ones, often ask about smaller packages, higher device and memory reliability, high-resolution analog-to-digital-conversion capability, battery monitoring, and lower power consumption.

Low-power-consumption concerns also often require the system to support multiple low-power or sleep modes because the systems may not always be fully active. Another concern of end-system integrators is the shelf life of the device before implanting it in a patient, because the power supply must reside in a sealed casing and physicians cannot place it into the casing at the time of implantation. A significant time lapse may occur between when a vendor manufactures a system and a physician implants it in a patient.

Other concerns of design teams to meet and maintain regulatory certification include how long a semiconductor manufacturer will provide and support a component and the company's commitment to maintaining pin-compatible devices. If the team needs to recertify the system, the cost of the recertification process may become unjustifiable. A design team may do an end-of-life purchase if the supplier places a component on end-of-life status; in some cases, the volume of these purchases are thousands rather than millions of units. Changes in the device's pins would require a recertification effort, so pin-compatible devices are essential.

Implantable systems generally represent market volumes much smaller than the market volumes for consumer multimedia applications. Whereas the consumer markets account for millions of units, implantable medical systems may account for hundreds or thousands of units. Gene Frantz, technical fellow at Texas Instruments, points out, "Some of these developers are doing the early work on three important challenges facing implantable electronics in the human body: how to operate the system on body heat, how to not boil the water surrounding the device, and how to survive the corrosion from existing in a salt-water environment." Although the electronics can reside in a hermetically sealed casing, the sensors must directly interface with the tissue and the salt-water environment within the patient's body.

Processors that can operate on the power they harvest from deltas in body heat may emerge not too far in the future, according to several semiconductor companies. A 1° temperature difference can supply a system with 2 μW of power. The impact of crossing this power threshold is that an electronic embedded system would have virtually unlimited battery power because it could always acquire the power it required from its environment—in this case, a human body. This feature could enable implantable control systems to remain in a patient's body for longer than the few to 10 years of current implantable sys-

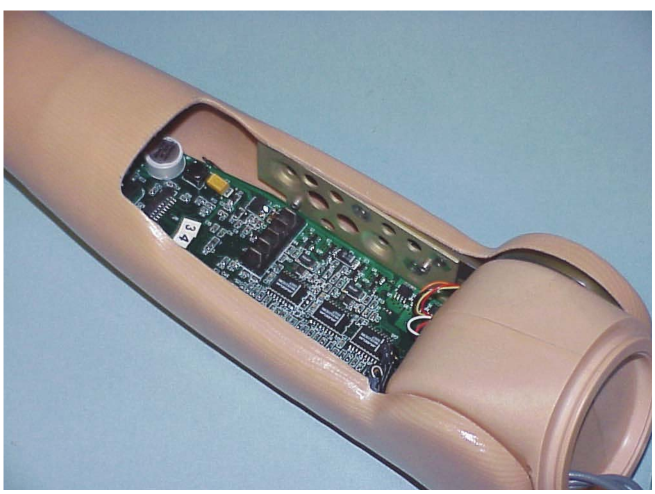

Figure 2 The Boston Digital Arm prosthetic arm from Liberating Technologies acts as a platform and central controller for various add-on peripherals, such as a wrist, a hand, a gripper, and shoulder actuators (courtesy Rehabilitation Institute of Chicago).

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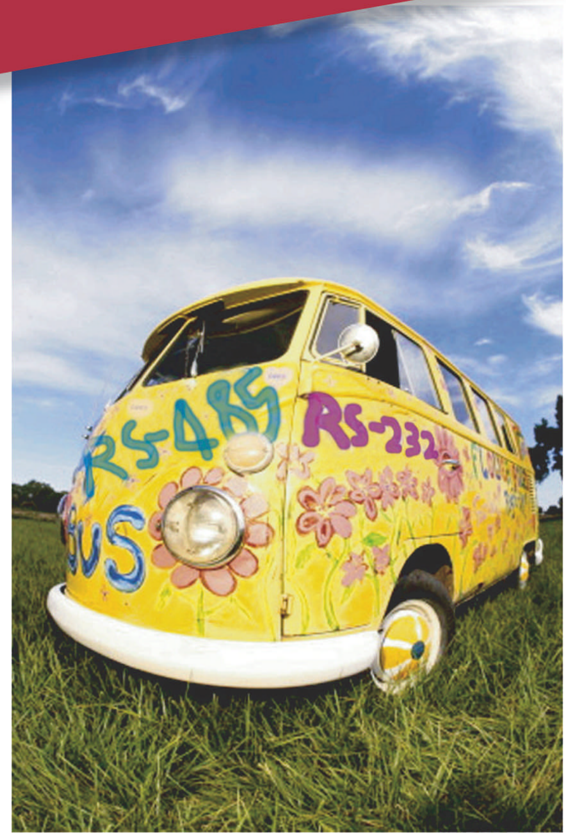

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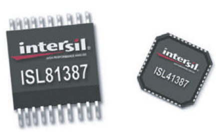

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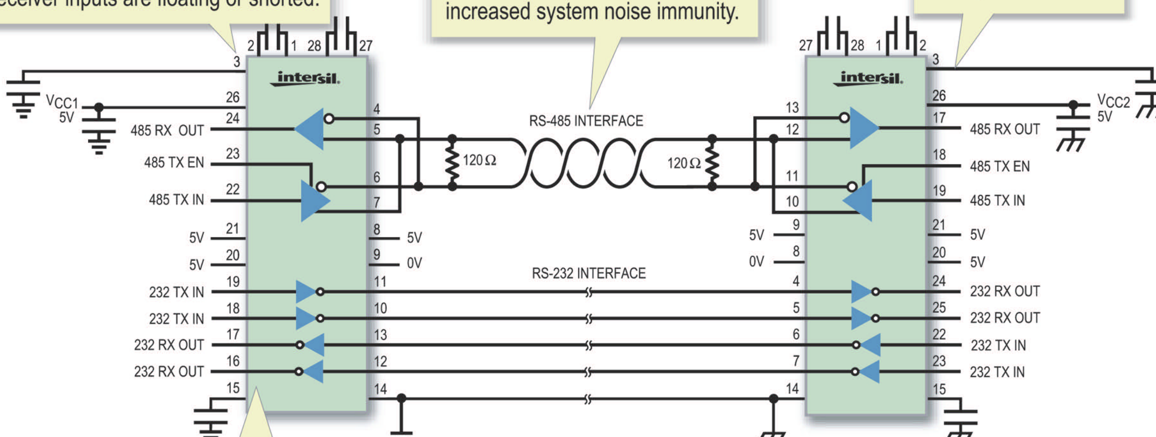

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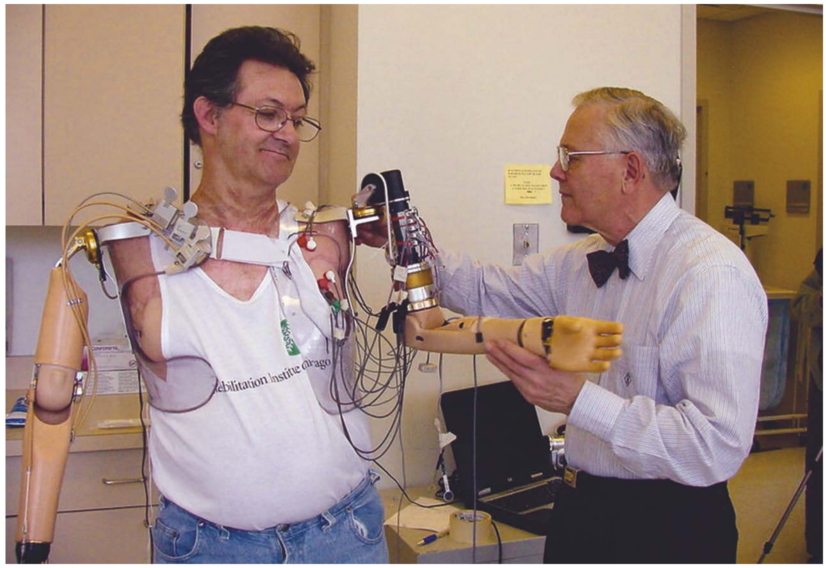

Figure 3 The advanced prosthetic device acting as Jesse Sullivan's left arm receives inputs rerouted from the nerves in his chest and the muscle activity that myoelectrode sensors detect (courtesy Rehabilitation Institute of Chicago).

tems. Body movement is another possible source of power for these future low-power systems. A contemporary approach to extending the battery life of implanted systems is to use rechargeable batteries or to place the power supply outside the body. In the case of implantable power systems, this approach often means the patient must periodically remain with a charging station for some time. The benefit the system provides for the patient offsets the inconvenience of being periodically tethered to a charging station. Another method researchers are exploring for recharging implanted batteries involves trickle-charge methods.

Heat dissipation is a significant concern for high-density computing systems, such as central-office communication equipment or server farms. It is also a concern for systems that are implanted in parts of the body in which the circulation of fluid is insufficient to remove the heat that the implanted system generates, especially if the system is usually operating, versus dormant. An example of this type of system is a permanent, microelectronic, retinal implant. The implant is the work of Mark S Humayun, MD, PhD, and his research team at the Biomimetic MicroElectronic Systems Engineering Research Center at the University of Southern California (Los Angeles).

The retinal-implant system attempts to restore partial sight to patients who have lost vision due to age-related macular degeneration or retinitis pigmentosa. The research has focused on patients that could once see rather than patients who were born blind. The Model 1 system combines a small camera and a DSP to transmit images to an implanted 4×5-mm retina chip with 16 electrodes in a 4×4 configuration. The Model 2 version of the system is 20% of the original model's size and supports 60 electrodes. The Model 3 version under development will have 1000 electrodes and a special chip coating that will allow the chip to conform to the shape and movement of the eye (**Figure 1**).

CLOSED-LOOP CONTROL

Closed-loop control is an essential capability for many systems performing continuous sampling and control. Narrowly defined, life-sustaining systems, such as implanted heart defibrillators and pacemakers, autonomously sense the environment and act on the data they receive to perform their function. For many systems today, the loop is not

autonomously closed; rather, the patient closes the loop. In devices such as insulin pumps, the patient must be aware of and explicitly control how the insulin pump operates. Factors such as the patient's intake of carbohydrates; amount of stress; amount of physical exertion, such as engaging in sports; and amount of rest affect the timing and dosing of insulin. Companies such as Medtronic MiniMed are investigating how to produce an artificial pancreas by incorporating the insulin pump into an autonomous, closed-loop system that could continuously monitor blood-glucose levels.

The prosthetics market, though relatively small, will likely garner much attention when researchers make advances. The recent stories about Jesse Sullivan, "the world's first bionic man," are one example of this technology. In May 2001, working as a high-power lineman, the 54-year-old Sullivan had a life-changing event: He was electrocuted so severely that doctors had to amputate both of his arms (**Reference 2**). Todd Kuiken, MD, PhD, and other researchers at the Rehabilitation Institute of Chicago developed a prosthetic-arm and -hand assembly for Sullivan. (You can watch a video of Sullivan demonstrating the use of his arm at the Web version of this article at www.edn.com/060302df1.) The technology represents the effort of one group of people, and the interface to Sullivan's nervous system represents another team's efforts to provide a glimpse of where prosthetics could be heading. However, even though the prosthetic arm is under Sullivan's control, he currently must use his eyes to conscientiously and explicitly close the system's control loop; no other feedback mechanism to the controller yet exists.

THE MAGIC OF THE BIONIC-MAN SETUP IS THE MYOELECTRODE INTERFACE THAT SITS DIRECTLY ON THE SKIN AND MEASURES MUSCLE CONTRACTIONS.

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+ Go to www.edn.com/060302df1 for a video of "bionic man" Jesse Sullivan demonstrating the use of his prosthetic arm.

+ For more on electronics in health care, go to www.edn.com/article/CA402151.

The prosthetic arm is the Boston Digital Arm from Liberating Technologies (**Figure 2**). It is a platform that provides an elbow to the patient, but it can also act as the controller for additional prosthetic devices, such as wrists, hands, grippers, and shoulder-lock actuators. Its software enables it to operate with a variety of input devices, including touchpads, servo controls, switches, and myoelectrodes. Myoelectrodes pick up the signals from muscle contractions, whereas movement of a residual limb can actuate the touchpads, servo transducers, and switches. The software can pass through the inputs from these devices to the peripherals, or it can directly control the peripherals based on these inputs through attached PWM interfaces. As part of the evolution toward a closed-loop system, researchers are developing an analogue of spinal loops.

The magic of the bionic-man setup is the myoelectrode interface that sits directly on the skin and measures muscle contractions. Sullivan basically uses the same nerve signals he used to control his arm and hand before his accident. In general, the muscle contractions that control the arm are those that would normally occur when he tries to move a set of muscles in the arm or the hand. After Sullivan's accident, he no longer had muscles to contract, so researchers moved the nerves to muscles on its chest (**Figure 3**). By inferring his intent from the muscle contractions, the prosthetic arm, wrist, and hand systems can respond appropriately.

COMMUNICATION

Our world is an increasingly connected one, and personal medical devices are not exempt from this trend. The human body is possibly the next great challenge for networking standards. As more med-

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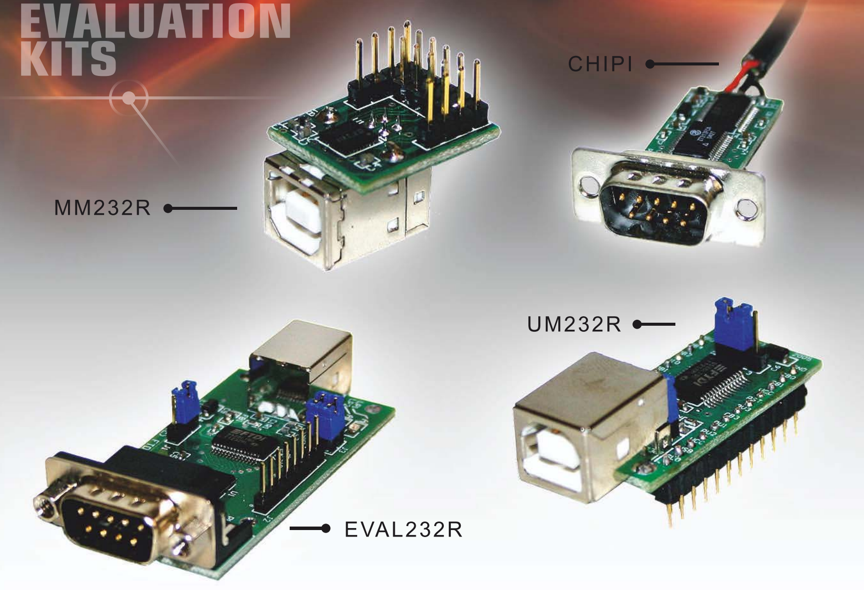
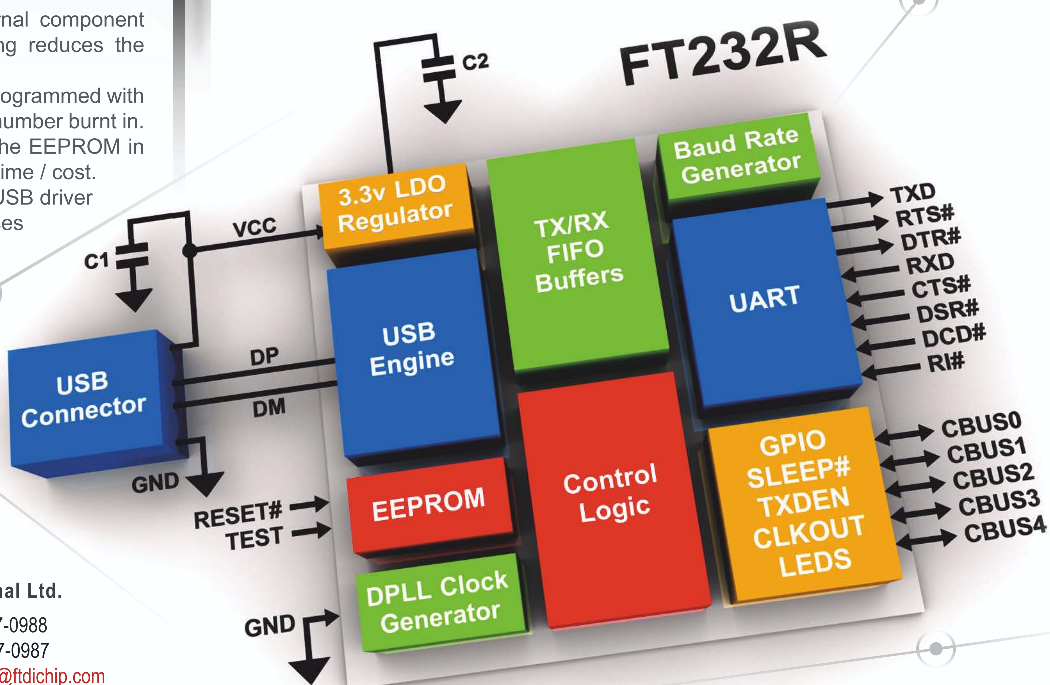
EVALUATION KITS



BLOCK DIAGRAM



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ical devices enter the home, the need increases to reduce the cost of medical care by transmitting relevant data to the doctor's office without a physical visit. The medical standards for network connectivity differ from those commercially available to homes. To support connectivity in home monitoring systems, design teams are exploring commercially available interfaces, including USB connections. Medical devices that support USB connection may also help push and increase the robustness of the wireless-USB standard.

Wireless communication with implanted devices is a growing capability, especially because it avoids the need for a physical interface implanted in the patient's skin. Home-based RF communication within the MICS (Medical Implant Communication Service) medical-communications band of 402 to 405 MHz for implanted medical devices is replacing inductive communication because it can help a patient avoid an office visit to communicate with the implanted device. The Bluetooth technology is emerging as a future method for wireless connection to implanted devices, especially to create a connection to a cell phone to contact the doctor's office or communicate with the patient.

The data-communication requirements for implanted devices typically could support data rates of approximately 100 kHz. The low data rates help these systems minimize both the patient's body's absorption of the data signals and data-communication events to conserve power. Typically, the systems run at low data rates with higher data rates for burst communications. The communication may involve dumping collected data for analysis by a physician and for patches or parameter updates for the implanted-device controller.

Other concerns for designers of electronic medical systems are how to deal with technological obsolescence and how to upgrade or change the systems. The rate of improvement for many of these systems is so significant that the devices every couple of years become smaller and more effective than the earlier versions. One way of handling the upgrade issue is to use software-programmable control systems. Another way is to place the controller outside the patient and have it wirelessly communicate with the sensors, pumps, and motors that reside within the patient.

The cell phone presents an interesting opportunity for convergence with future medical devices. For example, it could act as the gateway between the medical device and the doctor's office. It could also act as a user terminal to directly collect or deliver feedback to or from the patient. However, the most profound convergence opportunity of the cell phone stems from the fact that it is currently the closest thing to a universal personal controller that everyone carries with or keeps near themselves, virtually all the time. This feature makes the cell phone a possible candidate as a form factor for external controllers for semiautonomous implanted systems. As implanted systems become more common and less costly, it is not inconceivable to consider multiple such systems in patients. The cell-phone form factor could act as the master controller for such patients to avoid interference or anomalous interactions between multiple implanted devices. EDN

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BY BRUCE LEE • TEXAS INSTRUMENTS

Optimizing heterogeneous architectures

A SYSTEMS APPROACH TO MULTICORE-DSP ARCHITECTURES EXTRACTS THE HIGH PERFORMANCE THAT TODAY'S APPLICATIONS REQUIRE.

The myriad DSP (digital-signal-processing) applications requiring the performance and integration of SOCs (systems on chips)—from consumer communications to multimedia products—have created new challenges for developers. Many of these challenges stem from the inherent complexity of the integration, development, testing, and verification of heterogeneous architectures comprising multiple processors, coprocessors, accelerators, and peripherals. A typical heterogeneous SOC comprises many subsystems and processors. For example, a multimedia processor may have a GPP (general-purpose processor); multiple DSPs; audio/video interfaces; codecs; multiple accelerators; wireless interfaces, such as WiFi; flash memory; high-speed communication links; sensors; and display controllers. With a comprehensive set of multicore-aware tools that address shared-resource contention, performance optimization based on actual usage scenarios, and power management across multiple cores, developers can confidently unlock the power of SOC devices and achieve fast market response. Additionally, proper adjustment of these subsystems enables optimization across features, power usage, and performance without requiring developers to completely redesign the product, as they might have to with a less integrated architecture.

Traditionally, a design team working with a heterogeneous architecture, such as a GPP and a DSP, usually divides itself into at least three groups. One group writes code for the GPP and primarily handles control processing. A second group writes code for the DSP and on-chip coprocessors, taking care of most of the data processing. A third group is responsible for system integration, bringing together both designs from the other two teams as well as dynamically repartitioning the system as new constraints and limitations manifest themselves (**Figure 1**). Most programmers worry about code density, memory usage, power consumption, and cache efficiency in a block of code. But you cannot accurately and individually measure these characteristics apart from the complete system. Contention for processing cycles, memory, and peripherals among multiple blocks of code determines the efficiency with which code runs.

The system-level-design group can see trade-offs that the programming teams cannot. For example, the complexity of programming the function on a processor usually determines the decision to program a function to the GPP or the DSP. The group usually partitions control and user-interface functions to the GPP, which is better suited to them, and data-processing functions to the DSP. Sometimes, however, the obvious partitioning is less efficient.

Consider the autofocus function of a digital camera, an ideal task for the DSP to handle. It is easier for programmers to write the autofocus function for the DSP rather than for the GPP, and the code is more compact and runs faster. Given that the DSP also consumes less power than the GPP, this decision appears sound.

However, when taking into account typical camera-usage patterns, the choice is more complex. Often, a user turns on and focuses a camera but either is not looking at the screen or is waiting for the perfect moment to shoot a picture, meaning that the DSP is not in use. If the designer implements the autofocus function on the DSP, then, during this time, both the GPP and the DSP must be fully powered. If the designer implements the autofocus function on the GPP, assuming that enough overhead is available, the DSP could be in a powered-down state. When the user takes the picture, the DSP quickly returns to an active state and captures the image with minimal latency.

The trade-off is that the autofocus function may be less efficient to implement on the GPP, requiring more CPU cycles and

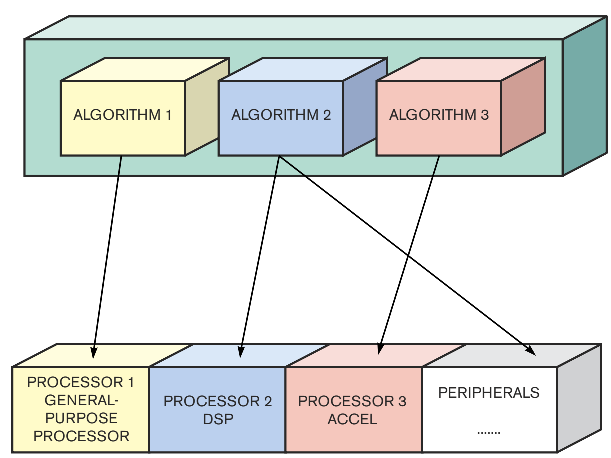


Figure 1 Traditional fixed partitioning yields design teams that usually divide into system- and processor-level development groups.

slower response; however, the significant power conservation that results from being able to power down the DSP, increasing overall battery life, more than offsets this inefficiency (see **sidebar** "Slave to efficiency").

DYNAMIC PARTITIONING

When weighing partitioning advantages at a system level, programmers have to consider multiple usage scenarios. For example, the user is sometimes shooting numerous pictures in succession. If the GPP is in full use, the bottleneck in the system may be writing to the flash or the hard-disk drive, which limits both the maximum number of pictures that the camera can queue and the speed at which a user can take successive pictures. By offloading processing tasks from the GPP, the system can more quickly save images, increasing the performance of the camera. In this scenario, the system achieves optimal performance if the designer implements the autofocus function on the DSP.

Dynamic partitioning allows the programmer to implement a function on both processors, enabling optimized performance under both of these scenarios. When the picture queue is empty, the GPP handles autofocus, and the DSP powers down. When the user takes the first picture, the GPP wakes the DSP to capture the image. At the same time, it passes execution of the autofocus function to the DSP. While the DSP is active, it handles autofocus. When the DSP is no longer required—that is, when the user is waiting to take another picture—the DSP alerts the GPP that it is ready to power down again. The GPP resumes executing the autofocus function and tells the DSP to power down. The programmer can seamlessly create an autofocus task for the GPP, the DSP, or both if the function can execute on either processor.

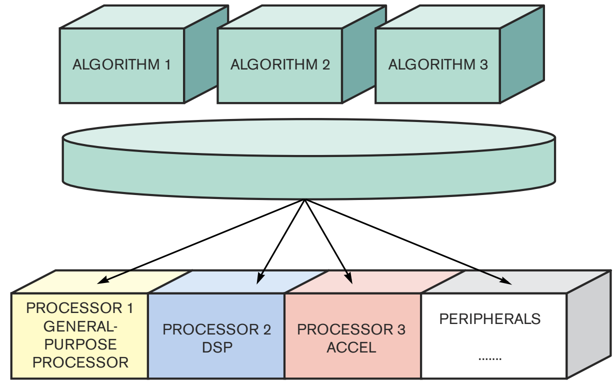


Figure 2 With tools and techniques such as dynamic partitioning, developers can optimize the performance of complex multicore architectures.

The chief concern when implementing dynamic partition-

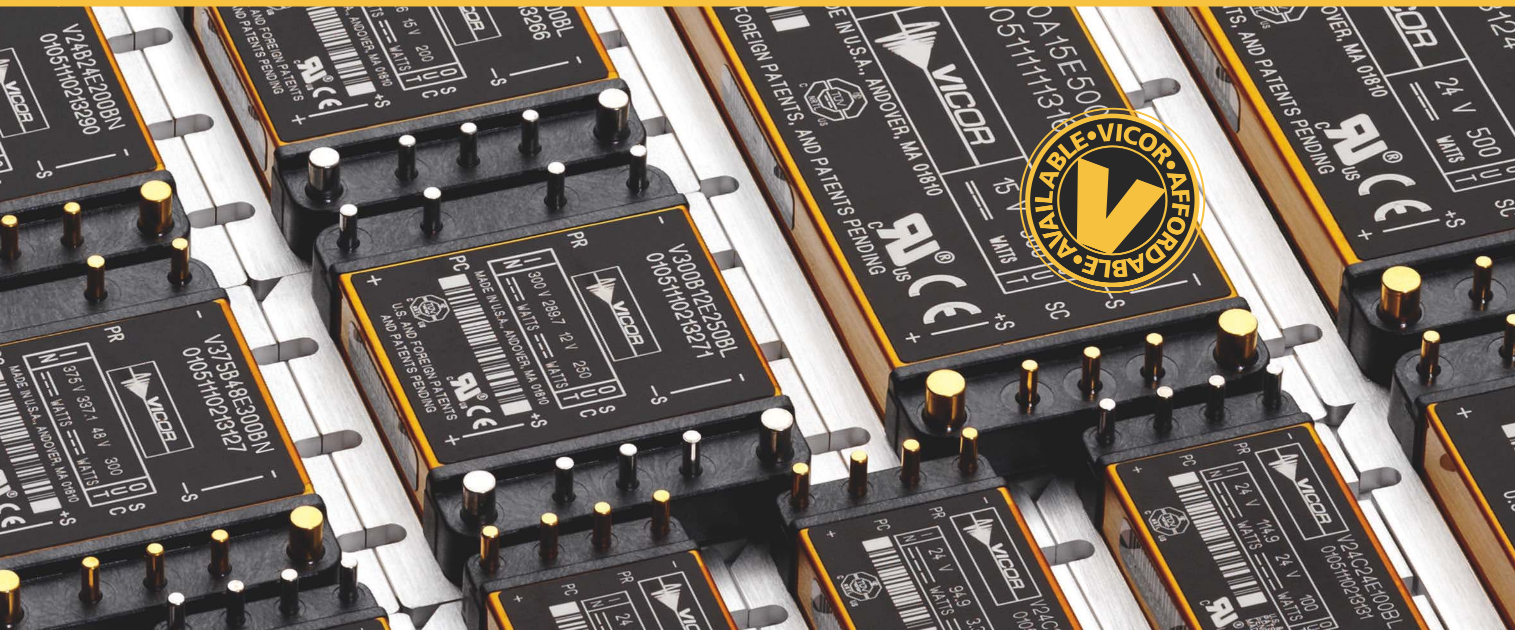
SLAVE TO EFFICIENCY

One technique for conserving power in a heterogeneous system is to run the multiple processors in a master-slave configuration. The master processor manages system events and the user interface, and the slave processor powers down the system; both processors need not consume power during low-usage or idle periods. In general, the GPP (general-purpose processor) or control processor acts as the master, because designers usually implement system-management and user-interface functions on this processor. The system can handle simple events, such as updating a clock or responding to the keyboard, without waking the DSP. If the DSP were master, then any event would trigger waking the GPP to handle it. For this primary reason, the GPP is the master, even though it typically consumes more power than the DSP.

When a processing event occurs, the master wakes the slave with the function it has to perform. For a multifunction device, overlays can complicate waking the DSP. To increase processing efficiency and power usage, you must load the proper algorithms into the DSP's fast program memory–which may be too small to hold all of the algorithms a device might need to support–before you awaken it. In most cases, you can store the program overlays in the extended memory of the master processor. In this way, the master processor can overlay the appropriate code in the slave processor's fast program memory.

Although the system-level team manages overlays, overlays complicate code writing for the other two groups on the design team. They must write code without fixed address dependencies; the code must execute from anywhere in program memory and access variables from relative pointers. Given a limited amount of fast program memory, programmers shouldn't place infrequently used code in it. Programmers may also need to limit the use of global variables. Although using global variables may simplify programming, they consume scarce memory resources whether or not those variables are in use at the time. If you are using an RTOS, you can configure the operating system or kernel to manage these concerns for you.

Note that you need not entirely power down the slave. In some cases, you may just want to slow down the slave to maintain a proper function and performance. For example, you can reduce the slave clock rate to a level just low enough to perform real-time autofocusing. Programming the slave is like pressing the gas pedal on your car: You maintain full control of speed and power usage, and no power goes to waste.



AVAILABLE•VICOR•AFFORDABLE

ing is that the programmer must write the same code twice for different processors. In most cases, they write such code in C; therefore, porting this code between the processors requires minor adjustments to the optimized code that the appropriate compiler produces. Note that, when you have both sets of code at hand, you gain other advantages. For example, the autofocus function runs faster and consumes less power on the DSP than on the GPP. Today's development environments have advanced tools for profiling memory usage, including cache visualization; power-consumption monitoring; and bus-traffic analysis, enabling you to determine whether this information is true once you can profile execution on both the GPP and the DSP.

With both sets of code, you can also begin to test more complex partitioning schemes that you would otherwise be unable to evaluate. The performance of the system is not equal to the sum of its parts. It depends highly on the usage scenario and other active code. For algorithms such as video that put a heavy load on the DSP, you could shift the autofocus function back to the GPP. You could test partitioning scenarios among several functions, determining which offers the best power consumption and performance. You could automate such testing within the development environment, running through various combinations to find the optimal configuration based on performance, power consumption, or both. Having two sets of code allows system integrators to experiment with new configurations without forcing unexpected changes back onto the programming groups. However, you can't achieve any of these goals if you are locked into running the code on only one processor (see **sidebar** "Cutting core count").

DANCING THE DEBUGGER TWO-STEP

An important system element of heterogeneous architectures is debugging of emulation circuitry. Such internal circuitry in the processors reduces the amount of debugging instrumentation in your code, giving you a more accurate runtime profile of your system. You also have a better idea of how you're using memory and can better optimize the use of fast memory. For example, high-performance DSPs include advanced circuitry to support nonintrusive ICE (in-circuit emulation), manage JTAG scanning, monitor and control power, enhance trace capabilities, monitor bus activity, perform high-speed data exchange, enable system triggering, and support other functions critical to providing high system visibility during debugging sessions.

Another critical component is multiple-core awareness in the debugger and development environment. You need to be able to synchronously stop multiple processors to solve some debugging problems. Such tools speed development by keeping you aware of overlays updating variable addresses and watch points when code moves within an overlay or between processors. You might also need to occasionally disable the debugger. Perhaps you want to test the responsiveness of a core coming out of sleep mode; it can't be asleep if it's supplying trace information. Alternatively, you may need a communications stack to continue

CUTTING CORE COUNT

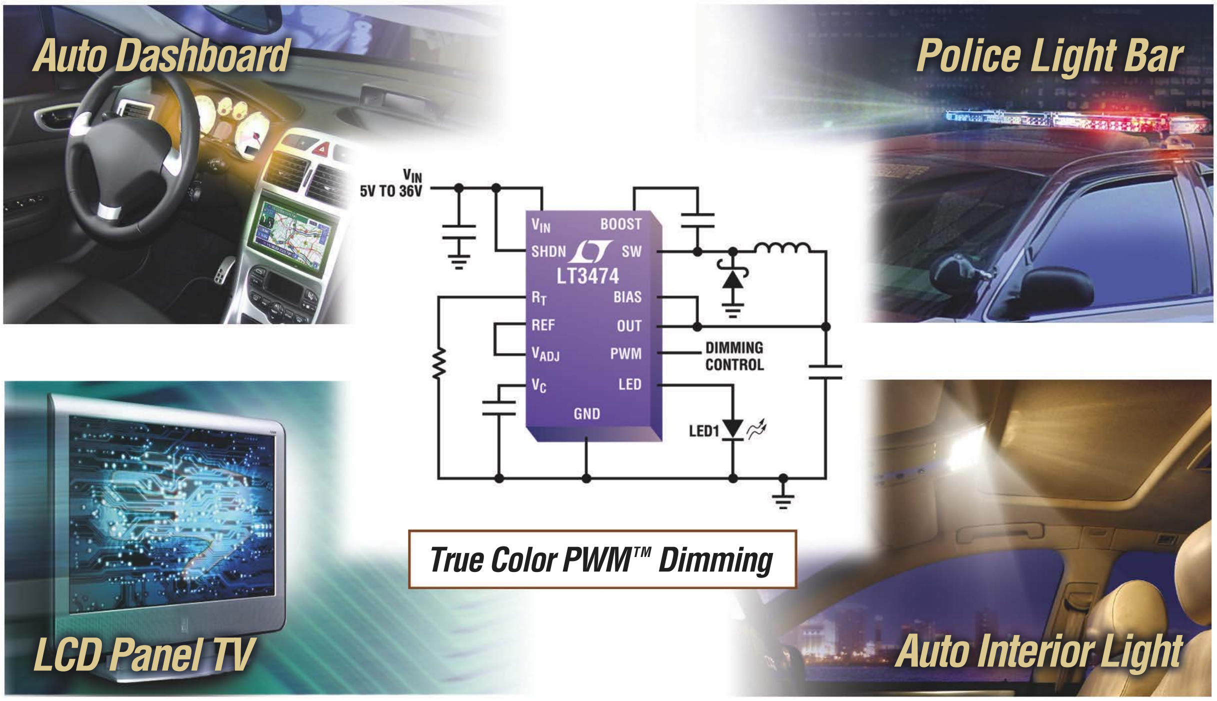
With the increasing capabilities of processors, designers can scale back some multicore designs to a more traditional, single-core design. For example, a typical DSP can also handle user and peripheral controls. On the other side, a powerful GPP (general-purpose processor) can handle a single channel of MP3 decoding without the help of a DSP. Designers can now implement multicore systems in a single-core chip: a single DSP, GPP, or FPGA.

It is equally important to understand that a multicore SOC (system on chip) may be a poor fit for a single-function device, such as a radio-controlled watch or a hearing aid. With these devices, it would be uncommon to need user-interaction and -reprogramming capabilities. Programmers can typically dedicate the core in these applications to do the job in predetermined conditions and use much less power. The flexibility and scalability of a multicore device add little value for these applications.

Additionally, in some products, power consumption is less of a concern. For these products, the designer typically increases the clock rate to get the processing power to do the various jobs a single core usually handles. A device operating at approximately 1 GHz is a typical choice. For infrastructure applications, the power consumption per channel is competitive, even if the device power is 1 to 2W. You can scale its needed performance and power consumption by selecting clock rates of 600 MHz to 1 GHz and still maintain code compatibility.

Design engineers may also ask, "When do I decide how many cores I want to use for my design?" The answer to this typical question is to wait as long as necessary, but don't compromise the software or features. This approach provides the flexibility of a design that can evolve throughout the process. Product requirements change frequently in response to market situations during the development cycle. So many companies adopt a spiral model for product development. Each spiral involves feedback, refining and redesigning, optimization, cost analysis, and other factors. More design flexibility means more spirals. An original multicore SOC design may end up as a simple single-core system, or it could go the other way. In most cases, it is easier to scale down a multicore SOC to a simpler, single-core design. Many companies have developed in-house or commercial-level tools to facilitate high-level design by mixing software and hardware modules. So, a more important determination is how flexible and capable the design team is when responding to rapidly changing market situations.

High Power LED Drivers



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Selected High Power LED Drivers

Part Number	Topology	V_{IN} Range	Max. I_{LED}	Package
LT®3474	Buck	4V to 36V	1A	TSSOP-16E
LT3477	Boost/Buck/ Buck-Boost	2.5V to 25V	1.5A	TSSOP-20E, QFN-20
LT3479	Boost	2.5V to 24V	1.5A	TSSOP-16E, DFN-14
LT3486	Boost	2.5V to 24V	0.35A x 2	TSSOP-16E, DFN-16
LTC3783	Boost/Buck/ Buck-Boost	3V to 36V	>1.5A Controller	TSSOP-16E, DFN-16

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processing, even though the system has encountered a breakpoint, so that you don't lose information.

Remember that you can use communication stacks such as USB or IEEE 1394 to transfer useful debugging information when the application is not using them. With a stack on both cores, you can more easily debug multiple cores synchronously. You also gain control over how you can pass and format debugging data without needlessly impacting the overall system. For example, if you use printf only in debugging code, you could cause the linker to bring in large library elements that would otherwise not be part of your system.

Developers familiar with only one side of the process—either GPP or DSP—have difficulty evaluating trade-off decisions early in the design process. Additionally, they can't repartition a function to optimize performance or enable dynamic partitioning, and the team that ends up porting the code cannot use many of the lessons they learned writing the code. With the right combination of code and tools, however, they can start to view their application at a system level, instead of as separate processing units. They can work at a higher level of abstraction rather than think of programming the GPP or the DSP.

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AS DEVELOPERS TEAR DOWN THE WALLS BETWEEN SUBSYSTEMS, THEY CAN UNLOCK THE ADVANCED CAPABILITIES OF EVEN THE MOST COMPLEX SOC ARCHITECTURES AS SIMPLY AS THEY DO WITH SINGLE-CORE ARCHITECTURES.

KNOW THY USER

It's important to spend time evaluating usage scenarios before you begin partitioning. It is a waste of resources to write code for both processors for a function that achieves no gains through dynamic partitioning. Begin by defining typical and worst-case usage scenarios. Then evaluate the scope of each function in the context of each scenario and its dependencies upon other functions.

Next, prioritize functions. You cannot compromise the processing of an image for storage, and it has the potential to become a system bottleneck. On the other hand, you can scale back the preview function, showing the picture a user is about to take, either in quality or in resolution if the system is overloaded. Users would rather have high-quality captured images than high-quality temporary images that they may never look at.

Developers need to package functions that they can dynamically partition so that the system integrator can easily use either version. Consider implementing a standardized set of coding conventions and APIs that abstract where a function runs and "wraps" the algorithm for system-ready use. Such guidelines are readily available; for example, Texas Instruments provides the TMS320 DSP Algorithm Standard, also known as Xdais. You probably also need to create a transparent transfer function that passes all relevant state, global, and system variables between processors to ensure a smooth transition when you dynamically repartition a function; no glitches should be on the screen when handing off autofocusing. An embedded kernel or operating system, such as BIOS/Link, provides straightforward mechanisms for efficiently bridging master and slave cores without requiring developers to reinvent such mechanisms.

Consider which peripherals and computational units a function needs to access. Some processors enable you to turn off portions of a chip that you aren't using. For example, you can use DMA to increase performance of a function. However, if the system is not in full use, you might increase power efficiency by dynamically not using DMA and turning off the DMA circuitry.

You can scale down functions. For example, if you have a dual processing core, you can choose to simultaneously process two images or two halves of the same image. In the first case, you need two full image buffers; in the second case, you can get away with a single image buffer by working on the same image in two parts and halving memory needs. Alternatively, some devices have multiple accelerators and coprocessors that allow for a long processing pipe. As a result, you can achieve high-performance processing through optimized parallel computing; imagine 10 engines running in parallel to process a block of data. Again, you have full control on how to use the available engines.

SOC programming used to be a difficult undertaking. However, as SOC designs become hardware/software hybrids and developers further abstract designs, designers can evaluate trade-offs at the system level. With the advanced high-level tools available today, a developer can seamlessly design a heterogeneous GPP, DSP, or another subsystem, bringing a system perspective across the entire design team. In this way, the traditional three-group development team can evolve to a more efficient single team with common expertise. This team, working in a single unified design environment, can develop a base hardware and software design for different products; for example, they can use the same heterogeneous SOC design for DSC (digital-still-camera) and DV (digital-video) camcorder products.

As developers tear down the walls between subsystems, they can unlock the advanced capabilities of even the most complex SOC architectures as simply as they do with single-core architectures (**Figure 2**). With the right tools and techniques, such as dynamic partitioning, they can squeeze more performance and longer battery life from their designs and more quickly bring products to market. EDN

AUTHOR'S BIOGRAPHY

Bruce Lee is a senior engineer at Texas Instruments. He has a bachelor's degree in electrical engineering from McGill University (Montreal, PQ, Canada) and more than 10 years of R&D experience in communications, robotics, and machine visions.

LINEAR TECHNOLOGY

DESIGN NOTES

High Voltage Current Mode Step-Down Converter with Low Power Standby Capability – Design Note 383

Jay Celani

Introduction

Low power standby requirements are typically associated with battery-powered systems. Automotive systems, for example, commonly require power supplies to maintain output voltage regulation even under no-load conditions—while drawing minimal quiescent current to preserve battery life. Rising energy costs, however, have extended the need for low current standby operation to line-powered systems, such as small plugged-in appliances for home and business.

Designing a power supply that is very efficient at light loads is particularly difficult in systems where high input voltages and substantial load currents are required. A common approach in such high power systems is to add a secondary power path for low current operation—a potentially significant increase in the cost, board space and complexity of the power supply.

A better solution is to use the LT®3800 as the core of a single-supply synchronous DC/DC converter. The resulting power supply is simple and efficient. An LT3800-based converter requires few external components, maintains high conversion efficiencies over a wide load range and supports low power standby operation for compliance with system power-management requirements.

High Efficiency at Standby

The LT3800 is a $4V_{IN}$ to $60V_{IN}$, 200kHz fixed-frequency controller that uses synchronous operation and N-channel MOSFETs to maximize high current efficiency. Current mode operation with continuous high-side inductor current sensing yields fast transient response and excellent line regulation. Low current standby requirements are met using Burst Mode® operation. A reverse inductor current inhibit feature also increases efficiency during light-load conditions. The LT3800 runs directly from the converter input supply, so there are no local supplies required to power the IC. The IC is also designed for easy use of output-derived power which further increases conversion efficiency. Cycle-by-cycle current limiting maintains the

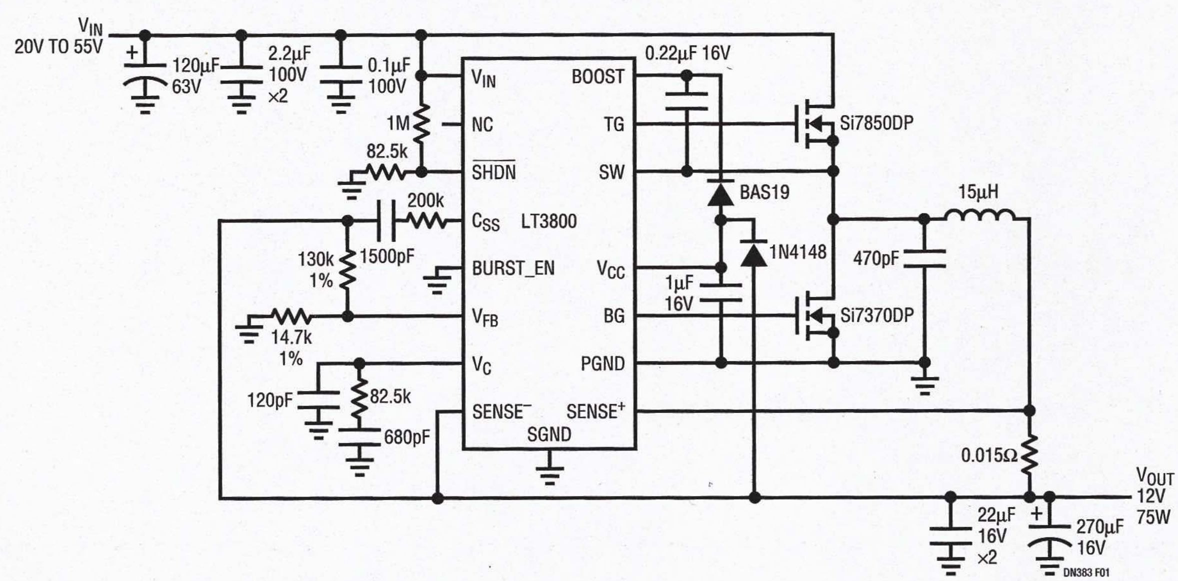

Figure 1. LT3800 12V, 75W Buck DC/DC Converter with High Efficiency at Light Loads

programmed current limit, even during instantaneous short circuit fault conditions.

12V/75W Synchronous Buck DC/DC Converter

Figure 1 shows a 12V, 75W DC/DC converter that can operate with input voltages from 20V to 55V. The 20V minimum input is set by a programmable UVLO function implemented using the precision hysteretic threshold of the LT3800 $\overline{SHDN}$ pin. The 55V upper bound is limited by switch FET margin. This converter provides full-load efficiencies above 95%, as shown in Figure 2, and can maintain a no-load output voltage with only 0.1mA of input supply quiescent current.

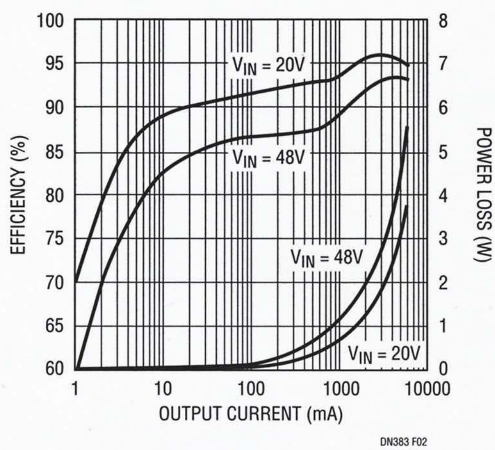

Figure 2. The DC/DC Converter in Figure 1 Exhibits High Efficiency Across a Wide Load Range and Produces Peak Efficiencies Above 95%

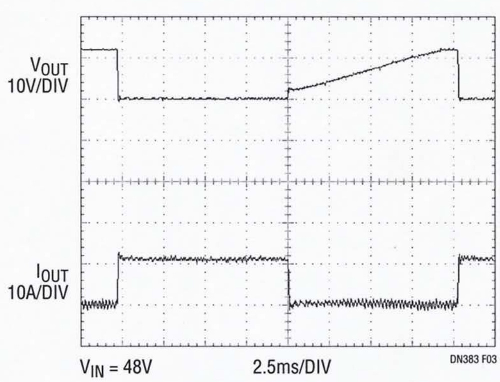

Figure 3. Current Limit is Maintained During Instantaneous Short-Circuit and Auto-Reset Soft-Start Yields a Graceful Recovery from the Fault Event

This DC/DC converter incorporates a controlled dV/dt soft-start function which servos the converter output voltage to a programmed rising rate during start-up—in this case 1.3V/ms, yielding a start-up rise time of just under 10ms. The LT3800 automatically resets the soft-start function if the output drops out of regulation, so recovery from a short circuit or brownout event is graceful and controlled.

The light load efficiency enhancement features of the LT3800 produce a supply that maintains high conversion efficiency across a 4-decade range. This DC/DC converter also features excellent heavy-load efficiency, producing peak conversion efficiencies as high as 96%.

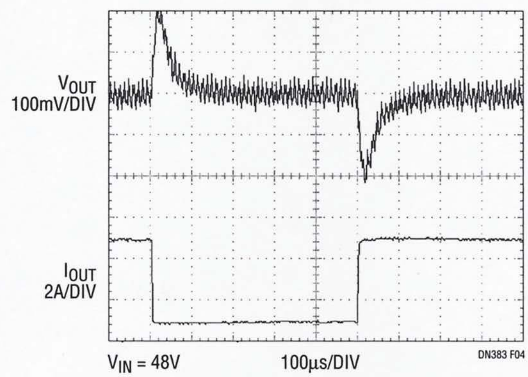

Figure 4. 1A to 5A Load Step Generates <2% V_{OUT} Transient

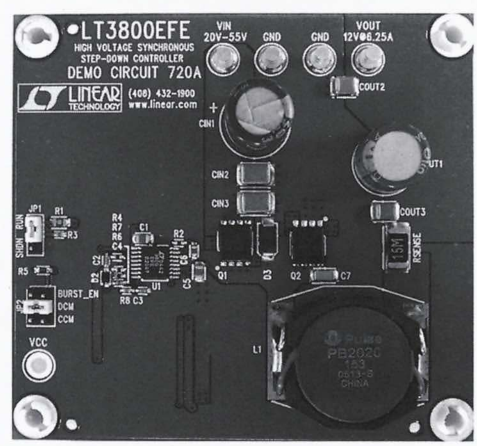

Figure 5. LT3800 12V, 75W DC/DC Converter Layout

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Op amp can source or sink current

Alfredo H Saab and Steve Logan,
Maxim Integrated Products Inc, Sunnyvale, CA

When you design for electronics applications, such as sensor or amplifier bias supplies or special waveform generators, a controlled constant-current source or sink circuit can serve as a useful building block. These circuits exhibit high dynamic-output impedance and deliver relatively large currents within an allowed range of compliance voltage. You can implement a constant-current circuit with an op amp and a discrete external transistor, but you can also design a bipolar version of a current source or sink around a single op amp and a few resistors (**Figure 1**). The constant-current sink circuits in **Figure 1a** through **Figure 1c** offer various compromises between precision, dynamic impedance, and compliance range.

The circuit in **Figure 1d** describes a bipolar current source with a simpler feedback configuration than that of the usual Howland-current pump, which requires positive feedback and presents variable input impedance. **Figure 1e** shows a constant-current source. All of these circuits exhibit excellent linearity of output current with respect to input voltage.

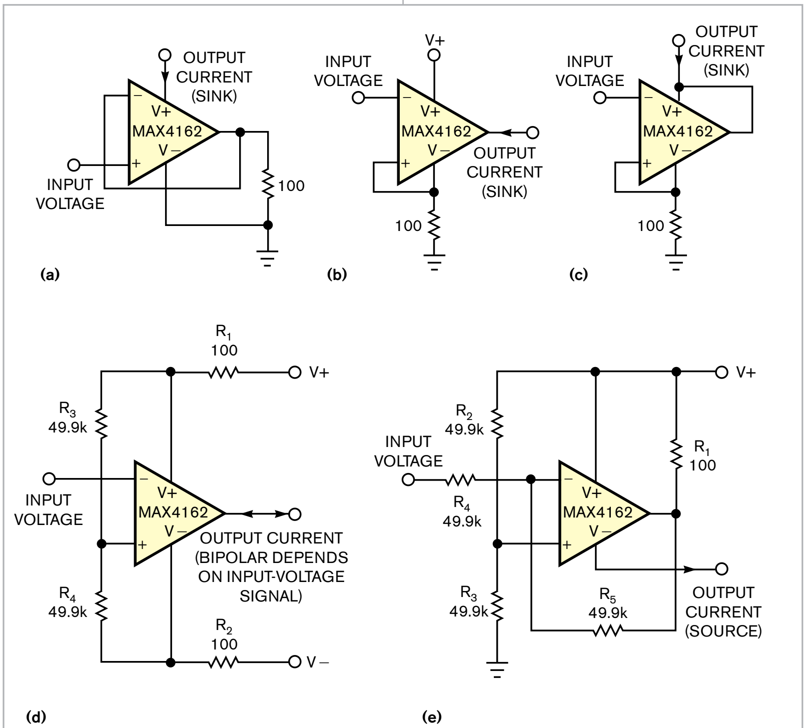

Figure 1 This compendium of constant-current circuits includes current sinks (a, b, and c), a bipolar sink or source (d), and a current source (e).

The output from the circuit in **Figure 1a** includes an uncertainty due to the op amp's quiescent current, which adds to the calculated output current. For example, in most applications, you can neglect the MAX4162 op amp's quiescent current of approximately 25 μA. The circuit in **Figure 1b** behaves similarly, but its quiescent current subtracts from the ideal output-current value. The circuit in **Figure 1c** provides a current sink with no quiescent-current error, and the circuit in **Figure 1d** presents a bipolar output—that is, it sinks or sources current—depending on the polarity of the input voltage. Its performance depends on close matching for the resistor pairs R_1 and R_2 and R_3 and R_4 and good tracking of the positive- and negative-power-supply voltages. Any difference between the absolute values of the supply voltages appears as an offset current at 0V input voltage. To achieve insensitivity to power-supply-voltage variations, the current-source circuit in **Figure 1e** requires close matching of resistor pairs R_2 and R_3 and R_4 and R_5.

You can use the following equations to calculate output currents for the circuits in **Figure 1**. Note that $R_{LOAD}=100\Omega$ in these examples. In **Figure 1a**, $I_{OUT}=-V_{IN}/R_{LOAD}+25\ \mu A$; in **Figure 1b**, $I_{OUT}=-V_{IN}/R_{LOAD}-25\ \mu A$; in **Figure 1c**, $I_{OUT}=-V_{IN}/R_{LOAD}$; in **Figure 1d**, $I_{OUT}=-2\times V_{IN}/R_{LOAD}$; and, in **Figure 1e**, $I_{OUT}=V_{IN}/R_{LOAD}$. The equation for circuit **1d** assumes perfect matches—that is, $R_3=R_4$, $R_1=R_2$, and $V+=V-$. It also assumes that R_4 is much greater than R_1.

For a fixed value of output current in each of the five circuits in **Figure 1**, the graphs of **Figure 2** show the circuits' dynamic impedance and range of useful output voltage (current compliance). The graphs show a high nominal output current of 5 mA to better display the higher end of the current-amplitude range. Depending on your application, you can optimize each circuit's dynamic impedance and current range through a judicious choice of op amps and resistor values.**EDN**

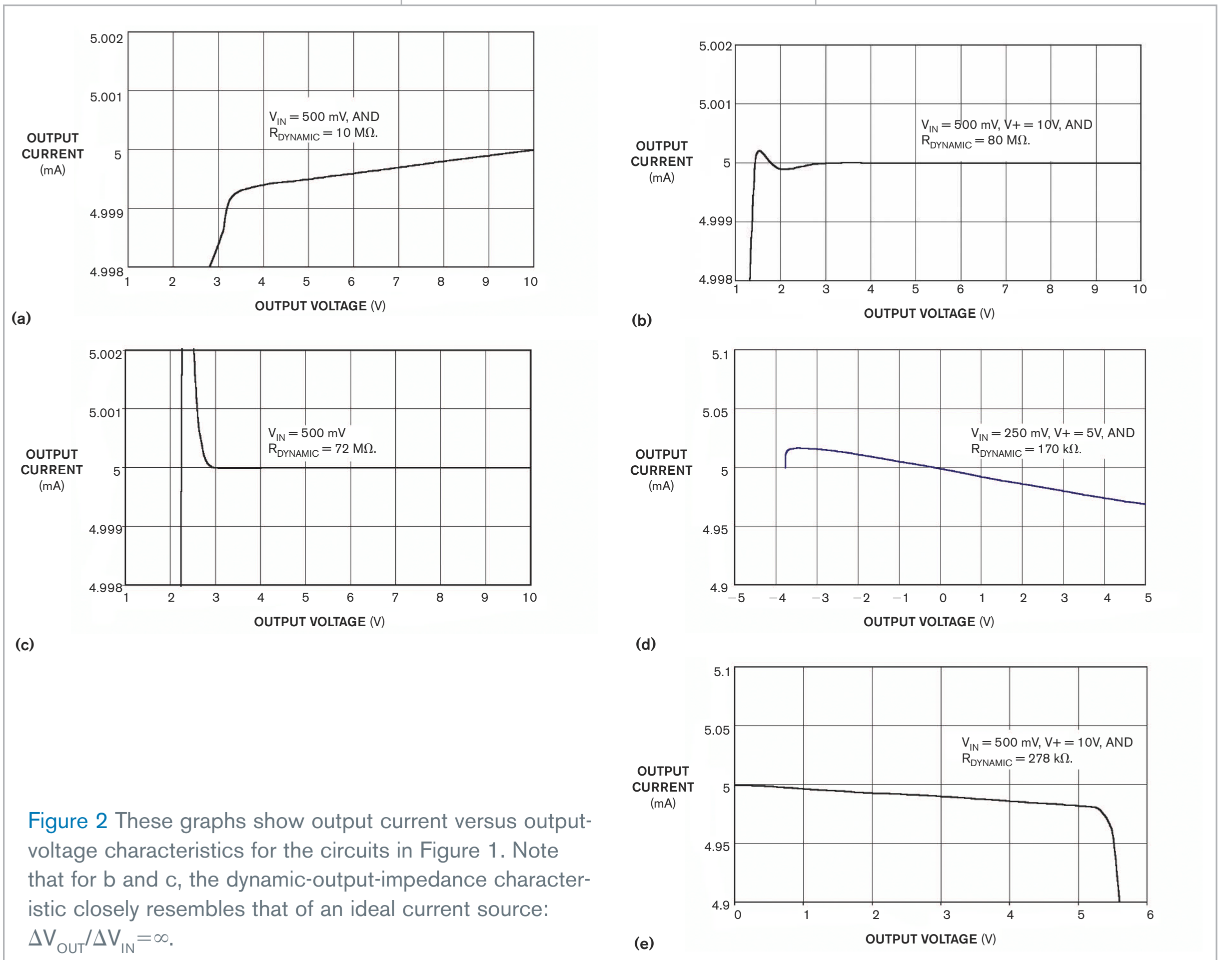

Figure 2 These graphs show output current versus output-voltage characteristics for the circuits in Figure 1. Note that for b and c, the dynamic-output-impedance characteristic closely resembles that of an ideal current source: $\Delta V_{OUT}/\Delta V_{IN}=\infty$.

Simple digital filter cleans up noisy data

Richard Rice, Oconomowoc, WI

Many systems use an ADC to sample analog data that temperature and pressure sensors produce. Sometimes, system noise or other factors cause the otherwise slowly fluctuating data to "jump around." To reduce higher frequency noise, designers often install an analog RC (resistor-capacitor) lowpass filter between the sensor and the analog-to-digital-conversion stage. However, this approach is not always ideal or practical. For example, a long time constant of minutes would require very large values for R and C.

Figure 1 shows an analog RC lowpass filter and its design equations. As an alternative, you can clean up noisy signals that remain within the ADC's lin-

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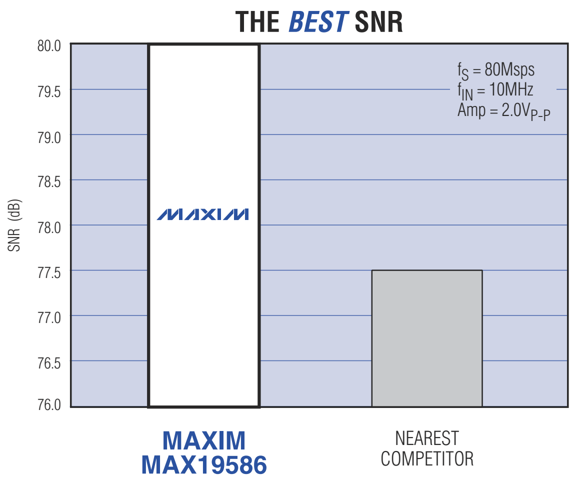

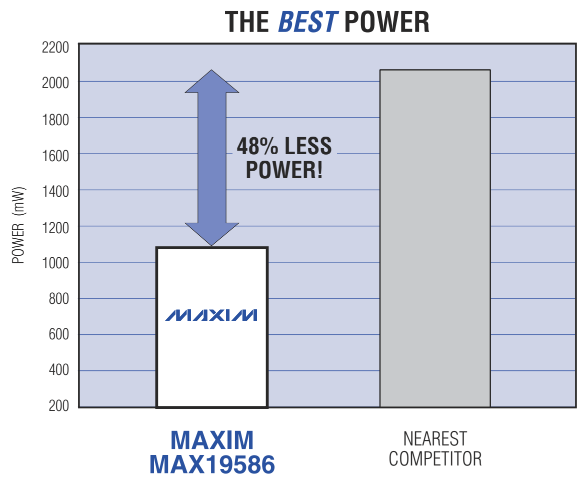

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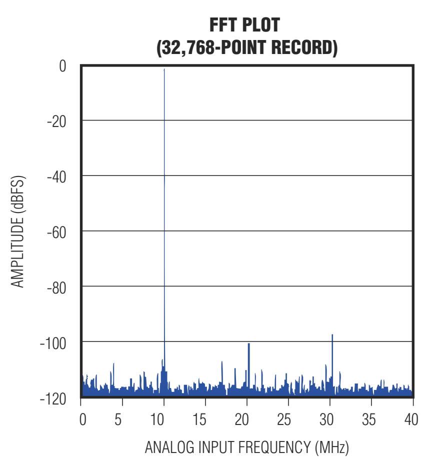

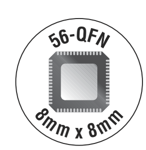

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ear range by using the digital equivalent of an analog RC lowpass filter. The filter's software comprises only two lines of C code: $LP_{OUT}=LP_{ACC}/K$, where the output value of the filter is LP_{ACC} divided by a constant, and $LP_{ACC}=LP_{ACC}+LP_{IN}-LP_{OUT}$, where you add the difference between input and output to update LP_{ACC}. You specify all variables as integers.

Each time the analog-to-digital conversion acquires a new input sample, LP_{IN}, the software produces an output value, LP_{OUT}, which comprises a lowpass-filtered version of the input samples. Calculate the value of the constant, K, based on the sampling rate of the system and the desired time constant for the filter as follows: $K=T\times SPS$, where $K>1$, and SPS is the system's sampling rate. For example, for a system-sampling rate of 200 samples/sec and a desired time constant of 30 sec, the constant K would equal 6000 samples. Applying a step change to the routine's input requires 6000 samples to reach approximately 63% of its final value at the output.

The lowpass accumulator, LP_{ACC}, can grow large for large time constants and large input values. It can grow as large as K times the largest possible LP_{IN} value. Under these conditions, you need to make sure that LP_{ACC} does not overflow, and you may need to specify a larger data type to contain LP_{ACC}. To avoid a long settling time during start-up, before the start of the sampling loop, you can initialize LP_{ACC} to a value of K times the current input value.

You can extend the basic filter concept presented to accommodate higher order filters with greater high-fre-

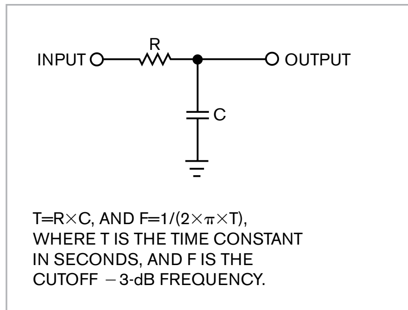

Figure 1 In some circumstances, a classic RC lowpass filter does an adequate job of removing noise from signals.

quency rejection by executing multiple filter code segments in sequence. Also, you can use an array of variables for LP_{ACC} and an array of values of the constant K to filter signals that multiple data channels acquire. EDN

Single switch selects one of three signals

Felix Matro, JL Audio Corp, Phoenix, AZ

This Design Idea shows how you can use a single-pole momentary-contact switch to select one of three signal sources by scrolling through three output states. The circuit in **Figure 1** comprises commonly available components from the CD4000 CMOS-logic series, along with a general-purpose NPN transistor. The total cost of the components doesn't exceed \$1. Only one of circuit's three outputs, CH_1, CH_2, or CH_3, goes low at any given time, and you can use these outputs to control analog switches, relays, or the gates of JFET switches. As long as you apply power, the

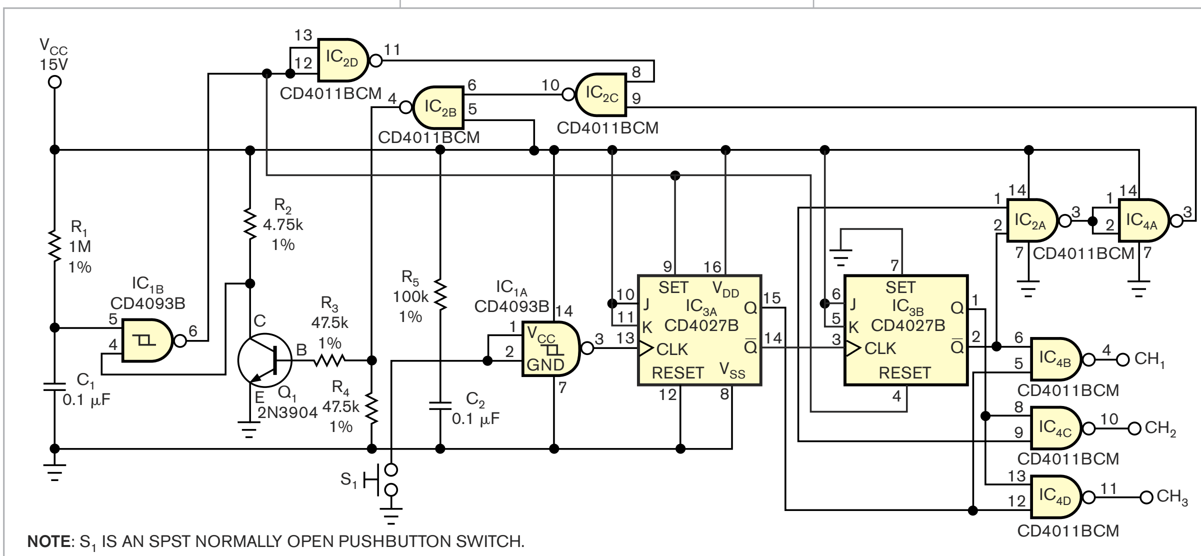

Figure 1 A handful of active and passive components form a one-of-three selector switch. Press switch S_1 once to advance to the next channel and twice more to revert to Channel 1.

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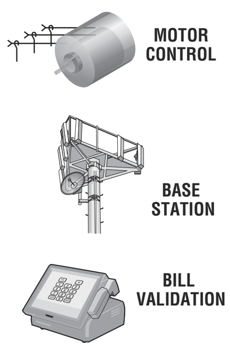

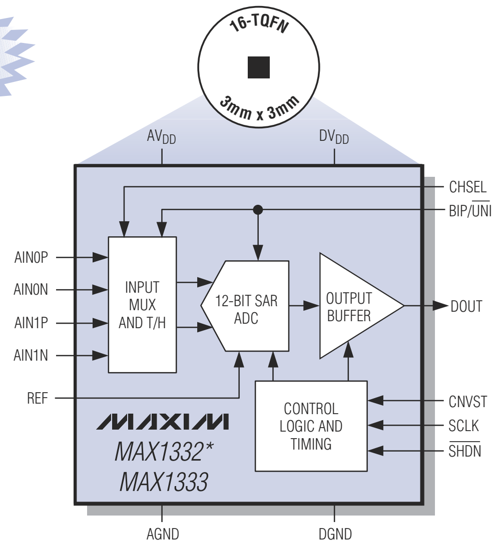

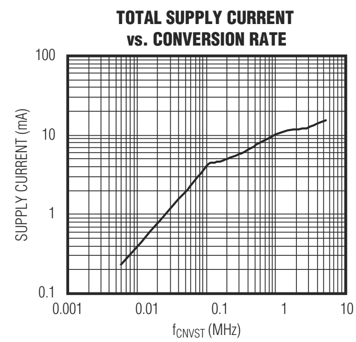

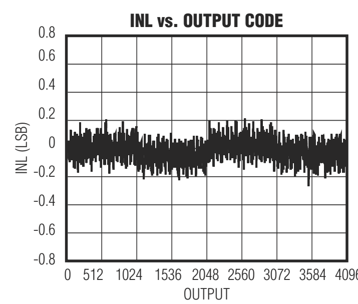

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MAX1333	12	+2.7 to +3.6	2	16-TQFN	6.25
MAX1334*	10	+4.75 to +5.25	4	16-TQFN	3.75
MAX1335	10	+2.7 to +3.6	4	16-TQFN	3.37
MAX1336*	8	+4.75 to +5.25	6	16-TQFN	1.85
MAX1337	8	+2.7 to +3.6	6	16-TQFN	1.85

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selected output does not change, making the circuit a good choice for applications requiring nonvolatile operation. Quiescent-current consumption averages only about 15 μA at room temperature, 25°C, a low value even for battery-powered applications.

The heart of the circuit comprises a dual JK flip-flop, IC_3, that's configured as a 2-bit ripple counter. Without additional circuitry, the counter would allow selection of four signal sources. Upon initial application of power, a reset circuit comprising R_1, C_1, and IC_{1B} always sets the CH_1 output to a logic-low level.

When the $\overline{Q}$ outputs of IC_3, pins 2 and 14, both go to logic zeros, the feedback chain comprising IC_{2A}, IC_{2B}, IC_{2C}, and IC_{4A} pulls Q_1's base to a logic-high level, which in turn pulls one input of IC_{1B} to a logic low. This action causes the counter to skip the 00 state and advances the count to the 01 state. Components R_5, C_2, IC_{1A}, and normally open momentary-contact switch S_1 constitute a debounced switch that provides clock pulses for both sections of the counter, IC_3. When a user pushes S_1, the counter advances to the 10 state, and a subsequent push advances the counter to the 11 state. A third push restarts the cycle. To summarize, IC_{4B} decodes the counter's 01 state and pulls CH_1 low, IC_{4C} decodes the counter's 10 state and pulls CH_2 low, and IC_{4D} decodes the counter's 11 state and pulls CH_3 low. The layout of the circuit should be noncritical, but use a low-leakage capacitor for C_1. Connect unused logic inputs to ground or V_{CC} as appropriate. EDN

R_5, C_2, IC_{1A}, AND NORMALLY OPEN MOMENTARY-CONTACT SWITCH S_1 CONSTITUTE A DEBOUNCED SWITCH THAT PROVIDES CLOCK PULSES FOR BOTH SECTIONS OF THE COUNTER.

Low-cost audio filter suppresses noise and hum

Richard M Kurzrok, RMK Consultants, Queens Village, NY

The low-cost composite passive filter in this Design Idea requires no dc power and can enhance the performance of audio equipment and instrumentation by rejecting power-supply hum and spurious pickup from AM, FM, and low-band VHF transmissions (**Figure 1**). The composite filter comprises a cascade of three simple filters: a T-section highpass filter to reject power-source hum and two π-section lowpass filters to reject spurious RF signals. As a starting point, the three filter sections present a lossless 0.01-dB Chebyshev response at a 50Ω impedance level, but you can scale the components' values to meet other impedance requirements.

Table 1 lists the components the prototype filter uses. With the exception of inductor L_3, all the components are standard values that are available off the shelf. Switch S_1 provides a bypass mode that permits rapid frequency-response measurements without connection and disconnection of the prototype's BNC connectors. To construct the prototype, wire all components to a section of perforated breadboard stock supported by metal spacers that mount inside a die-cast aluminum enclosure. This method of shielded construction has proved its worth in other laboratory-accessory applications (**Reference 1**). **Table 2** lists the filter's measured insertion loss over a range of 40 Hz to 200 MHz.

Low-cost polarized electrolytic capacitors C_1 through C_6 provide reasonable performance, but observe input polarity for signals with a dc component. For a modest increase in cost and assembly time, you can enhance filter performance and reproducibility by selecting the values of these capacitors to meet a 10% or better tolerance. For best results, use nonpolarized film-dielectric capacitors for C_1 through C_6. For noncritical applications, you can relax the tolerances for the remaining capacitors and use off-the-shelf inductors for 22-mH L_1, 0.68-mH L_2, and 3.9-μH L_3.

Redesigning the filter to match the 600Ω impedance that you find in classic audio circuits would increase the

TABLE 1 COMPONENTS IN THE PROTOTYPE FILTER

Reference designators	Values	Description
C_1, C_2, C_4, C_5	10 μF	50V electrolytic capacitor, ±20% tolerance
C_3, C_6	4.7 μF	50V electrolytic capacitor, ±20% tolerance
C_7, C_9	0.15 μF	Polypropylene capacitor, ±2% tolerance
C_8, C_{10}	0.033 μF	Polypropylene capacitor, ±2% tolerance
C_{11}, C_{12}	0.001 μF	Polypropylene capacitor, ±2% tolerance
L_1	22 mH	Inductor, ±5% tolerance
L_2	0.68 mH	Inductor, ±10% tolerance
L_3	3.85 μH	Inductor, 27 turns of AWG #28 magnet wire hand-wound on T37-2 mixture (Carbonyl E) toroidal core
S_1	NA	DPDT panel-mounted toggle switch
J_1, J_2	NA	50Ω BNC panel jack
NA	NA	Hammond 1590H-BK die-cast aluminum enclosure

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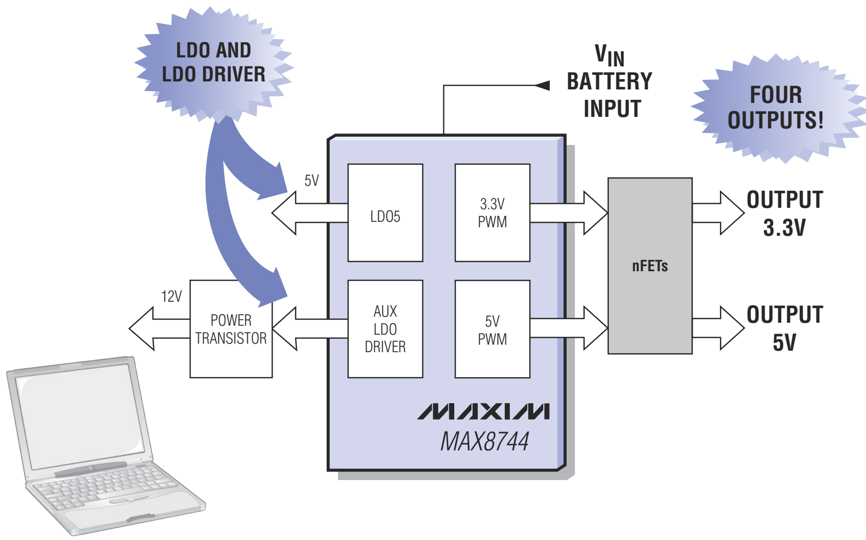

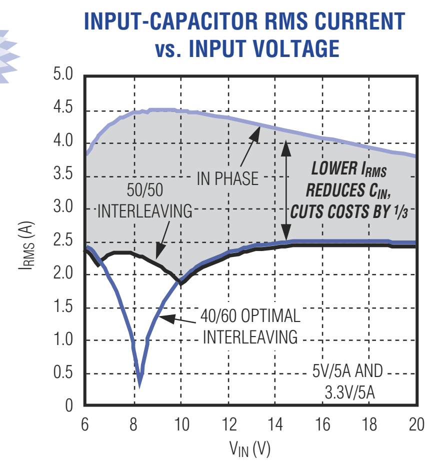

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MAX1533	5	3.3V/5V	n/a	32-TQFN (5 x 5)	5.10

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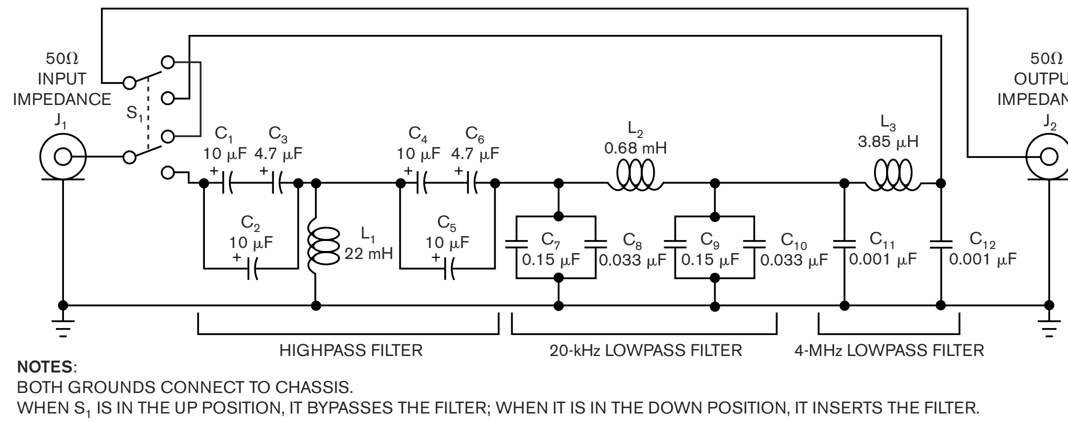


Figure 1 A highpass filter and two lowpass filters help reduce or eliminate low-frequency hum and high-frequency noise from audio signals.

inductors' values by an order of magnitude, which would increase the inductors' dimensions and costs. An alternative design approach could use cascaded active-RC filters, which would pave the way for their inclusion into completely integrated composite-audio filters. EDN

REFERENCE

1 Kurzrok, Richard M, "Simple Lab-Built Test Accessories for RF, IF, Baseband, and Audio," *High Frequency Electronics*, May 2003, pg 60.

TABLE 2 FILTER INSERTION LOSS

Frequency (kHz)	Insertion loss (dB)	Frequency (MHz)	Insertion loss (dB)
0.04	45.2	0.1	42.3
0.07	35.4	0.3	60
0.1	29.4	0.5	60
0.2	17.3	1	55.5
0.3	10.9	2	52.2
0.5	5.5	3	51.1
1	2.7	4	56.2
2	2	5	60
5	1.9	10	46.5
10	2.1	25	44
15	2.7	50	40.5
20	4.5	100	39.5
30	11.7	150	45
50	24.5	200	44

Microprocessor's single-interrupt input processes multiple external interrupts

Abel Raynus, Armatron International Inc, Malden, MA

On the lower end of the performance spectrum, many widely available and inexpensive microcontrollers pay for their small pc-board footprints by omitting functions. For example, most low-end processors provide only one external-interrupt input pin and only one address vector in memory for the service routine that processes external IRQs (interrupt requests). However, a project occasionally requires that several interrupt-service programs must process multiple external interrupts from various sources. Cost and inventory constraints may make it undesirable to choose another microcontroller whose only advantage is the availability of a few more interrupt pins.

For example, Freescale Semiconductor's (www.freescale.com) popular Nitron family of flash-memory microcontrollers, such as the MC68HC908QT and QY, offer only one IRQ input pin. You can use one-time-programmable versions of the family, such as the MC68HC705KJ1 or MC68HC705J1A, that offer five external-interrupt inputs but omit some of the family's valuable functions, such as flash memory, built-in analog-to-digital conversion, and an advanced instruction set. You could also select a larger microcontroller, such as the MC68HC908JL3, from the same product family to gain eight external-interrupt inputs at the expense of significant increases in cost and pc-board area.

This Design Idea offers an alternative that retains the small processor and adds extra interrupt inputs. The technique involves applying the interrupt signals to an AND gate to generate an IRQ signal and using the microcontroller's inputs to recognize the interrupt's source. For example, consider the four external-interrupt sources in **Figure 1**. If you apply no interrupt signals and if all of the AND gate's inputs rest at logic ones, the IRQ level also remains at logic one. Applying an interrupt signal (a logic-zero level) to any one of four inputs, INT1 through INT4, drives the gate's output to a low level and triggers the interrupt. The interrupt-service routine recognizes the interrupt's source by testing the levels of input pins PA0, PA1, PA4, and PA5 and executing the corresponding interrupt-service routine.

The MC68HC908QY2 microcontroller, IC_1, includes built-in pullup resistors that eliminate the need for external resistors, and you can use an inexpensive and readily available 74LS21 for IC_2. For demonstration purposes, this circuit displays the address of an incoming interrupt by lighting one of four corresponding LED indicators for 3 sec. The software routine in **Listing 1** that assigns a priority to each interrupt uses the standard set of assembler instructions and can apply to any microcontroller. You can download **Listing 1**, as well as the sample's assembler code and its accompanying table of equations (**Listing 2**), from www.edn.com/060302di1. EDN

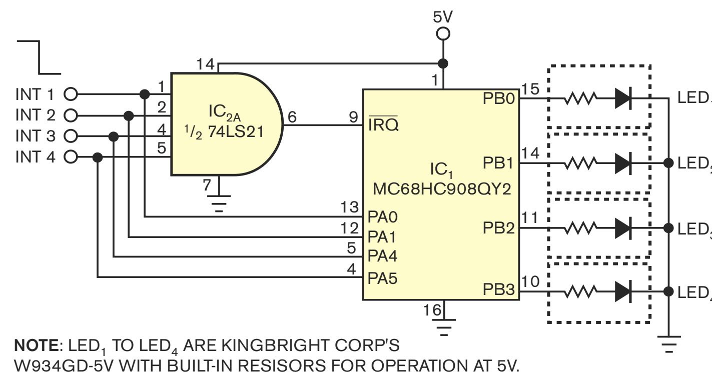
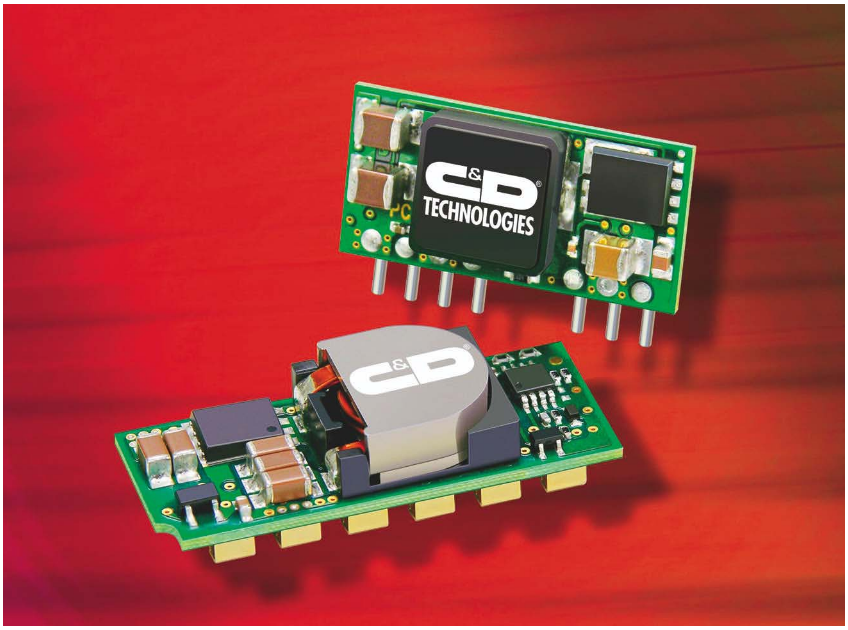


Figure 1 An external AND gate plus a software routine expand a microcontroller's single interrupt input into four inputs.

productroundup

POWER SOURCES



Point-of-load converters minimize need for external components

The surface-mount LSM2 and through-hole LSN2 nonisolated, point-of-load dc/dc converters require no heat sinks or external filter components. These devices feature 0.75 to 5V user-selectable outputs and 2.5 to 5.5V or 9 to 14V input-voltage-range options, suiting distributed-power and intermediate-bus architectures. The range comprises six modules with 6, 10, and 16A output-current options for each input voltage and can deliver as much as 52W of output power. The 16A LSM2 and LSN2 converters cost $13 (1000).

C&D Technologies, www.cd4power.com

Converters target wireless power amplifiers

Delivering a 250W output power, the JHW250 series of dc/dc converters comes in a half-brick format for RF power-amplifier applications. Targeting wireless base stations and similar telecom equipment, these isolated converters operate over a 36 to 75V-dc range and provide a single 30.2V regulated output. Measuring 2.28×2.4×0.5 in., each module in the JHW250 series costs $86.10 (1000).

Tyco Electronics Power Systems, www.power.tycoelectronics.com

Switcher integrates FET device, supports 5.5 to 36V input

The high-efficiency, 500-kHz, nonsynchronous TPS5430 Swift converter provides 90% efficiency and 2% output-voltage accuracy as low as 1.23V. This step-down dc/dc IC integrates an FET delivering a continuous 3A output current and supports 5.5 to 36V input voltages. Operating at −40 to +125°C, the device suits environments requiring good thermal performance. Targeting point-of-load-system applications, such as industrial systems, digital televisions, DVDs, battery chargers, and 12 to 24V distributed-power systems, the TPS5430 comes in an HSOIC package and costs $1.85.

Texas Instruments, www.ti.com

400-mA dc/dc converter delivers 0.5 to 5V outputs

From a single-cell lithium-ion input, the synchronous LTC3444 dc/dc converter delivers as much as 400 mA of continuous output current to 0.5 to 5V outputs. A buck-boosting design enables operation from input voltages above, below, and equal to the output voltages. The IC provides a continuous high-efficiency transfer function through all operating modes, suiting it for single-cell lithium-ion 3G WCDMA applications. A 1.5-MHz switching frequency allows for the use of small ceramic capacitors and inductors. The LTC3444 comes in a 3×3-mm DFN package and costs $2.40 (1000).

Linear Technology, www.linear.com

Lithium-ion-battery charger includes a cold-temperature offset

The linear, single-cell SC804 lithium-ion-battery charger integrates a cold-temperature-offset pin that allows an external resistor divider to adjust the charging-temperature range. The device allows a board design to function in multiple applications requiring different temperature ranges. A 3 to 14V input-voltage range provides protection for portable devices from 12V adapter overshoots and third-party adapters. A 3V undervoltage lockout suits the battery charger for current-limited adapters. Additional features include a 1.5A continuous-charge current; a 4.2 or 4.35V output voltage; programmable precharge, fast-charge, and termi-

productroundup

POWER SOURCES

nation current; and a battery pack with 1% voltage accuracy and adapter flexibility. The SC804 battery charger costs $1.43 (1000).

Semtech Corp, www.semtech.com

Power-conversion-IC family uses an on/off-control scheme

Using a 700V MOSFET with low-voltage control circuitry on a monolithic IC, the TinySwitch-III also features an integrated autorestart, input-undervoltage and output-overvoltage protection, hysteretic thermal shutdown, and frequency jittering to minimize EMI. Selectable current limits provide the choice of three current-limit values without the need for additional IC pins or external components, allowing for maximum efficiency or greatest power-output optimization. An on/off-control scheme delivers virtually constant efficiency regardless of load, as opposed to PWM and self-oscillating designs that exhibit diminishing efficiency as load decreases. Available in DIP-8 and SMD-8 packages, the 6W TNY274PN costs 79 cents (1000), and the 28W TNY-280PN costs $1.45 (1000).

Power Integrations, www.powerint.com

Power supply targets PC modification

Measuring 31×45×20 mm, the picoPSU-120 is 10 to 20 times smaller than standard PC power supplies. Using HyperWarr technologies, the device provides 120W of power for small PCs using a 12V power source. Suiting PC modification, embedded-system applications, robotics, and industrial applications, the ATX-compliant power supply plugs directly into the ATX connector. The picoPSU-120 costs $49.95.

Mini-box, www.mini-box.com

Compact ac/dc power supplies use regulated triple outputs

Providing 20W output power in a compact, fan-cooled case, the HF20W-TL series ac/dc switchers have an 85 to 264V-ac input and robust filtering. Three models provide 5/±12, 5/±15, or 5/12/−5V-dc regulated triple-output combinations. Standard features include a 1% maximum line/load regulation, a 3-kV-ac I/O isolation, a 0.5-mA input-leakage current, and a 20-msec holdup time. The series has a 100,000-hour MTBF in accordance with military standard HDBK 217F and meets CE and EN60950 requirements. Available in a 4.4×3×1.42-in. case, the HF20W-TL series costs $19.75 (100).

MicroPower Direct, www.micropowerdirect.com

4W single-output switching power supply provides 5.5V dc

With a 90 to 264V-ac universal input and regulated output voltages, the single-output DA4 series switching power supply delivers 5.5V dc with 4W total power and 15-msec typical holdup time. For 0 to 0.75A loads, the device features overload and short-circuit protection and built-in EMI filtering. Measuring 60×28×45.8 mm, the DA4 wall-mount series costs $5.

Emerson Network Power, www.astecpower.com

productroundup

POWER SOURCES

VR11 PWM controllers integrate a load line

The ISL6306/07 family combines with the vendor's FET drivers to provide control and switching functions for VR11 CPU-core, multiphase, buck dc/dc converters on desktop, workstation, server, and industrial-PC motherboards. These devices feature two-, three-, four-, five-, and six-phase operation for flexible voltage-regulation design. An integrated load line and overcurrent-protection temperature compensation allow the same current-limit threshold over temperature without the need for external components. The family controls the microprocessor's core voltage by driving as many as six synchronous-rectified buck channels in parallel. The ISL6306 targets desktop and embedded systems, and the ISL6307 family suits servers and voltage-regulator modules. In addition to the ISL6306/07 family, the vendor also features the ISL6326/27 VR11 controller family with a dual-edge PWM scheme that is pin-to-pin-compatible with the ISL6306/07 and requires no capacitors. The ISL6306 comes in a QFN-40 package and costs $2.47. The ISL6307, ISL6307A, and ISL6307B come in QFN-48 packages and cost $3.15, $3.41, and $3.52 (1000), respectively.

Intersil Corp, www.intersil.com/power

INTEGRATED CIRCUITS

ICs feature iTMDS technology

Enabling manufacturers to build high-resolution HDTVs supporting 30- and 36-bit RGB deep color, the SiI 7170 transmitter and SiI 7171 receiver use iTMDS (internal-transition-minimized-differential-signaling) technology. HDTV internal links allow color depths of 36 bits at 1920×1080-pixel progressive (1080p) resolution. The products also feature a scalable bandwidth of 25 to 225 MHz and DVI 1.0 environment compliance. The SiI 7170 comes in a thermally enhanced MQFP-128 housing, and the SiI 7071 comes in a thermally enhanced TQFP-128 package. Both products cost $6 (10,000).

Silicon Image Inc, www.siliconimage.com

Two advanced DVD-codec series incorporate DEPF

These advanced DVD codecs incorporate a 108-MHz video DAC and DEPF (diagonally enhanced picture formatting). The MS9300 chip series suits optical-DVD recorders, and the MS9400 chip series targets DVD recorders and includes a hard-disk drive with a capacity as high as 400 Gbytes.

Magnum Semiconductor, www.magnumsemi.com

Image processor uses VXP technology

As the latest addition to the vendor's family of image processors, the GF9351 image processor uses VXP technology, providing enhanced features in fourth-generation broadcast-quality algorithms. The product includes TruMotion-HD, providing 1080i-to-1080p adaptive deinterlacing; FineEdge, with dynamic directional interpolation; FidelityEngine, featuring image enhancements for removal of unwanted noise; and RealityExpansion, including 10-bit image processing for natural color.

Gennum Corp, www.gennum.com

Dual-channel video decoder features video-compression technologies

Video-compression technologies in the BCM7400 dual-channel video decoder include AVC (advanced video coding), VC-1, and MPEG-2, providing support for HD (high-definition-) and standard-definition-television programming. Additional features include dual audio and video HD channels, delivering HD programs to multiple televisions; a 128-kbyte, second-level cache providing 875 Dhrystone MIPS; integrated PVR capability; an advanced 2- and 3-D-graphics engine; an integrated content-security processor; and 10/100 fast Ethernet and USB 2 integrated-peripheral interfaces. The BMC-7400 comes in a QFP-1521 packaging and costs $49.50 (10,000).

Broadcom Corp, www.broadcom.com

Stereo-codec card suits digital video

Targeting sound cards, digital televisions, and portable video recorders, the 103-dB-SNR, 24-bit sigma-delta-DACWM8569 stereo codec includes oversampling and digital-interpolation filters. The device also features a 100-dB-SNR sigma-delta ADC and programmable audio-data interface modes supporting I²S, DSP, and left- and right-justified digital-audio formats. Analog supply voltages range from 2.7 to 5.5V, and digital supplies range from 2.7 to 3.6V. Available in an SSOP-28 package, the WM8569 costs $1.33 (10,000).

Wolfson Microelectronics, www.wolfsonmicro.com

productroundup

COMPUTERS & PERIPHERALS

SATA RAID storage systems run at 3 Gbytes/sec

Comprising hardware-accelerated iSCSI, Fibre Channel, and U320 SCSI host systems, the vendor's Vtrak M-Class SATA RAID (redundant-array-of-inexpensive-disks) system now includes the M200p, M300p, and M500p U320 SCSI host systems. These 3-Gbyte/sec SATA RAID storage systems feature NCQ (native-command queuing), staggered spin-up, and drive-hot-swap support, as well as an I/O processor based on Intel Xscale technology, and ECC cache memory with battery-backup cached data protection. An M200p comprises an eight-bay, 2U, dual-host U320 SCSI; an M300p has a 12-bay, 2U, dual-host U320 SCSI; and an M500p has a 15-bay, 3U, dual-host U320 SCSI. The eight-bay model, without drives, costs $3699.

Promise Technology, www.promise.com

LCD monitors target professional, corporate markets

This family of high-end LCD monitors includes the 60-in. SyncMaster 460pn, the 40-in. SyncMaster 400pn, the 60-in. SyncMaster 460p, and the 40-in. SyncMaster 400p. The 400pn and 460pn provide an Ethernet connection and the vendor's MagicNet technology and digital signage without a dedicated PC for each display. The 400p and 460p feature the same high-end display technologies without the MagicNet enhancements. Each monitor has an 8-msec response time, with a 1366×768-pixel resolution, a 170° horizontal and vertical viewing angle, a 500-cd/m^2 brightness, and an 800-to-1 contrast ratio. Additionally, the monitors feature interfaces for composite video; S-video; component video for DVD and HDTV at 480 i/p, 720 p, and 1080i; and RGB analog and digital interfaces for PCs. Targeting the professional and corporate markets, the SyncMaster 460pn, 400pn, 460p, and 460p cost $6999, $5299, $6749, and $4999, respectively.

Samsung, www.samsung.com

Four- and eight-port RAID controllers use NCQ technology

The four-port 2420SA and eight-port 2820SA SATA-II controllers build on the vendor's SATA product line with NCQ (native-command-queuing) technology. The vendor also offers a data-protection suite, which includes support for RAID (redundant-array-of-independent-disks) 5EE hot space, a RAID 1E striped mirror, Copyback Hot Spare, and RAID 6 technology for the 2820SA. Targeting workstations and servers, the eight-port controller has a 64-bit, 133-MHz PCI-X host interface, and the four-port controller targets high-density servers. Both cards come standard with 128 Mbytes of ECC-protected DDR DRAM; 256 Mbytes of DRAM and a battery unit are optional. The 2420SA and 2820SA cost $375 and $575, respectively.

Adaptec Inc, www.adaptec.com

Barracuda drives have 0.5-Tbyte capacity

The Barracuda 7200.9 family combines an 80-Gbyte to 0.5-Tbyte capacity with 3-Gbyte/sec Serial ATA 2.5 throughput and NCQ (native-command-queuing) technology. Ultra ATA 100 interface drives are also available.

Seagate Technology, www.seagate.com

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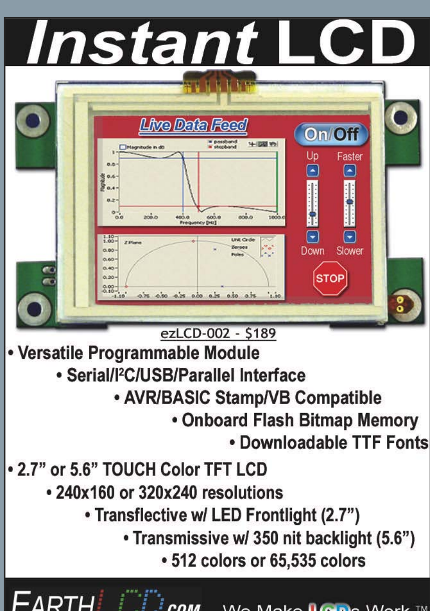

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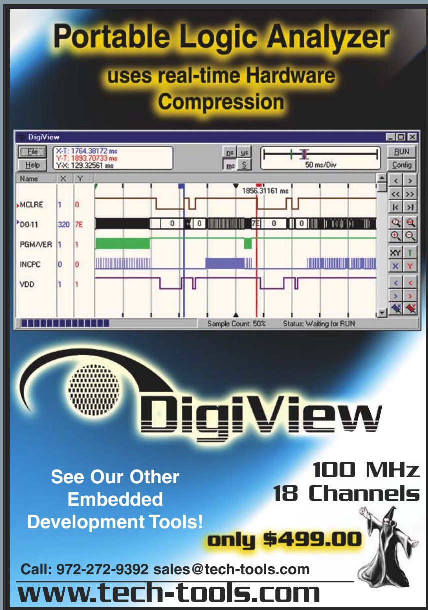

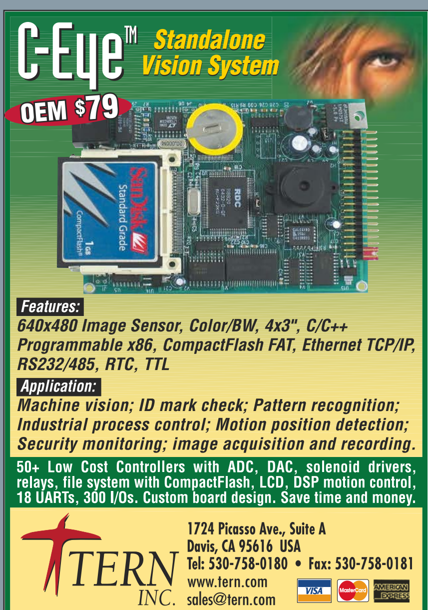

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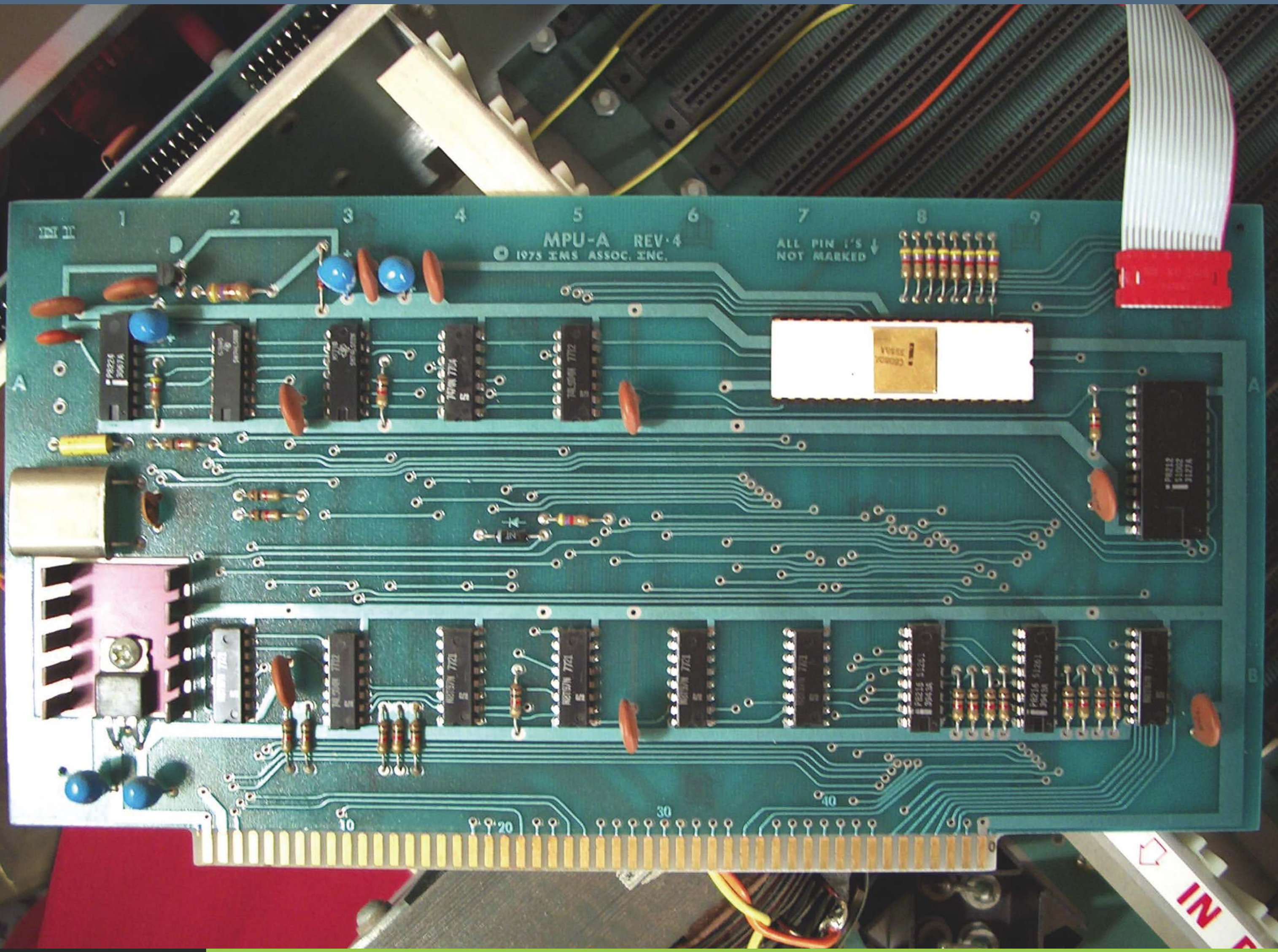


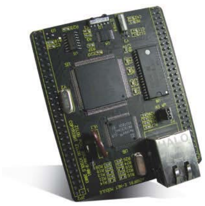
PHOTO COURTESY COMPUTER-HISTORY.ORG

STATS Debuted in PCs in 1975 / 200,000 operating by the mid-1980s / Based on the 8080

S-100: the first "industry-standard" bus

The PC era exploded when the January 1975 cover of *Popular Electronics* magazine announced the Altair 8800, a $397 computer kit that included the Intel 8080 microprocessor, 256 bytes of memory, and an open expansion bus. The bus, originally called the Altair bus and later renamed the S-100 bus, allowed users to add memory and peripherals and became the common architecture for many early PC systems. By the early 1980s, there were 200,000 S-100 systems in operation, with nearly 100 manufacturers offering hundreds of compatible plug-in boards.

MITS (Micro Instrumentation and Telemetry Systems) founder Ed Roberts based the bus design on many of the 8080 microprocessor signals and a supply of low-cost, 100-pin edge connectors. The original specifications included two unidirectional, 8-bit data buses; a single bidirectional, 16-bit address bus; and plenty of status, control, and clock signals. Individual boards required voltage regulators to translate the 8V and ±16V backplane power into 5V dc for TTL ICs and ±12V dc for RS-232 drivers. To deal with the differences among some board vendors, the IEEE finally standardized the S-100 bus in June 1981 as IEEE-696. The S-100 bus slowly slid into obscurity over the next five years as the world turned its attention to the IBM PC.—by Warren Webb



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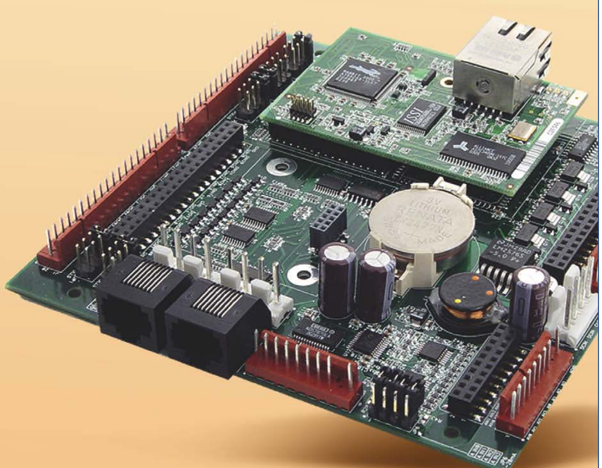

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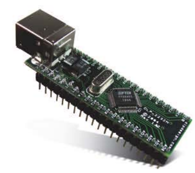

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Metering

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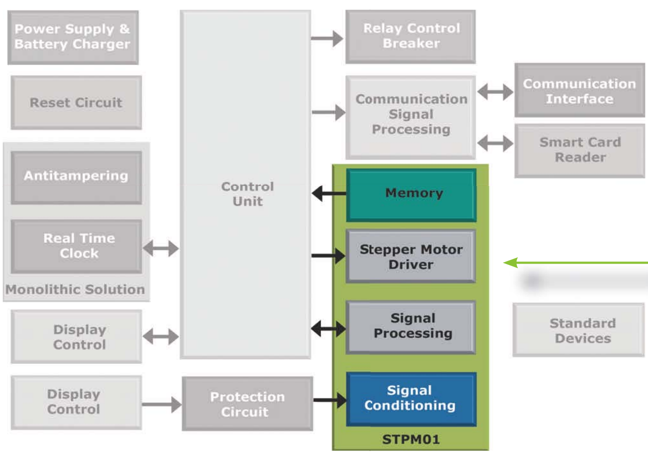

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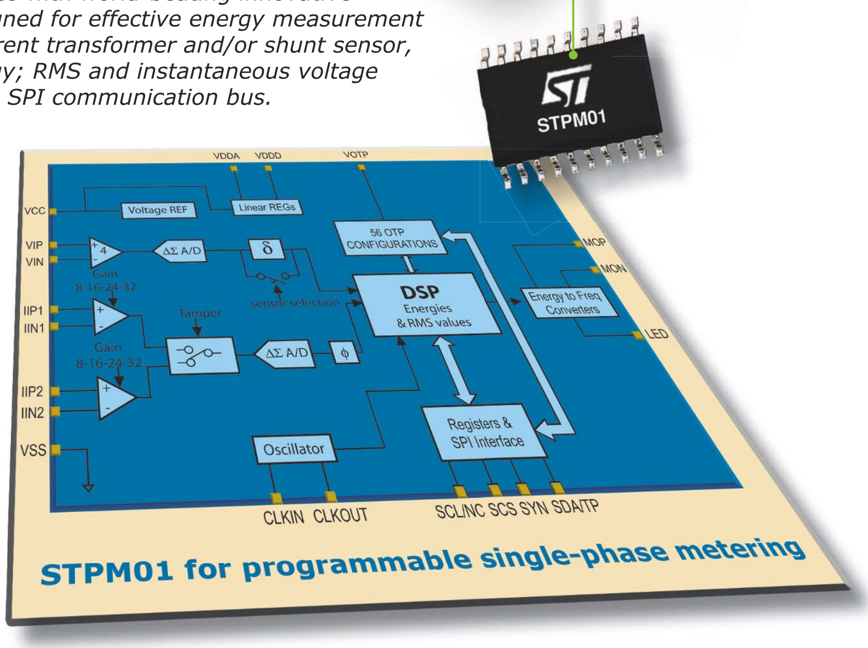

STPM01 Main Features

- Active, reactive, apparent energies and RMS values
- Shunt, current transformer, Rogowski coil sensors
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- OTP for calibration and configuration
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For further information, datasheets and application notes visit www.st.com/STPM01

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