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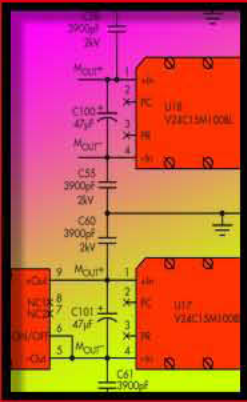
EVC MLCCs enter the power electronics fray, going up against its film and Al-electrolytic brethren



MODULAR DC-DC CONVERTERS CONTINUE TO SERVE THE MILITARY

COTS apps take advantage of the enormous size and format range of these high-density converters

editorial

by Paul Whytock

THE NANO "PICK-ME-UP" FOR BIOELECTRONICS

Ever play that game called Mikado, sometimes known as pick-up sticks? You hold a bunch of thin colour-coded sticks, let them fall onto a table, and then try to pick them up one at a time without moving adjacent sticks. The problem is that if one of the sticks is in contact with another, it's almost impossible.

But this Mikado-like contact scenario may prove to be the basis for organic nanoscale wires, which would provide an alternative to traditional silicon methods of creating chips. How so?

In a rather unique technical collaboration between the Chinese Academy of Sciences and the Nano-Science Center at the University of Copenhagen in Denmark, specialists from these two bodies developed nanoscale electric contacts out of organic and inorganic nanowires. The wires are configured in a contact pattern similar to the Mikado game. These contact points have created switching abilities that could compete with conventional transistors.

The researchers used organic nanowires combined with tin-oxide nanowires. Like the Mikado game, the nanowires cross in a device consisting of four to six active transistor elements. A particularly encouraging sign is that the devices demonstrate a low operational current, high mobility, and good stability, all of which are necessary characteristics in order to compete with silicon.

Organic nanowires may be just what's needed to perpetuate Moore's Law, satiating the inherent desire of the electronics industry to double the transistors on a chip every two years. Don't forget, nanoscale is between 1 and 100 nanometres, and a nanometre is one billionth of a metre.

However, scientists have already found that working at nanoscale dimensions can mean throwing away the physics rule book when it comes to certain materials and their conventional insulation or conductive characteristics.

For instance, make an insulator of nanowire proportions and it is no longer a true insulator. Certainly it will still stop an electron passing through it. But at the nanoscale level, the electron somehow travels around the exterior of the insulator.

Other examples of quirky behaviour at nano-scale dimensions involve gold and aluminum. Reduce aluminum to the nano world and it loses its non-magnetic properties. And the conductive characteristics of gold change to a more semiconductor-like state.

Nanoscale research delivers some surprising results. There's no doubt that the successful marriage between biology and electronics to create successful bioelectronic chips would hugely impact our world.

Just one fascinating example would be in the application of artificial limbs. Connecting electrodes between the prosthetic and the wearer would interpret not only electrical signals, but chemically produced biological ones as well. The result would be a life-changing level of control. ■

NEXT: **Delay lines clarify long-distance keyboard video**

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DELAY LINES CLARIFY LONG-DISTANCE KEYBOARD VIDEO

Essex, England: Four triple analogue delay lines for video signals, developed by Intersil, provide clear video images at distances up to 300 metres for keyboard-video mouse applications. Apps include those for offices, banks, supermarkets, or classrooms, or any video carried over long distances of inexpensive twisted-pair cable.

The ISL59920, ISL59921, ISL59922, and ISL59923 triple analogue delay lines provide skew compensation between three high-speed signals. They are suitable for compensating for the skew introduced by a typical CAT-5, CAT-6, or CAT-7 cable (with differing electrical lengths on each twisted pair) when transmitting analogue video.

The delay lines enable users to meet a variety of bandwidth and transmission-length requirements using a single cost-effective design solution. The entire family is footprint-compatible with Intersil's EL9115 silicon delay line product. Now users have a choice of bandwidths, ranging from 150MHz up to 230MHz, which increases the range of video resolutions that can be handled up to UXGA and 1080p. The new family also has a reduced offset of ±25mV.

AVR MCUs deliver CAN, LIN connectivity

San Jose, Calif., USA: Atmel's new family of AVR microcontrollers—the ATmega16M1, ATmega32M1, and ATmega64M1—target the industrial control market. They were developed to serve the need for high-accuracy pulse width modulation (PWM) for advanced motor-control applications that feature CAN and LIN connectivity.

The new family of devices feature 16, 32, and 64kB of flash, general-purpose I/O pins, analogue-to-digital converter, analogue comparators, power stage controller, and 8 and 16bit timers. Based on the AVR 8bit RISC architecture, the ATmega16M1, ATmega32M1, and ATmega64M1, integrate all of the basic peripherals necessary to satisfy the needs of complex motor-control algorithms.

The devices are the first AVR microcontrollers in a 32-pin package that offer CAN and LIN support, according to the company.

Murata acquires MLCC operation

Hoofddorp, Netherlands: The Murata Manufacturing Co. Ltd. has purchased Panasonic Electronic Devices' (PED) multilayer ceramic capacitor (MLCC) business. The two companies will work together to ensure a transfer of technology, distributors, customers, patents, and other facilities by 20 January 2010.

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"PED is a respected supplier of MLCCs in the European market and beyond, so this purchase furthers Murata's goal of providing diverse, advanced, and cost-effective solutions," says Terry Churcher, president of Murata Electronics Europe.

One-button test for 10GBASE-T compliance

Beaverton, Ore., USA: Tektronix claims to have developed the first one-button solution for the full-range of 10GBASE-T measurements, following the release of XGbT test automation software and test fixtures.

Market adoption of 10G Ethernet is expected to grow exponentially over the next several years, driven by bandwidth-hungry applications like streaming video, VoIP, IPTV, video conferencing over Ethernet, virtualisation technology, server consolidation, etc. Such growth means that the entire supply chain for 10GBASE-T will demand low-cost, reliable, fast, and easy-to-operate test equipment.

TSMC heralds 28nm SRAM yield breakthrough

Hsinchu, Taiwan: According to the Taiwan Semiconductor Manufacturing Company, it's

become the first foundry to achieve 28nm functional 64Mb SRAM yield across all three 28nm nodes (LP, HP, and HPL). The 28nm LP process will serve as a fast time-to-market and low-cost technology for cellular and mobile applications. The 28nm HP process is expected to support devices such as CPUs, GPUs, chipsets, FPGAs, networking, video game consoles, and mobile computing applications.

"This accomplishment underscores TSMC's process technology capability and value in 28nm. It shows TSMC is not only able to extend conventional SiON technology to 28nm, but is also able to deliver the right 28nm HKMG technology at the same time," says Dr. Mark Liu, senior VP, Advanced Technology Business at TSMC.

The 28LP process is expected to enter risk production at the end of Q1 of 2010, followed by 28HP risk production at the end of the second quarter, and 28HPL risk production in the third quarter.

Nano research boosted by Japanese participation

Manchester, England: Professor Paul O'Brien and his research team at the School of Chemistry, University of Manchester, are joining forces with Murata Manufacturing Co. Ltd., a Japan-based manufacturer, to form a new research collaboration. Murata signed a deal with the university to work on a research and development collaboration in the field of nanotechnology.

Japan is the second largest Asian supplier of Foreign Direct Investment (FDI) projects to the U.K. It remains the most significant investor from Asia. In 2008/09, Japan contributed 81 new projects and created 1405 new jobs, the sixth largest FDI source to the U.K. ■

NEXT: Modular dc-dc converters continue to serve the military

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by Keith Nardone | *Vicor Corp.*

MODULAR DC-DC CONVERTERS CONTINUE TO SERVE THE MILITARY

COTS applications take advantage of the enormous size and format range of these high-density converters.

Compact, high-power-density dc-dc converters, introduced in 1984, quickly found homes in military applications due to their small size, high performance, and reliability.

1. To satisfy multiple requirements, dc-dc converters come in a range of physical sizes, input and output voltages, and power levels.

The converters (bricks) were packaged in a modular form factor that simplified power system design and reduced the time it took to bring a product to market.

A full quarter century after their introduction, bricks are still being specified for many applications, both commercial and military, but the attributes of bricks are especially well suited for military COTS applications. These high-density power components have earned acceptance in military and defense apps, where high performance, reliability, and low cost are critical.

The variety of available dc-dc converter modules is rather expansive, coming in a range of sizes and formats (e.g., full bricks, half bricks, quarter bricks, etc.) *(Fig. 1)*. High-density converters—usually characterised by high-frequency operation, allowing them to achieve their small size, high power density, and efficiency—can be found in thousands of combinations of input voltage, output voltage, and power level.

Such a modular dc-dc converter, when combined with discrete components, can satisfy many unique power requirements. Because each module is a proven, prequalified performer, designers using these converters enjoy an advanced starting point toward a finished power supply.

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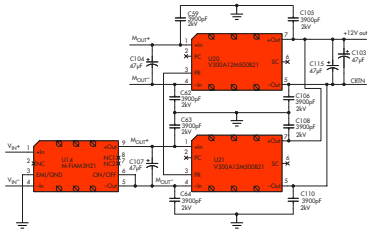

2. This high-power design example features MIL-STD-704 270Vdc input, MIL-STD-461 EMI compliance, and single 12Vdc output (800W).

The military commonly uses input voltages of 28Vdc for ground and 270Vdc for airborne and AC, but modular components offer just about any spec that's need for a particular application. Modular components used for COTS applications satisfy other input characteristics as well, including low- and high-line conditions and the capability to handle voltage spikes, surges, and excessive input ripple.

Available output powers range from tens of watts to kilowatts, from single outputs to 40 outputs. Most

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high-density dc-dc converter modules are qualified to stringent environmental requirements, and some standard bricks (those that are fully encapsulated) handle high-g forces. The building-block design approach is flexible, as can be seen with a high-power-output design *(Fig. 2)* and a multiple-output design *(Fig. 3)*. Such an approach is also cost-effective and offers quick turnaround and reliable performance.

Early designers had to supplement the capabilities of modular dc-dc converters by using discrete components to implement auxiliary power system features, such as ac-dc rectification, filtering, power factor correction, etc. That option is still open, but specialised accessory components have become increasingly available.

Together with the power components, these matched, compatible accessories—such as filters, holdup capacitors, heat sinks, and ac front ends—allow users to quickly assemble complete power systems. They can simply select and interconnect standard, modular parts to meet their design requirements.

Compatible front-end accessories, for example, provide a number of performance features such as input

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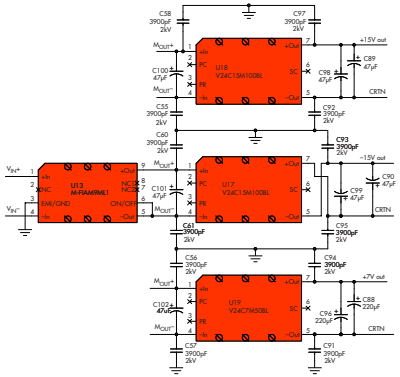

3. Featured in this multiple-output design is MIL-STD-1275 28Vdc input, MIL-STD-461 EMI compliance, ±15V and +7V outputs

transient protection, EMI filtering, and inrush current limiting *(Fig. 4)*. In addition, they have international agency approvals and can accommodate the wide range of input source voltages necessary to reach worldwide defense markets.

Military-targeted dc-dc converters typically satisfy U.S. Department of Defense definitions for non-development items (NDIs) and commercial off-the-shelf (COTS) equipment. They meet key military performance specs for input power quality (MIL-STD-704, 1275, 1399), EMI levels (MIL-STD-461), environmental requirements (MIL-STD-810, 202), and component derating. Full encapsulation of the "brick" package enables the modules to meet severe environments of humidity, fungus, salt fog, explosive atmosphere, acceleration, vibration, and shock.

Bricks may not always be the first choice for some power designers. However, it's proven technology, and they are a cost-effective, low-risk, quick way to get to market solution for these power engineers.

TIME TO MARKET

Bricks are a good choice over a custom, discrete approach when time to market is an important criterion. Development time is shorter, less expertise is needed, and the modules represent an advanced starting point toward a final power solution. The power-supply designer can even obtain rapid delivery of small prototype quantities in the final form factor well before the system design is completed.

Every designer, whether designing commercial or military products, wants to get their products out there quicker. When it comes to the military, though, there's often a higher value placed on that capability.

Designers of military electronic systems have shown a preference

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for older tried and true architectures. The reasons are not hard to find: demonstrated reliability, long lifetimes, compatible accessories, experienced applications support. Bricks and brick-based power solutions offer rich options for designers of military power solutions.

Furthermore, bricks are versatile, being applied to a large variety of end uses for the military and aerospace industries. Destinations include aircraft and ground vehicle and naval applications, underwater-type applications, and man-pack-type applications.

Obsolescence is always a big issue in MIL and MIL-COTS apps. Typically, a military program takes several years to get going, and will serve several years in the field. As a result, support is going to be required.

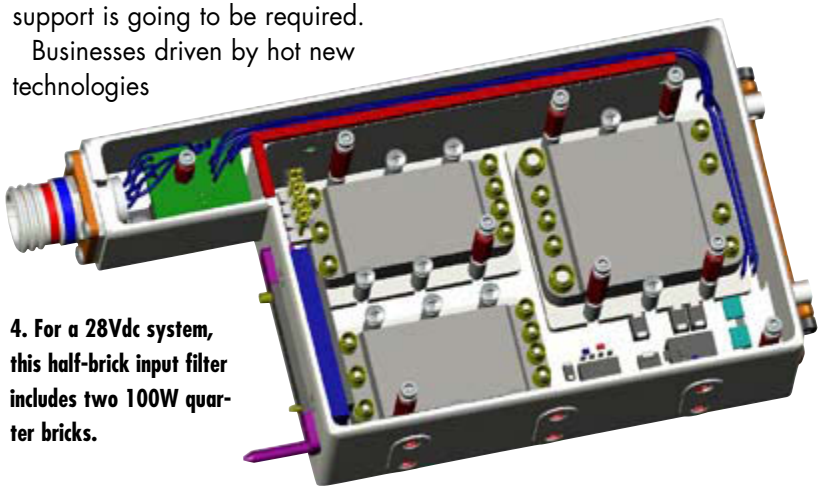
Businesses driven by hot new technologies may well offer COTS products, too. But many of them are focused on the short term, including how long they will support their products. The proven brick technology with its stable manufacturers already have a very long track record, which gives confidence that they will likely be here for the long haul.

CUSTOM SOLUTIONS

Brick manufacturers offer multiple sizes, common platforms with common components used within those platforms, and a large mix of customer-selectable voltages and powers to satisfy unique requirements. What's more, mass customisation is now a reality. An online suite of advanced power-design tools is in place, enabling designers to specify and verify the performance and attributes of custom solutions in real time.

For mission-critical applications, fault tolerance with bricks can be achieved by redundancy, i.e., the existence of at least one extra, or "redundant," converter in the system. Such a system of converters is commonly referred to as an N+M array, where N converters are required to satisfy the power requirements and M additional modules provide redundancy.

All modules in the array must be able to supply undisturbed power in the event of shutdown or failure of one module, in spite of the sudden change in load current demanded of each. To satisfy these criteria, it's essential that the individual converters share the load current, in order to minimise the dynamic response required of each. Bricks will typically load share automatically. ■



4. For a 28Vdc system, this half-brick input filter includes two 100W quarter bricks.

KEITH NARDONE *is director of business development, Aerospace & Defence, Vicor Corp.*

NEXT: The blurring line between telematics and infotainment

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by Randy Frank | *IEEE*

THE LINE BETWEEN TELEMATICS AND INFOTAINMENT BLURS EVEN FURTHER

The only line that customers care about, though, is the bottom line in terms of connectivity.

Telematics and infotainment appear to be on a collision course within the automobile. The terms themselves have caused some confusion. Telematics refers to the combination of telecommunications and informatics, basically wireless communication. Infotainment indicates the combination of information and entertainment. Even the analysts can't agree on what differentiates telematics and infotainment.

"You call five different people, you are going to get five different answers," says Mark Fitzgerald, senior industry analyst, Strategy Analytics. "We drew a line in the sand with telematics, saying that it needs to have GPS capability and two-way communications." For example, wireless, hands-free talking via Bluetooth is considered infotainment, not telematics.

1. M/A-COM Technology Solutions' GPS module includes a GPS antenna, GPS receiver, microprocessor, memory, CANbus transceiver,

According to Fitzgerald, the connectivity of portable devices is really pushing market acceptance. "That's why Sync has been very popular, very quickly," he says. Ford says that its dealers have sold vehicles featuring its Sync infotainment system, which was introduced in the company's 2008 vehicles, twice as quickly as those without the system.

CONNECTIVITY

When it comes to wireless connectivity, cellular, GPS, satellite, and broadcast AM and FM are well-established technologies for vehicles. Wireless protocols emerging for vehicle usage include Wi-Fi, WiMAX broadband and 4G Long-Term Evolution (LTE) (broadband

2. With the TrueAuto USB82514 USB 2.0 high-speed four-port hub from SMSC, consumers can connect to an external port or two, and system designers can use the remaining ports for internal system connectivity.

cellular), Radio Data System (RDS), and perhaps more. Increasingly popular navigation systems require GPS technology to precisely identify the vehicle's location.

SiRF, a member of the CSR plc Group of companies and a leading GPS IC supplier, partnered with M/A-COM Technology Solutions to help create a networked GPS module. The new GPS transceiver provides location information to the new generation of vehicle-based communications and entertainment systems. To simplify system design, the unit's antenna efficiency and receiver sensitivity allow for installation almost anywhere on the

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TABLE 1: FEATURES IN EACH SYNC GENERATION				
Announce-ment	CES 2007	CES 2008	CES 2009	CES 2009 Preview
	Sync	Sync rev. 1	Sync rev. 2	Sync (future)
Feature 1	Voice commands as well as simple button control	911 assist	Personalized traffic reports	Avatar as personal electronic assistant
Feature 2	Bluetooth connectivity for cell phone	Vehicle health reports	Precise turn-by-turn driving directions	Internet connectivity
Feature 3	MP3 connectivity for music through USB port		Up-to-date informa-tion	
Feature 4	USB connectivity for storage devices and charging		Improved voice dialog	
Feature 5	English, French, and Spanish language capability			
Subscription	None required	None required	No subscription for three years	

vehicle, including hidden mounting locations *(Fig. 1)*.

For other wireless applications, Brian Droessler, director of Connectivity Group North America for Continental Automotive Systems, points out the difference between wireless alternatives depending on the transmission requirements. For example, the vehicle can receive traffic data from an RDS channel on the FM band, a satellite radio connection, or a cellular two-way communication. A one-to-many broadcast scheme will work well for traffic information. However, a driver or passenger who is sending a search request and receiving data in the vehicle environment will require cellular.

"Just because of the reach and the coverage," says Droessler. "Wi-Fi hot spots don't blanket the road like cellular does. You can go through your different wireless technologies and for many reasons, you kind of end back at cellular." Cellular technology is an integral part of OnStar, Sync, and Continental's recently introduced AutoLinQ system.

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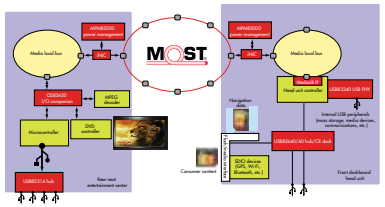

3. SMSC's MOST network provides vehicle connectivity between dashboard-mounted head-unit and rear-seat displays. The company's USB units connect the user's brought-in flash media devices and USB products as well as internal peripherals.

Inside the vehicle, Bluetooth offers one more wireless connection, especially for interfacing to the user's "brought in" cell phones. But hard-wired connectivity also provides access for cell phones as well as other brought-in consumer electronics products. Direct audio connections to iPods and other music players are one means. USB provides multiple connection possibilities.

SMSC has become involved with USB technology for vehicles with infotainment and telematics applications. "USB, of course, is the technology of choice for connecting to most consumer devices," says Henry Muyshondt, senior director of business development for SMSC's Automotive Infotainment Systems Group.

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4. The popular OnStar system uses a simple three-button user interface to provide conectivity, including navigation and emergency services.

The company's USB83340 and USB82660 deliver an automotive-grade USB 2.0 hub and flash media card controller, and its USB82514 is an automotive-grade USB 2.0 high-speed four-port hub. A USB controller can be used for connecting a consumer's brought-in product to obtain data and for recharging its batteries, but it will also connect embedded devices such as a USB transceiver or mass-storage device inside the head unit *(Fig. 2)*.

The availability of low-cost 2-Gbyte data cards opens new possibilities for in-vehicle telematics usage. For instance, navigation data could be saved on an inexpensive SD card instead of using a DVD player. The card could be easily and inexpensively upgraded, or a new map area can be added as required.

Muyshondt also has extensive insight into high-speed distributed systems in the passenger compartment. "The infotainment system is the only basis upon which you can bring telematics in and out of the car because the infotainment system is what eventually actually connects to the eyes and the ears of the people inside the car," he says.

SMSC's Media Oriented Systems Transport (MOST) provides the infrastructure where multiple devices can communicate with each other, automatically coordinate functions, and distribute audio and video around the vehicle *(Fig. 3)*.

Initially introduced as a fiber-optic system running at 25 Mbytes/s, a version has been introduced that employs unshielded twisted-pair or shielded twisted-pair cabling that runs at 50 Mbytes/s. Toyota has this version in several models, including the newest Prius. The very latest generation of MOST uses optical fiber and runs at 150 Mbytes/s. "It's not on the road yet, but the systems are being actively developed that use it," explains Muyshondt.

TABLE 2: CAPABILITIES OF FREESCALE PROCESSORS

Applications processor Core	i.MX25 applications processor family 400-MHz ARM9	i.MX35 applications processor family 532-MHz ARM11	i.MX51 applications processor family 600-MHz+ ARM Cortex-A8
Graphical content Determines: user interface (UI) look and feel; navigation mapping detail and update rate	2D for basic touchscreen inputs	3D-looking for animated graphics, smooth zooming, scrolling, and 2.5D navigation	Full 3D with lighting, reflections, and textures for true 3D navigation and the most sophisticated UI
Speech recognition Determines: vocabulary size; response time (or latency)	Digit dial: "Call 1-2-3-4-5-6-7" "Play," "pause," "repeat"	Voice dialing: "Call Peter home" "Play artist Elvis"	Natural language: "Get me Peter at his house" "Play me some Elvis songs"

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BOOSTING COMPUTING POWER

General Motors' OnStar pioneered telematics for the masses more than a decade ago and continues to increase its services. As a result, GM continually boosts the performance of its embedded processor *(see "Expanding Telematics For The Masses")*. The simple three-button interface to an embedded cellular phone connects the user to a service center and automatically calls the center if an accident occurs *(Fig. 4)*.

Announced at the Consumer Electronics Show in 2007, Ford's Sync provides infotainment for the masses based on the ability to easily connect to the user's cell phone, portable media players, and USB storage devices. Sync has had two system enhancements since its introduction *(Table 1)*. Both GM's OnStar and Ford's Sync will be standard equipment on each company's U.S. vehicles by the end of 2009. Not surprisingly, GM and Ford have taken different approaches to telematics and infotainment.

"They are both coming from their heritage, either the traditional telematics e-call side or the infotainment side," says Michael Haight, automotive product marketing manager, Freescale Semiconductor. "They are certainly blurring the lines." Freescale processors are used in both OnStar and Sync systems.

"We are somewhat agnostic between those two approaches because for us it's the difference between hardwired to maybe a 3G modem versus being Bluetooth connected to a 3G-enabled cell phone," says Haight. "What's really driving our products in terms of capabilities is more things like voice recognition capabilities and graphics rendering capabilities."

Aimed at more natural language speech recognition, the iMX51 processor, announced at CES 2009 in January, is already in the design-in phase for future vehicles. In contrast, Freescale's iMX35, an ARM11 core processor, used in the Ford Sync, requires spoken input in a specified order *(Table 2)*.

ARM is the core for telematics and infotainment entry points as well as higher-end systems. Engineers feel that ARM provides the core technology for telematics and infotainment.

"There are two reasons for that," says Boris Vittorelli, automotive segment manager at ARM. "Essentially, there's a lot of consumer and mobile communications type of technology in those systems and we have a very rich software ecosystem in that particular area. Then, obviously, we have a market which is pretty widespread from entry level to the very high end."

Initially, ARM7 was a starting point. Today, the ARM9, ARM11, Cortex-A8, and Cortex-A9 are being evaluated for infotainment/telematics applications. Even though the performance is available from ARM, there are still design choices.

"If you start offering rear-seat DVD and entertainment, or if you start to offer dual displays and integrate rear-vision cameras and new functionality, then you are out of the performance envelope of an ARM11. You have the choice to go superscalar or to go symmetric multiprocessing. There's pros and cons in both," says ARM's Vittorelli. "We see both ARM11 MP and Cortex-A8 being used in that space."

NEC chose multiprocessing to solve the conflicting needs of quick startup and extensive computing. ■

To read the entire article, go to www.electronicdesign.com.

NEXT: MLCC advance powers electric vehicles

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by Shoji Tsubota | *Murata*

MLCC ADVANCE POWERS ELECTRIC VEHICLES

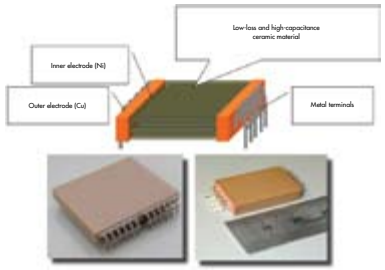
The EVC series of multilayer ceramic capacitors enters the power electronics fray, going up against its film and aluminum electrolytic brethren.

Until recently, it was necessary to use film or aluminum electrolytic capacitors in the power circuitry needed for electric and hybrid-electric vehicle types of applications.

These applications typically require tens or thousands of microfarads in capacitance for use as smoothing capacitors.

Such capacitors had to able to withstand the high ripple currents and harsh environments experienced in high-performance automotive environments. It simply wasn't possible to make a multilayer ceramic capacitor (MLCC) big enough for high-voltage applications. MLCCs also didn't have the maximum allowable ripple current needed for high-current applications.

Scientists at Murata were convinced they could make an MLCC that could take on film capacitors and aluminum electrolytic capacitors in power electronics applications. In fact, a new low-loss material developed for this project allows properties different from any other type of MLCC. The result was the biggest capacitor Murata has ever made—the EVC series—featuring a footprint 50 times larger than anything else in its capacitor range.



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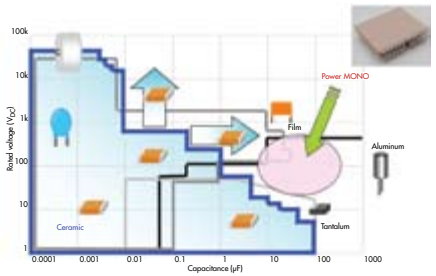
1. Low-loss ceramic is the main component for Murata's EVC series of MLCCs.

CONSTRUCTION AND PROPERTIES

The EVC series consists mainly of Murata's low-loss ceramic material *(Fig. 1)*. Throughout the ceramic material is a network of inner electrodes made of nickel, connected to a copper outer electrode, which is connected to metal terminals bonded with lead-free material.

For any large ceramic component, cracking whilst in situ in the circuit is a problem. The capacitor's terminals therefore had to be specially designed to prevent cracking when the printed circuit board it's mounted on is subject to mechanical stress.

On a graph of rated voltage versus capacitance *(Fig. 2)*, the EVC series falls outside the area traditionally occupied by MLCCs into a part of the matrix normally occupied only by film capacitors; as such, the EVC series represents a totally new class of MLCC. Its specially developed low-loss high-capacitance material enables an allowable ripple current per unit



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2. Rated voltage is compared against capacitance for various capacitor technologies.

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volume of 1.56A/cm^3, an order of magnitude higher than film capacitors, and two orders of magnitude higher than aluminum electrolytic types *(Fig. 3)*.

Because the permissible ripple current is much higher, designers can replace film or aluminum capacitors with lower-capacitance-value MLCCs, which can be mounted closer to other components because of their lower heat-generation characteristics. In some applications, the EVC series can contribute to reducing the requirements for system cooling and potentially a simpler overall cooling system.

The EVC MLCCs feature a capacitance per unit volume of 2.4µF/cm^3, compared to 1.2µF/cm^3 for film capacitors and 1.89µF/cm^3 for aluminum electrolytic types. This means that despite the relatively "huge" footprint for an MLCC (32 x 40 x 4 mm), capacitors in the EVC series are still smaller than their film/aluminum counterparts.

Murata's new technology lends itself in particular to electric and hybrid electric vehicles. These vehicles require high rated voltage components with high rated current, small size, and excellent thermal properties.

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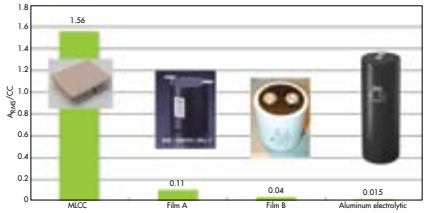

3. The EVC MLCC features a higher current per unit volume versus other capacitor technologies.

Figure 4 shows the powertrain of a typical hybrid electric vehicle with power coming from both the engine and an electric motor. The system features two inverter circuits—one driving the electric motor and the other driving the air-conditioning unit.

Each of these inverters are dealing with voltages up to 400V. Typically, film capacitors would be used as snubber capacitors in such inverter circuits. However, film and aluminum capacitors also tend to suffer from low heat resistance. That's because they both contain organic material.

The EVC series, made entirely from inorganic materials, has a very high intrinsic resistance to high temperatures. MLCCs can also provide better surge suppression ability than film capacitors due to their low equivalent series resistance and inductance (ESR and ESL). Now that the EVC series is available with rated voltage up to several hundred volts, they're finding homes in a number of electric vehicle applications.

As an example, EVC series capacitors have been designed into an electric scooter. Powered entirely by batteries, the scooter has a top speed of 100 kilometres per hour, acceleration of 0 to 80 kilometres per hour in 6.8 seconds, and can travel 68 miles on a charge of two hours. Its emissions are zero.

The electric scooter's power-conversion system utilises five Murata EVC series capacitors, on a board designed for smoothing the inverter. The EVC capacitors help to diminish the surge that's being generated by the IGBT (insulated gate bipolar transistor).

The properties of MLCCs substantially lower the voltage surge experienced when the IGBT switches, which might be enough to allow a lower working voltage of the IGBT. This could potentially allow the IGBT to be downsized. Downsizing the IGBT along with the downsizing of the smoothing capacitor can lead to shrinking the inverter system as a whole.

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KINETIC ENERGY RECOVERY SYSTEM

Another application involves a kinetic energy recovery system (KERS) for Formula 1 cars from a leading Italian auto-racing designer. The small size and light weight of this KERS system relies on components like the EVC series.

Due to changes in the technical regulations of Formula 1, KERS systems are allowed to be used during the 2009 season. KERS is a method of storing energy that would otherwise be wasted when braking. This energy can then be released to provide extra power on demand.

The rules permit 400kJ of energy to be stored per lap, which is to be released at at a maximum of 60kW. This is equivalent to a boost in speed of 6.7 seconds for each lap, and it's hoped the addition of such systems will add a new dimension to the sport, particularly regarding overtaking.

Designers of this KERS system selected Murata's EVC series for the power-conversion electronics in their KERS design due to the MLCC's good ripple performance in small and, importantly, lightweight package sizes. The weight of the KERS is particularly important since weight distribution inside the vehicle's body is critical for performance. The parts' small size is attributed to Murata's ceramic materials technology, which allows a very high capacitance per unit volume.

This application also demonstrates the EVC series' capacity to perform reliably in extreme and harsh environments. The parts have a high intrinsic resistance to high temperatures. EVC series capacitors maintain their ripple performance over the full automotive operating temperature range, up to 125°C.

Formula 1 teams often will develop ideas and technology that subsequently find their way into a number of commercial vehicles. Consequently, the KERS initiative has become partly an effort to encourage Formula 1 teams to develop "greener" technology.

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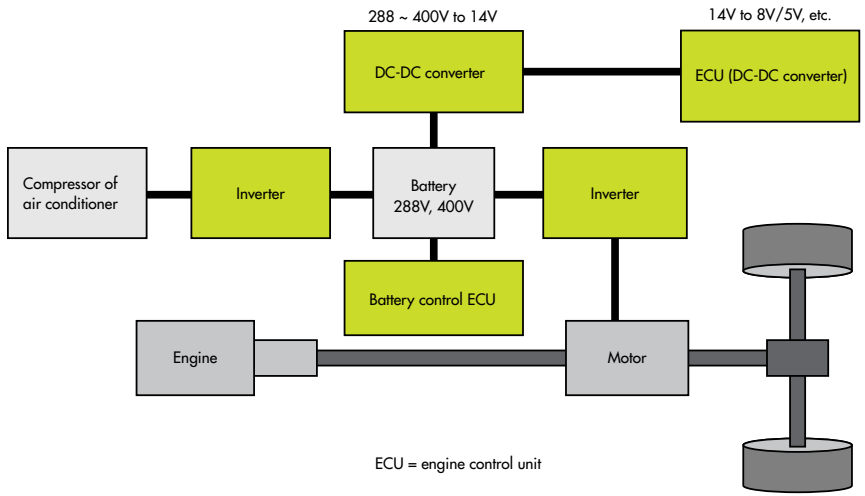

4. This example of a hybrid electric vehicle powertrain contains two inverter circuits: one to drive the electric motor and the other for the air-conditioning unit.

SHOJI TSUBOTA *is product manager, Ceramic Capacitors, Murata*

NEXT: **Create your own fan driver circuit for an active heatsink**

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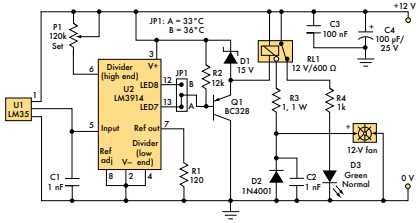
by T.K Hareendran | *Betron Technical Services*

CREATE YOUR OWN FAN DRIVER CIRCUIT FOR AN ACTIVE HEATSINK

Even robotic systems occasionally need a cooling fan. When they do, the cooling circuit must be an intelligent one that makes minimal demands on power consumption and space. The circuit described here is such a cooling fan driver for an active heatsink assembly. The driver uses readily available and inexpensive components, and it runs on a 12-V dc supply *(see the figure)*.

The circuit uses an LM35 temperature sensor chip (U1). The chip's output voltage varies linearly with temperature changes in Celsius degrees and operates over a wide temperature range. It exhibits very low self-heating in still air and has a low current consumption.

The circuit's operation is straightforward. U1's output feeds directly to the input of a fairly complex and versatile linear-scale dot/bar graph LED driver, LM3914 (U2). The driver contains 10 voltage comparators, each with its non-inverting terminal connected to a specific tap on a floating precision multi-stage



This driver circuit for a cooling fan uses an LED driver IC (U2) to pick up the voltage change from the sensor IC (U1) and create an output signal to activate the fan driver relay (RL1).

potential divider. All of the inverting terminals are connected in parallel and brought to the input through a unity-gain buffer.

The output of each comparator is externally available and can sink up to 30 mA. The current is internally limited, but can be externally preset from 2 to 30 mA via a single resistor. The inputs operate down to ground, and the device runs on a single supply of less than 3 V.

In this application, only two of the 10 outputs are needed to control the cooling fan's driver relay (RL1). When the temperature increases, U1's output goes high and U2 senses that analog voltage level at pin 5. When the temperature reaches 33°C, pin 13 on U2 goes low and forward-biases transistor Q1, energizing RL1. As a result, the 12-V dc supply is extended to the cooling fan through surge limiter resistor R3, activating the fan. Zener diode D1 suppresses the counter electromagnetic field (EMF) generated during the relay switching operation.

You can calibrate the circuit to activate at 33°C by adjusting the trim potentiometer (P1) and monitoring U2's output at pin 13. After checking the calibration to ensure it's correct, paint the pot's control to lock it in place. Jumper JP1 can be used to select between two preset fan switching modes—for example, 33°C and 36°C. ■

SERIES RESISTORS, BODY CAPACITANCE SCAN 16 BUTTONS WITH TWO MCU PINS

In an application using a pin-limited microcontroller (MCU), I needed to scan an array of 16 buttons. The technique I used involved a series string of resistors of identical value connected between two bidirectional pins of the MCU.

For simplicity, the example shown uses five resistors to scan four buttons *(see the figure)*. A metal pad

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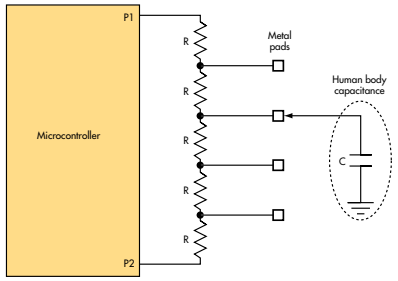
is created at each juncture between the resistors. When a person touches one of the metal pads, body capacitance creates an RC circuit that the MCU can sense.

P1 is first configured as an output, and P2 as an input. P1 drives a high level that charges the capacitor through the resistors in the string connecting P1 and the metal pad that's being touched. In the example, this resistance is 2R. The voltage level on P2 is sensed and the time at which the capacitor reaches a logic 1 is recorded. This time, T2, is proportional to 2R × C. Because P2 is a high-impedance input, the remaining resistors in the string have no appreciable effect on the time constant.

P1 and P2 are then turned into outputs and driven to a low level to dump the charge on the capacitance as quickly as possible. After that, the situation is reversed, with P2 becoming the output and P1 becoming the input. The capacitor charging time, T1, which is sensed by P1 in this condition, is proportional to 3R × C.

The MCU computes the ratio of T1 and T2:

$$T1/T2 = (3RC)/(2RC) = 3/2$$



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This arrangement uses two MCU pins that switch between output and input, which lets the device calculate the differences in the RC time constants to determine which button is pushed.

The ratio is independent of the actual human body capacitance or the resistor value (as long as all the resistor values are identical). The MCU looks for the closest match of the ratio in a table to determine which button was touched.

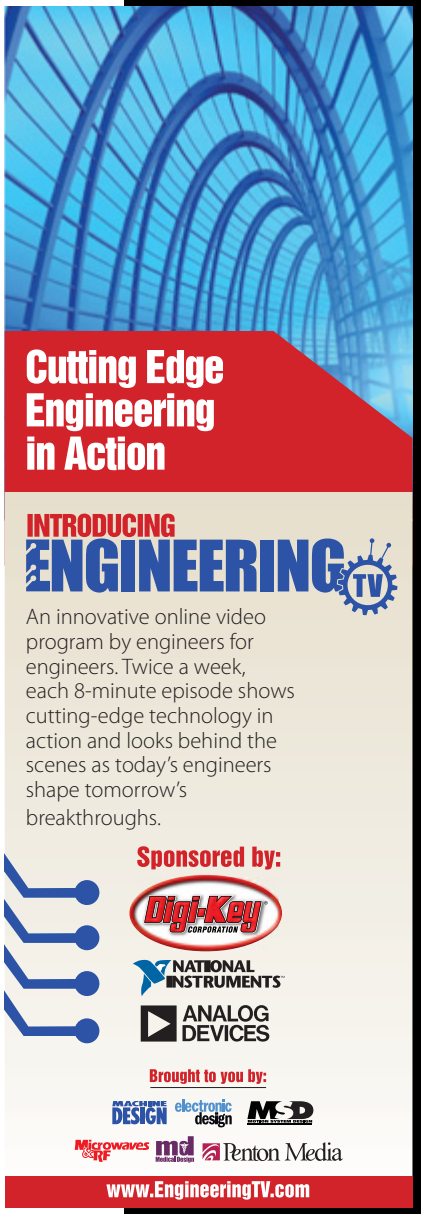
Assuming a human body capacitance of 100 pF, a value of 10 kΩ for R will produce a time increment of about a microsecond, something that most microcontrollers are able to sense.

As noted, I used this technique to scan as many as 16 buttons. An obvious limiting factor is stray capacitance along the resistor string and on the MCU I/O pins. You also need resistors with well-matched values, at least 1% or even 0.1%, depending on how many buttons you are scanning. The MCU pins also have to trigger at the same threshold voltage. If your production environment and MCU allow it, you can use a training session to teach the controller what ratio corresponds to each button and have it stored into the EEPROM or flash.

The resistors in the string serve to attenuate the effects of electrostatic discharge when a person touches a bare metal pad connected directly to the circuit. If electrostatic discharge is a concern, replace the metal pads with pushbuttons that connect a common capacitor to ground. In this case, you will be able to make C larger and reduce R to diminish the effect of stray capacitance. ■

DAVE VANDEN BOUT, *president, holds a BS, MS, and PhD in electrical engineering. He attended North Carolina State University, Raleigh, and the Massachusetts Institute of Technology, Cambridge.*

NEXT: Adopt a new approach to RF SiP design



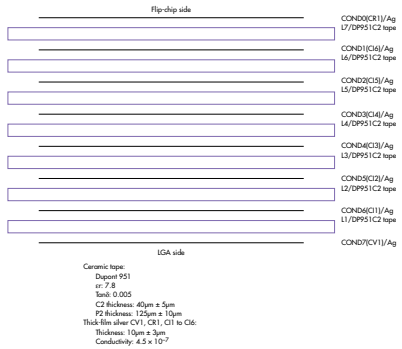
by Diana Moncoqut and Chris Barratt | *Insight SiP*

ADOPT A NEW APPROACH TO RF SiP DESIGN

Thanks to advances in circuit miniaturization and system-in-package (SiP) technology, the goals of smaller size and more functionality have become attainable. Still, broader standardisation of the the SiP approach is stymied by the lack of design automation and portability.

A methodology developed by Insight SiP help solve those portability issues while allowing for greater integration. The methodology shows that SiPs scale and optimize, enabling aggressive design schedules from system definition down to fully tested layout.

1. Shown is a typical LTCC technology file.



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DESIGN METHODOLOGY

Insight SiP's method uses a combination of circuit and electromagnetic simulation tools to create a design progressively from basic schematic representation to a complete 3D electromagnetic representation of the layout. Manufacture is only carried out on a design for which the completed layout has been fully simulated.

Passive integrated functions (laminate, LTCC, IPD) use 2.5D or 3D electromagnetic simulations, while active circuits go through harmonic balance or device modelling. The functionality contained within buried functions inside the substrate is created by going through an iterative process.

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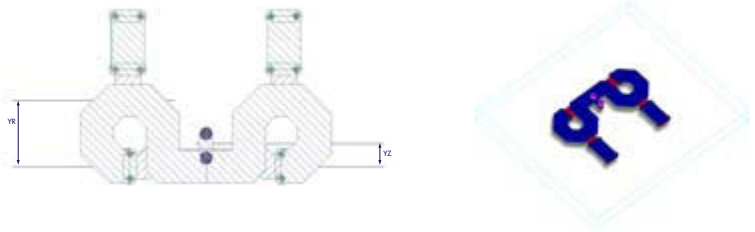

2. An LTCC mechanical object such as this resonator can be reused if the design transfers between two suppliers.

The first step in the design methodology is to develop a range of parameterized mechanical objects for a given technology. With these objects, simple RF functions, such as capacitors, inductors and resonators, can be created.

The second step in the design process is to couple the technology file for the target process to the mechanical objects. A series of batch-based electromagnetic simulations of the mechanical objects within the desired technology file framework creates data for a lookup-table-based model for each component (L, C, or more complex resonator element).

The process described above makes it possible to create a set of project- and technology-related schematic objects that can be optimized to produce the required RF functionality. Simulations using these models can be carried out in both the frequency and time domains. At this level of the design, circuit optimization is carried out in order to determine the parameters of the schematic/mechanical object.

The third step of the process is to create complete sections of physical layout with the mechanical objects using the circuit optimisation parameters.

A closed-loop iterative process is used to obtain final layout with the same electrical performance as the sum of the modelled portions. Coupling effects between blocks are compensated for at this stage. As a result, the mechanical objects can be placed close together without any risk of causing unseen effects. Designs created by this method are more compact than those that utilise a "P Cell" approach with large keep-out zones to avoid coupling.

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DESIGN PORTABILITY

RF SiP can be realized using a multitude of technologies. For each technology, different suppliers offer different materials, physical dispositions, and properties that require any design to be matched to the particular supplier.

Each technology and each supplier may be characterized by a technology file that describes the material parameters and physical disposition between the dielectric and metallic layers. In the case of organic and ceramic laminates, each supplier has a range of materials and layer structures that may be used. Figure 1 shows a typical technology file for LTCC.

Most SiP design methodologies that include integrated passive components rely on fixed libraries of components that are locked to a particular substrate supplier and stack-up. For high-volume consumer devices, it's increasingly important to ensure that any given SiP can be sourced from at least two independent manufacturers.

Insight SiP's methodology is based on a user-extendable library of mechanical objects; electrical models are created automatically for a given stack-up and/or technology. Thus, any design that's initially made for a particular supplier can easily be re-tuned for an alternative source. The second manufacturer can have a different set of electro-mechanical parameters (stack-up, dielectric constant, layer thickness, loss factors, metal types) and may even use an alternative technology.

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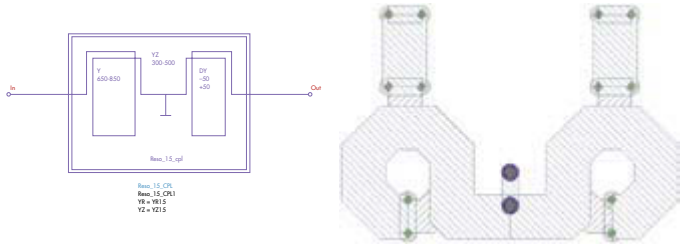

3. This schematic represents the LTCC coupled line resonator in Figure 2.

Once created, the mechanical objects of the first step above don't have a direct link to the material properties, nor to the vertical stack of the particular technology and supplier that's to be used. These objects can therefore be reused if a design is transferred between two suppliers. Figure 2 shows a typical LTCC mechanical object.

The second step of the methodology presented above is very easy to repeat with a new technology file, facilitating design transfer between suppliers and technologies. Figure 3 shows the schematic image of the LTCC coupled line resonator shown in Figure 2.

To re-design for an alternative supplier using the same technology, the process employs the same mechanical objects with a new set of technology values.

This process starts from the same basic schematic and simply re-optimizes the parameters of the objects to compensate for the new physical and mechanical parameters. The final EM closed-loop process, described in step three above, is then carried out to create new layout for the new supplier.

To change from one technology to another, equivalent mechanical objects with similar functions in both technologies must be created. In this case, the same basic schematic is used and the schematic/mechanical objects are swapped. Thereafter, the process is similar to the normal design flow.

To illustrate how the methodology works, consider the transfer of a Bluetooth filter design between LTCC suppliers. A three-pole, one zero filter, designed for a Bluetooth module to fit under the active components, was developed using the methodology to operate with one LTTC foundry. The filter is designed using semi-distributed transmission line resonators with resonator coupling to create a suitable frequency zero in the response. Figure 4 compares the two LTCC stacks.

As seen, the stacks and material properties of the two suppliers are quite unalike. Despite this, the mechanical objects were converted from one stack to the other and the process completed rapidly. Figure 5 compares the completed EM-tuned filters for both stacks.

It can be noted that the two filters are quite similar but the physical dimensions of the filters are slightly different to compensate for the LTCC stack differences. Electrical performance for both realisations was similar.

ANTENNA DESIGN

The integrated antenna design uses the same methodology of combining electromagnetic simu-

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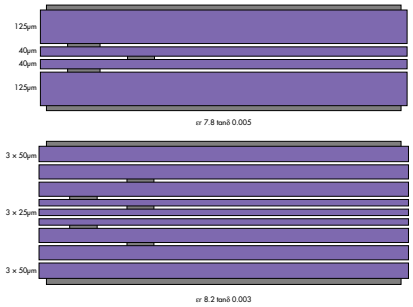

4. A comparison of LTCC stacks from two suppliers show marked differences.

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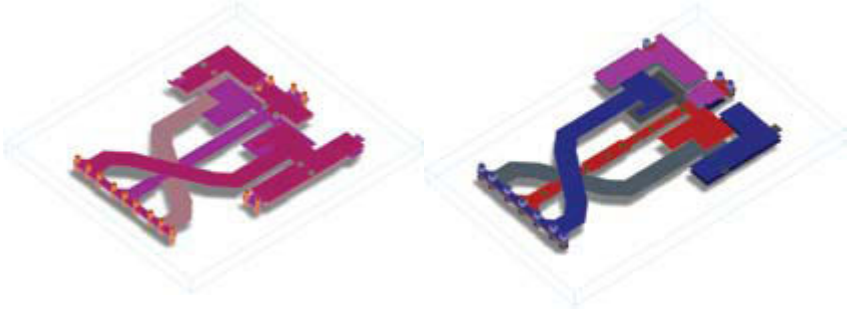

5. Here's a comparison of the full layout of filters from the stacks in Figure 4.

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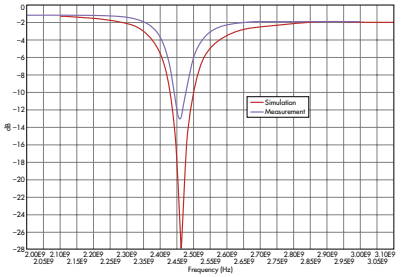


6. Results are given for the simulated and measured S11 parameters of the 2.4GHz antenna-in-package.

lations together with circuit-level simulation and optimization. A portion of the antenna has a schematic representation that can be simulated and optimized at the circuit level. This process helps circumvent lengthy parametric studies and significantly shortens the design cycle.

The methodology is used by Insight SiP to design antennas for various applications, including a quad-band GSM antenna as well as a 2.4GHz ISM band antenna. The methodology was also extended to implement a challenging UHF band antenna.

In the case of the 2.4GHz ISM module, the antenna was originally a printed trace wiggle antenna on a printed-circuit board. The antenna and ground plane measured 28.5 x 15 mm^2.

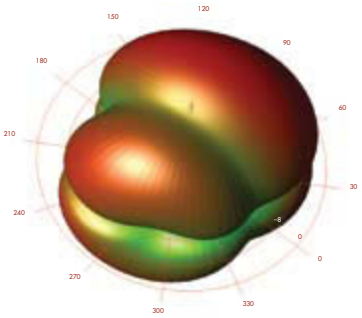
By applying the aforementioned technology, Insight SiP was able to integrate the module and antenna into an 8 x 12 mm^2 QFN-type package. In this case, the antenna takes advantage of the multilayered structure of the substrate in which it's embedded; it has at least a top and a bottom wiring layer. A portion of the surface is reserved for the antenna, while the remaining area is used for active and passive component placement/routing and ground plane.

The most challenging parameter in designing integrated antennas is the environmental impact. The operating environment parameters include indoor, outdoor, building materials, high-rise buildings, factories, and major highways. So, a good amount of simulations and validations must be completed to optimize the antenna design.

In terms of wideband response for the antenna developed using the above methodology, the ground plane and manufacturing variations don't significantly affect antenna performance. Figure 6 compares the simulated and measured S11 parameter for the 2.4GHz antenna-in-package.

Figure 7 shows the radiation pattern obtained with the antenna. The diagram, which plots the gain in dB of the antenna, illustrates the fact that antenna is indeed radiating in all directions of all planes. ■

7. The radiation pattern obtained with the antenna goes in all directions in all planes.



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DIANA MONCOQUT, *marketing director of Insight SiP, holds a PhD in electrical engineering from HEC School of Management, Paris, France.*
CHRIS BARRATT *is chief technical officer of Insight SiP.*

NEXT: Bob's mailbox

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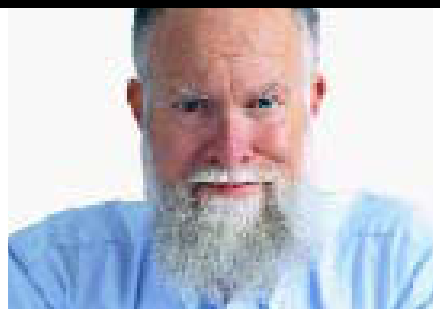

MAILBOX

Hi Bob,

Regarding quad op amps *("What's All This 'Free Amplifier' Stuff, Anyhow?")*, I thought I'd pass on this tidbit from my early days in the late 1970s. I was working at an industrial controls company on the east coast named Leeds & Northrup Co. (now defunct). (Yeah, I have collaborated with Leeds & Northrup. /rap)

At that time, they were producing a new line of industrial controllers with LED displays, rather than the older analog meter movements, to show process deviation from set-point. A stack of RC4136 "quad 741" op amps was used to drive the LED bargraph display. There were two display modes: single dot and bargraph. (That sounds like a Raytheon part number. /rap)

During burn-in, many of the bar-graph displays would go into full-scale oscillation at a rate of about two to three seconds per cycle. Failure analysis showed that the current required for an RC4136 to drive four LEDs was enough to melt the V_{SS} bond wire inside the package, however not enough to destroy the device. The oscillation was the bond wire expanding, detaching, cooling, and re-contacting the bond pads.

(Wild! Was the amplifier in an extremely high-gain circuit? And, was it driving an excessive load? I know a 741 can typically drive a lot more than it's rated to, but as you discovered, you can get in trouble doing this. /rap)

These devices would oscillate in this fashion during days of burn-in and still function just fine in single-dot mode when they were pulled out for final test!

• ***Ray Bowen***

Hello, Ray,

Wow, what a great story!

• ***RAP***

In looking over the schematic for the fancy PNP, I could not help but wonder about something *("What's All This PNP Stuff, Anyhow?")*. The current sources for sink and source are about 1 mA, while the current that is to be reflected into the output is 0.1 mA to 10 mA. Any mismatch in the sink, and source currents are going to show up in the output. (Yeah, but these currents are going to match well. That's why I defined those current reflectors. /rap)

I might be missing something. If the base of the PNP is a low impedance point (Isn't it a negative impedance point? So when current is dumped into it, it comes

out the NPN's collector and comes back out the PNP's collector. /rap), you have a common base transistor configuration. And in this, the current gain is about 1. There is voltage gain, but the Miller C is removed as it is shunted to ground and does not reflect the driving circuit and cause slow down.

• ***Jim P.***

Hello, Jim,

You are a DAC man. Don't be bamboozled by "paralysis by analysis." It works! You could even build it in nine minutes.

• ***RAP***

Sir,

The Early effect is quite confusing to me. Most textbooks talk about the Early effect only in the CE configuration and do not give finer details. Why are we not observing the Early effect in the CB output characteristics? (Because it is beta times smaller in the grounded base, so it is just less noticeable. Note: the Early effect in grounded-base is largely invariant of beta. In grounded-emitter, it is largely proportional to the beta. /rap)

Is it because we keep base emitter voltage constant to get constant I_E (No. If V_{BE} were kept fixed, the Z_{OUT} would get lousy again. /rap), unlike in CE where we need constant I_B? As in CE, I_C will increase due to a decrease in recombination at the base and due to an increase in V_{BE} ($I_C = I_S eV_{BE}/V_T$) but more due to the latter, and in CB, only recombination affects I_C. (Not really. You seem to throw that around as if I_S were a constant. That is not the case. See what I said about I_S in "What's All This V_{BE} Stuff, Anyhow? Part 1," at *www.national.com/rap/Story/vbe.html*, as well as in "What's All This V_{BE} Stuff, Anyhow? Part 2." /rap)

If so, then the change in I_C that we observe on the output characteristics shows the effect of base emitter voltage on collector current than that of base-width modulation. Is there a way to find the Early effect in CB configuration experimentally (measure hrb and measure hre; measure Z_{OUT} with fixed base drive, or fixed V_{BE})? (Why is the output impedance at the collector about the same when I_B is held constant or when V_{BE} is held constant? Think about it. /rap)

I read somewhere that since the base is very thin when further reduction happens due to the Early effect, the injection of carriers from base to emitter also decreases. Therefore, this also should decrease the base current. (I don't think there is anything there to see. When you measure I_B, you can't tell if it is from the injection or from the recombination. /rap) Exactly what things get changed due to the base-width modulation? (Many things. /rap) Please help.

• ***Ganesh Nithyanandam***

Hello, Ganesh,

Please, go measure some transistors. Help yourself.

• ***RAP*** ■

Comments invited! *czar44@me.com*

—or:

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