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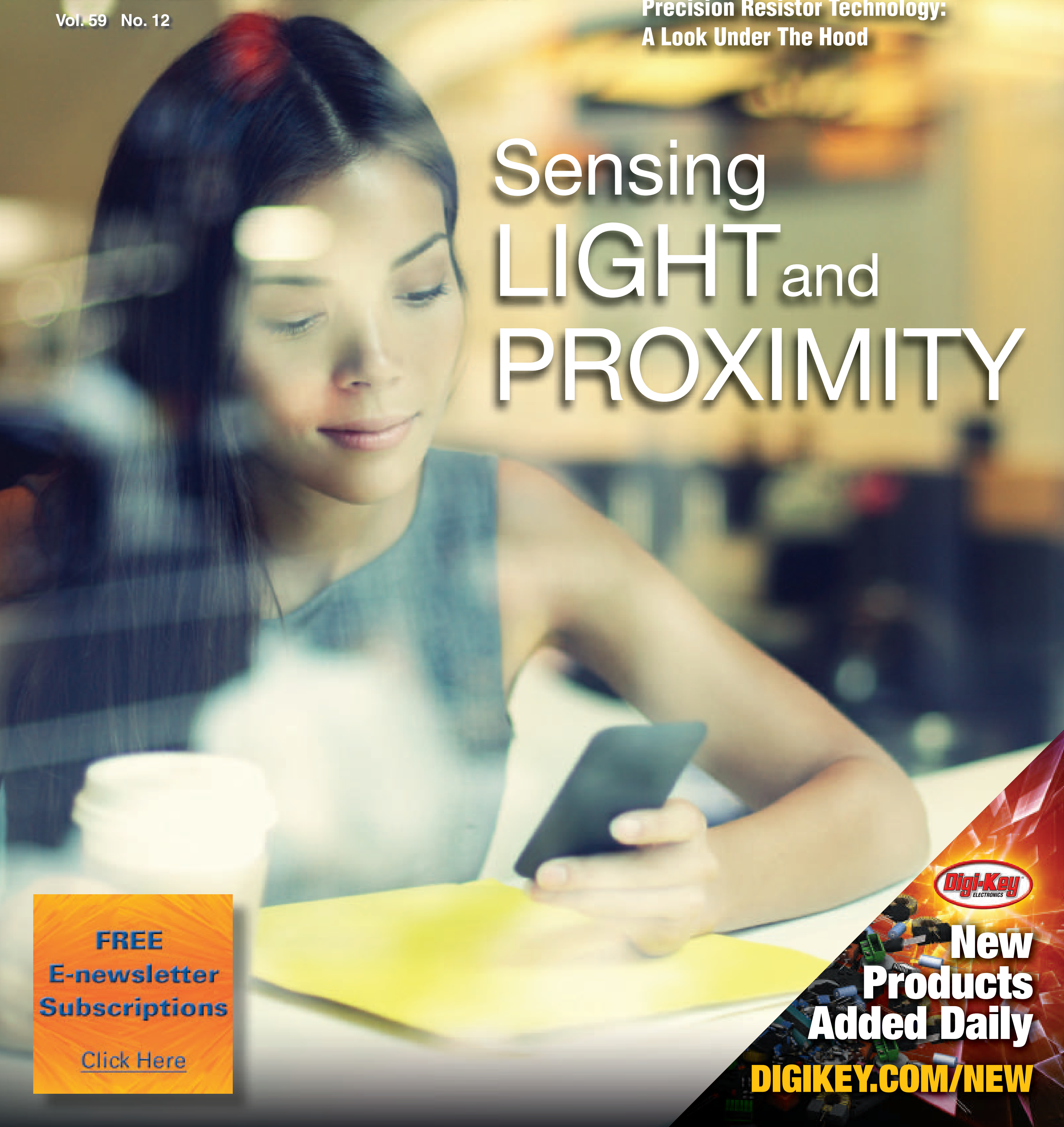
Heat Knows No Boundaries

Precision Resistor Technology: A Look Under The Hood

Sensing LIGHT and PROXIMITY



KASEY PANETTA | EDITOR
kasey.panetta@advantagemedia.com

Well, dear readers, we've made it through another crazy year here at *ECN*.

At the end of the year, I like to take a moment to look back and celebrate a few of the great stories and achievements of the past year.

First and foremost, the biggest change this year was bringing on our new—though not really new anymore—associate editor, Jamie Wisniewski. Jamie came to us from a different world of magazines, but has enthusiastically taken on the world of engineering (and made my job a little bit easier).

We also have a whole new look to the site, which was a big change for the editors. Personally, I think it looks great and I'm happy to usher a 55+ year publication into a new age.

So, without further ado, on to the good stuff. One of our biggest stories this year was, "This is why you shouldn't shoot down a drone." It was written by yours truly, about the legality of shooting down a drone that's hovering over your property. As it turns out, in this particular case, not only can you not shoot down drones, you definitely can't shoot them down when they're not over your property.

This conversation sparked one of our biggest themes for the year. With the increasing popularity of consumer drones and UAVs, comes a whole host of questions about the ethical use of the drones. We talked about how personal drones are hampering the efforts to fight wild fires in the west, but they are making it easier to reduce poaching in large reserves. The government got in on the ruling with the FAA's decisions on regulation, which in turn annoyed big industry tycoons like Amazon, who have bigger and better plans for new-age delivery systems for the drones.

It turns out, as with most technology, everything depends on the operator. More FAA rulings are on the horizon for 2016, and you can bet your bottom dollar we'll be covering them here on the site.

Amusingly, the second biggest blog of the year was a story about Buzz Aldrin's travel voucher for the Apollo 11 mission, because not even historical and technological breakthroughs are free from the drudgery of bureaucracy. Our reader's interest are varied and eclectic.

It looks like 2016 is shaping up to be a great year. In fact, we're trying to make it the year of the engineer. So I encourage you to email me with the story of how you ended up as an engineer, to be featured on the site.

See you in 2016,

Kasey Panetta

Kasey Panetta
Editor, ECN

Do you have something you'd like to talk about? Email me at Kasey.panetta@advantagemedia.com or tweet at me @kcpanetta.

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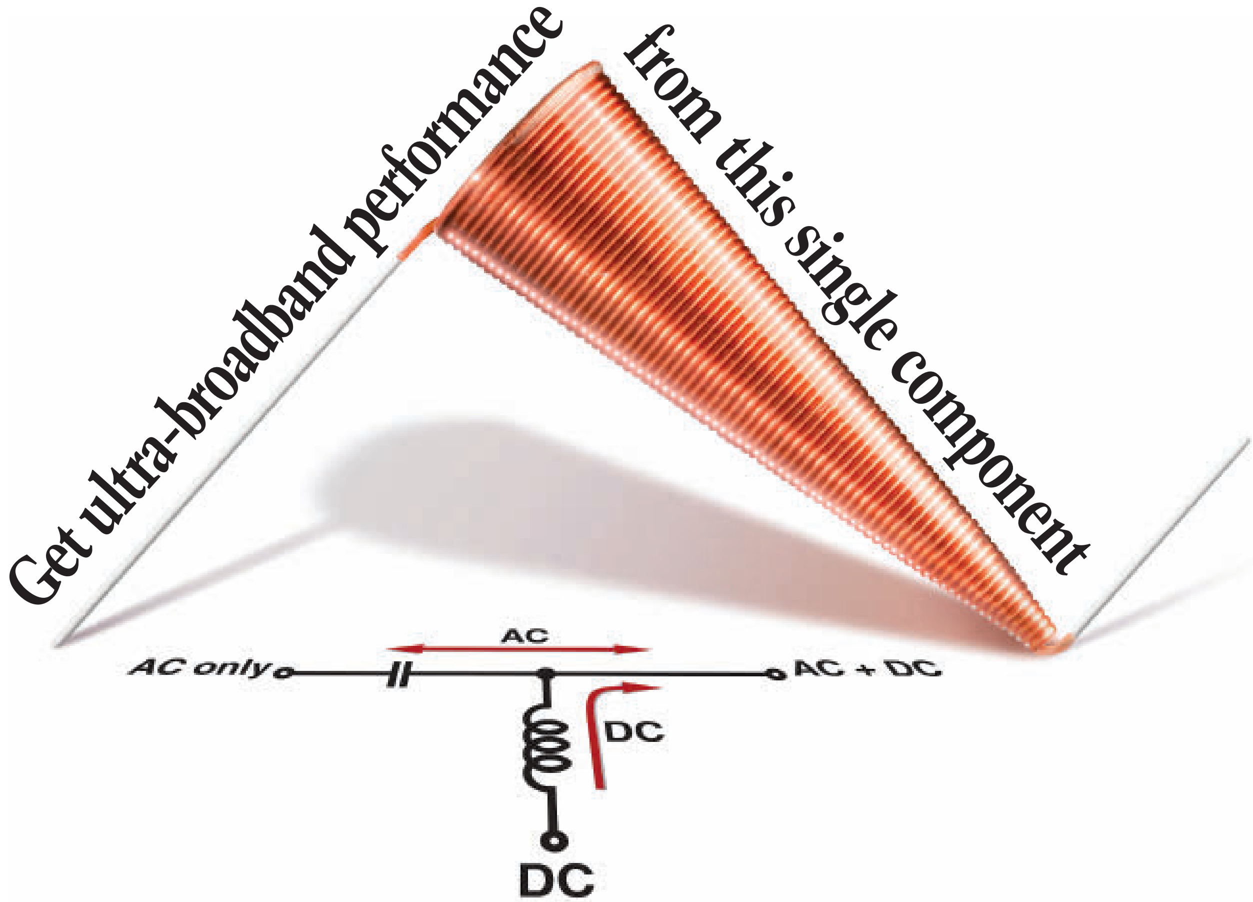

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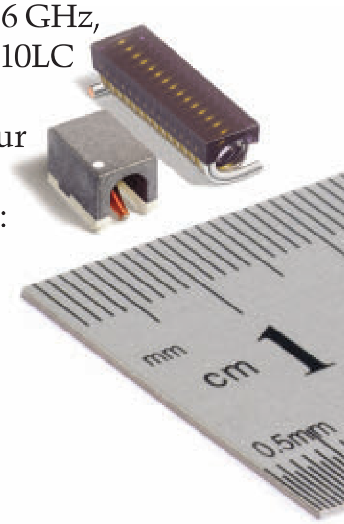

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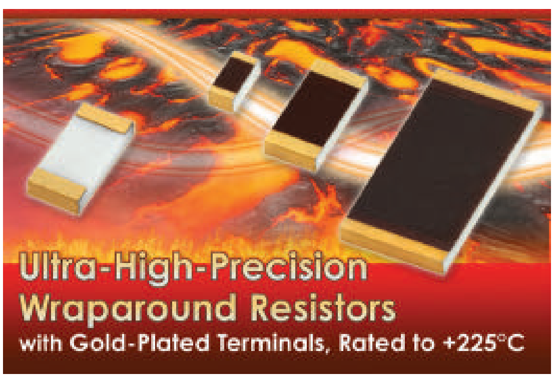
Energy Storage Modules Reduce Long-Term Costs of Backup Power

Power management company Eaton announced the XLM Supercapacitor Energy Storage Module designed to provide fast discharge for bridge events in uninterruptible power supplies (UPS) for mission critical applications where even brief downtime can have a major negative impact. The modules offer a highly reliable, green alternative to lead-acid-batteries and are designed to be maintenance free for grid storage and backup power applications. The XLM module can significantly lower the total cost of UPS ownership in cloud computing, data center, hospital UPS, semiconductor industry and other markets.

XLM modules enable graceful shutdown of systems, the ability to ride through power transients such as sags, spikes, and dropouts in order to smoothly transition to permanent backup solutions such as fuel cells or diesel generators.

For more information, visit www.eaton.com.

KEY SPEC:
These modules contain 69-watt hours and the ability to discharge 7,800 amps.



KEY SPEC:
The devices provide working power to 750 mW at +70 °C and 300 mW at +200 °C.

Ultra-High-Precision Wraparound Surface-Mount Chip Resistors Designed for Harsh Environments

To meet the growing demand for precise, stable, and reliable resistors that can operate in harsh environments, VPG Foil Resistors has introduced a new series of ultra-high-precision Z1 Foil Technology wraparound surface-mount chip resistors designed for high-temperature applications to +225 °C. Featuring gold-plated terminals for design flexibility, FRSG Series devices offer low TCR of 2.5 ppm/°C maximum from -55 °C to +200 °C, +25 °C ref.; tight tolerances to 0.01%; and load-life stability to 0.1% after 2,000 hours of working power at 200 °C.

Optimized for down-hole drilling, oil and gas exploration, and avionics, military, and space (AMS) applications, the resistors released today offer a resistance range from 10 Ω to 125 kΩ, with any conceivable ohmic value within this range — to six digits — available with no additional cost or lead time effect.

For more information, visit www.vishayfoilresistors.com.

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The MPU-600S series, available now from MicroPower Direct, provides 600W of output power in a compact U-Channel package. These power supplies feature a universal AC input; active power factor correction; full safety approvals; robust filtering and compact construction.

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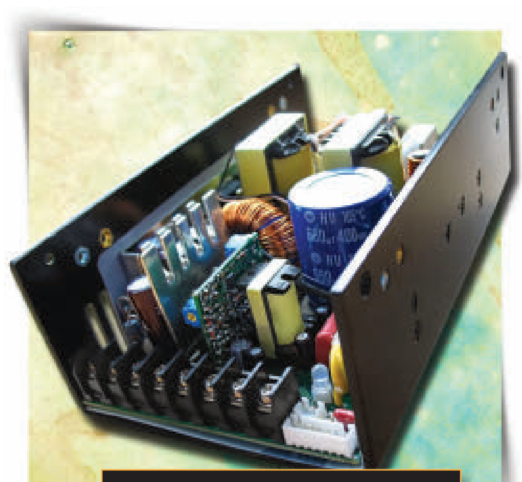
For more information, visit www.micropowerdirect.com.



KEY SPEC:
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12 million

Number of driverless cars estimated to be sold globally in 2035

Engineering Update #135: WiFi That Sees Through Walls

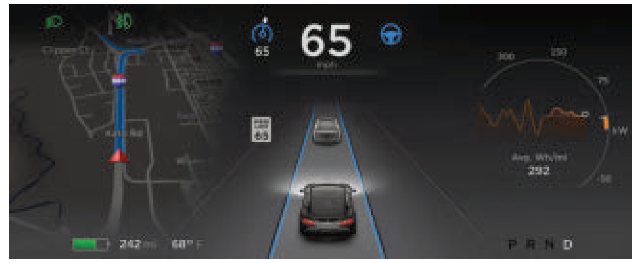
- **Artificial Skin Detects Both Pressure and Heat**
  A newly developed artificial skin can detect pressure and heat with a high degree of sensitivity, all at the same time, according to researchers from Ulsan National Institute of Science and Technology and Dong-A University in South Korea.
- **New Algorithm Helps Drones Avoid Obstacles**
  There is such a thing as obstacle-avoidance software, which uses images captured by each camera, and searches through the depth-field at multiple distances to determine if an object is in the drone's path.
- **Wi-Fi That Sees Through Walls**
  Have you ever been home alone and gotten that creepy feeling that someone is watching you? Well, now it could be the team at MIT and they're using Wi-Fi to do it. The researchers, who aren't going to watch you in your home because that was a joke, have recently expanded on technology developed two years ago that uses Wi-Fi signals to allow them to see through walls.

10 to 50 billion

Number of connected devices experts predict by 2020

Elon Musk Just Realized People Are Too Dumb for Tesla's Autopilot

By Kasey Panetta, Editor, @kcpanetta



Human stupidity is basically limitless. Seriously, spend five minutes trolling through YouTube and you'll be treated to dumb people doing things that will make you cringe from the safety of your computer.

At least that's what Elon Musk did. The Tesla CEO reportedly saw some videos online of morons using the Autopilot for some less than intelligent uses, and subsequently realized maybe we're not ready for this as a species.

This is why we can't have nice things.

@JamieECNmag Engineers: Are you smarter than America? (Only 6% of Americans answered all 12 of these questions correctly.) http://bit.ly/1I9Q1Hg

How Will Women In Space Survive Without Makeup Or Men?

By Kasey Panetta, Editor, @kcpanetta

Russia is planning a trip to the moon, and they're thinking about sending a rather unusual crew of people.

Unusual in the sense that there has never been an all-female crew for any mission, but the country is in the midst of an eight-day mock simulation that is putting the six female cosmonauts through their paces.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Sensing the IoT

IoT long-life wireless sensors require ultra-low power architectures.

By Florian Feckl, Applications Engineer, Texas Instruments

One of the most technical challenges in the Internet of Things (IoT) is sensor nodes that can be placed anywhere. These sensors measure parameters such as temperature and humidity (connected home), mechanical stress of motorway bridges (live maintenance monitoring) or the consumption of gas or water (smart flow metering). This data is gathered and processed by servers and needs an extensive coverage area to make a robust network with reliable data. The enabling technology is the wireless transmission of the sensor data to a central host system.

To realize a broad network like this, another critical aspect must be considered, which is that the whole sensor node must feature a very long operational lifetime. The higher the lifetime, the lower its maintenance cost. With the power optimization of microcontrollers and battery-types like $LiSOCl_2$ primary cells, these processors can be powered for 10 years or more.

Until now, radio frequency (RF) transmission of the sensor data for longer distances was not widely implemented. This wireless feature adds another level of complexity to the system's power considerations. While a wireless sensor node needs to consume the lowest possible average power, it also must be able to deliver high-peak currents for the occasional data transmissions.

From a power perspective, this means a combination of the lowest quiescent currents in the sensor system and an efficient high-power capability for the power amplifier. This requirement is a new challenge for selecting devices, as well as the whole power architecture itself.

Low Quiescent Current And Long Life

To ensure that IoT-sensors become a reality, operating the sensor must be cost-effective. Once the sensor is installed and started, it needs to operate as long as possible to minimize the period between maintenance visits and save cost.

This means that, on one hand, durable materials and components have to be chosen. On the other hand, the internal circuits also need to feature lowest current consumption to gain a longer runtime with a given energy from the battery.

Currently, these applications use specific primary batteries. Chemistry types like the $LiSOCl_2$ feature a very high energy density of more than 1 Wh/cm^3 and are broadly available on the market. These primary cells bring a very low self-discharge, another important property to consider. This makes them a designer's first choice for long-life applications.

To benefit from these parameters, the battery current must be limited to less than 5 mA. Currents beyond this increase the self-discharge rate, which reduces the cell's lifetime. As well, higher currents force the terminal voltage to decrease due to the internal impedance. In addition to the battery, the power-consuming components and power architecture must be optimized to minimize leakage currents.

Ultra-low-power microcontroller system-on-chip (SoC) devices feature several low-power modes to decrease current consumption. An ultra-low-power SoC extends the application lifetime due to its implemented standby mode where the device consumes around 2 μA when connected directly to the battery. Figure 1 shows the supply current of this device in a low-power mode (LPM3). The current consumption depends on the supply voltage (green trace).

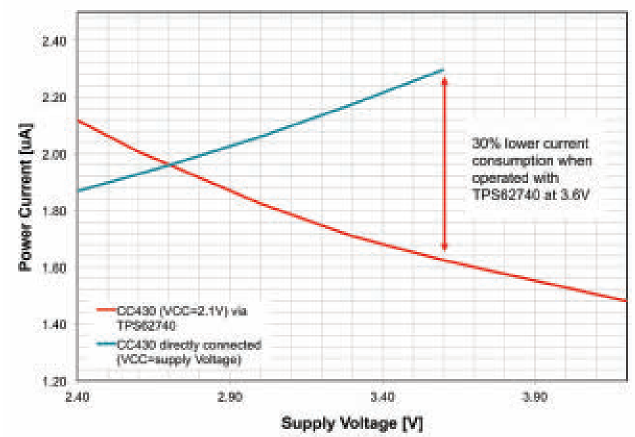

Figure 1: Combining a microcontroller SoC with a buck boost converter reduces power consumption by 30%. (All figures courtesy of TI)

Current consumption is further reduced when SoCs are used in combination with an ultra-low-power buck converter to decrease the supply voltage. These are step-down converters with a quiescent current of several hundredths of nano ampere. The blue trace shows current drawn by the application after stepping down the supply voltage to 2.1 V. The higher the battery voltage, the more power is saved due to the efficient step-down conversion. At the typical $LiSOCl_2$ battery terminal voltage of 3.6 V, overall current consumption goes down by 30 percent compared to the direct battery connection.

Peak Power For Wireless Transmission

Besides the low IQ aspect, the sensor must communicate the gathered and processed data to a base station. For example, this can be a local data concentrator, which is common for smart gas sensors in an apartment building. Besides the wireless metering bus (wireless M-Bus), this also can be the available global system for mobile communications (GSM) infrastructure used for field sensor nodes on motorway bridges.

A typical mode of operation is gathering and processing data throughout the day, then transmitting the collected data up to a few times a day. From a power perspective, this means that a low average current consumption in the range of microamperes is mostly needed, with a rare need of higher currents for several milliseconds.

The amount of energy needed for data transmission depends on the range and, therefore, the radio frequency protocol. Widely used standards are wireless M-Bus and GSM.

A comparison of three common standards is shown in Table 1. Each standard has a typical radio amplifier power condition and the required current for transmission duration.

Wireless standard	Amplifier conditions	Example currents	Duration
wM-Bus, 868 MHz	27 dBm P_{OUT}, 3.3V	100 mA	40 ms
wM-Bus, 169 MHz	30 dBm P_{OUT}, 3.6V	300 mA	100 ms
GSM	2G High power, 3.7V	2000 mA	577 µs per slot

Table 1: Power properties comparison of several wireless examples

In some cases, currents up to 2.5A are required by the radio amplifier. This amount of current cannot be delivered by the battery types described. Even currents of more than 5 mA should be avoided in order to not reduce the lifetime of a $LiSOCl_2$ bobbin-type battery.

Energy Buffering Concept

To enable pulsed-load operation as described, new power management concepts need to be considered. Since the battery cannot deliver the necessary current, the required energy needs to be stored when the radio is inactive so it can be used when the radio is active. To achieve this, a new power concept needs to be designed to buffer energy and decouple load peaks from the battery. An excellent medium for buffering energy are storage capacitors because of their high-energy density and large capacitance.

When using a switch-mode power supply (SMPS), a capacitor can be efficiently charged with different voltage than the battery. This can be done in a current-limited operation, which then defines the load current for the battery.

Once energy is stored in a capacitor, voltage is converted to the desired value, for example 1.9 V for the microcontroller SoC or 3.7 V for the radio power amplifier. This conversion takes energy from the buffer capacitor and decouples the load from the battery (Figure 2).

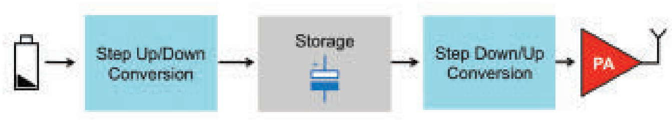

Figure 2: Capacitor storage concept

When using a SMPS buffering power architecture, two basic concepts to store energy apply:

Boost – storage – buck

Buck – storage – boost

Concept one steps-up the battery voltage to a higher voltage and charges a capacitor. Then the voltage is stepped-down to the desired values for the SoC or amplifier.

This concept uses smaller capacitor values because the stored energy is proportional to the square of the capacitor voltage. The higher the voltage, the more energy is stored in the same capacitor. Once the energy is stored in the capacitor, the voltage is stepped down to the desired value. The energy required for a transmission is extracted from the capacitor, and thereby decoupled from the battery.

The second architecture uses a buck converter that is directly connected to the battery. The voltage is stepped down to charge a storage capacitor. Here the storage capacitance value must be higher because the voltage is lower. However, this enables the usage of electric double-layer capacitors (EDLC), which are broadly available with a high capacity of several Farads. After the storage capacitor, the voltage is stepped up to the desired value (Figure 3).

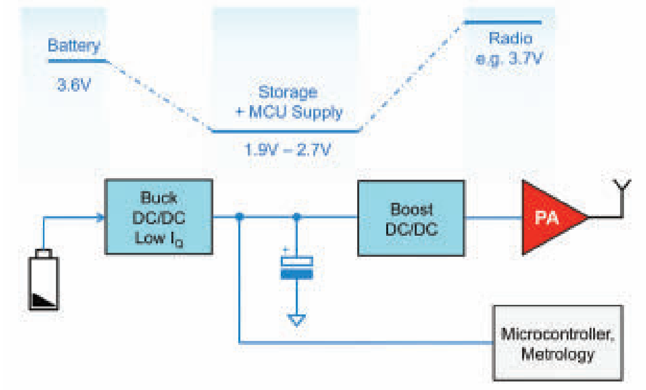

Figure 3: Wireless sensor node power scheme including "buck-storage-boost" buffering

Besides the higher available capacitance, this concept features three advantages:

- Due to the lower storage capacitor voltage, less safety considerations need to be taken into consideration, compared to a capacitor charged with a higher voltage.
- The already stepped-down voltage can be used to power the SoC microcontroller directly. This reduces overall current consumption with just one SMPS being active at all times.
- The lower voltage enables the usage of EDLC-type capacitors. These capacitors are available with high-capacitance values.

When using a buck-storage-boost concept in a wireless sensor (Figure 3), the lowest EDLC voltage is defined by the minimum required SoC supply voltage. The energy is then buffered by charging the capacitor to its maximum voltage of 2.7 V just prior to radio transmission. This keeps the average supply voltage close to the minimum of about 1.9 V. During radio transmission, the EDLC is discharged to the defined minimum voltage.

Conclusion

The requirement of lowest-quiescent-current devices in combination with high power is a challenge for power architectures. Using the energy-buffering concept of "buck-storage-boost" solves decoupling of the load peaks by storing the required energy in an EDLC. It also achieves lower overall power consumption because of the lower supply voltage of the microcontroller. There are less safety concerns, as the storage capacitor uses a lower voltage. This concept can combine energy buffering in a storage capacitor with a reduced overall current consumption to allow longer application runtime. ECN

Sensing Light and Proximity

The module advantage in smartphone light sensing and proximity applications.

By Dewight Warren, Senior Product Manager, Advanced Optical Sensor division, ams AG

The apparently simple act of switching off a touchscreen display when it is held close to the face is accomplished by an astonishingly precise assembly of an IR transmitter and an optical sensor along with some optical components. In an extremely space-constrained product such as a smartphone, the tolerance for misalignment or for variations in emission or reflectance characteristics is very tight.

While proximity functions may be implemented with a discrete IR LED, optical sensor and other components, this exposes the system designer to a considerable development risk: the apparent simplicity of proximity systems is deceptive, and there are numerous ways in which a proximity system can fail in development and in production.

This article explores the challenges involved in designing and manufacturing a fault-free proximity sensing system, and describes the ways in which manufacturers of integrated optical modules seek to eliminate the risk of failure in a high volume-manufactured end product.

By detecting user proximity, the smartphone can

turn off the display backlight and the touch screen when the smartphone is held up to the user's ear saving battery life and helping to prevent inadvertent touch screen interaction. Gesture detection uses the same set of components to allow the smartphone to recognize simple hand gestures such as display screen scrolling and button selection.

Proximity and gesture detection require not only an optical sensor but also an IR LED (infrared light emitting diode). The IR LED is pulsed in a controlled sequence to determine user proximity and possibly user gestures. The IR LED can be either separate to the optical sensor or integrated into the same package as the optical sensor. The former arrangement is referred to as a discrete implementation whereas the latter arrangement takes the form of a module where the ambient light sensor and the IR LED are integrated into the same package. To understand why modules may be the preferred approach, a short background discussion on some of the system implementation is-sues in smartphone proximity and gesture detection will be discussed next.

Fig. 1: By detecting user proximity, the smartphone can turn off the display backlight and the touch screen when the smartphone is held up to the user's ear saving battery life and helping to prevent inadvertent touch screen interaction. (All figures courtesy of AMS ag)

In theory, proximity detection using infrared (IR) light is fairly simple. An IR emitter such as an IR light emitting diode (LED) will generate a light pattern which is invisible to the human eye in the general direction of an object that requires proximity detection. A portion of the emitted light will bounce off of the object and be reflected back to a sensor. If the object is not present within the field of view of the emitted light pattern and also within the sensor field of view or if the object is too far away, the system will sense that no object is present. Once the reflected signal rises above the ambient noise floor, the sensor can begin to discern how far away the object might be based on the strength of the reflected signal.

In a real world environment, proximity detection

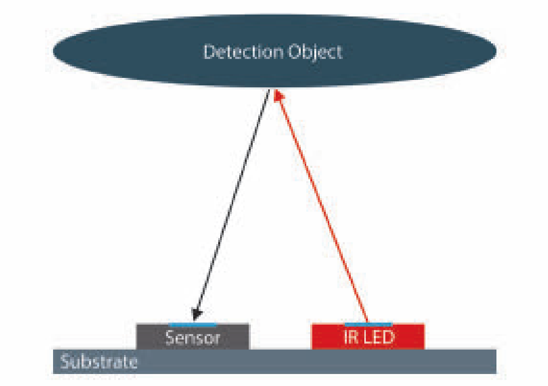

Fig. 2: Simplified proximity detection system

using IR light is complicated by a number of physical constraints. First, in smartphone designs, the detection system will reside under glass. The over-laying glass creates several issues. When light passes through glass, it is attenuated and refracted (bent) as well as small portion (usually about 4 percent) of the light is reflected.

The reflected light causes the biggest issue. Since the glass is so near the emitter, even a small portion of unwanted reflected light from the glass can easily overpower the reflected light from the detection object since the travel distance from the glass to the detection object and back to the glass will heavily attenuate the light signal during its journey. As shown in Figure 3, some of the emitted light will be reflected off both the inside and the outside surfaces of the glass and this reflection must be mitigated to create a reliable system.

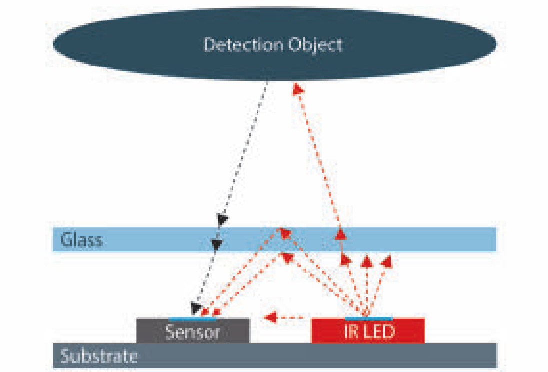

Fig. 3: Complications when glass is added to the system

A similar issue is that some small amount of IR light will be emitted directly toward the sensor. Again since the sensor is so close to the IR LED emitter, even a small amount of signal can overwhelm the reflected light from the detection object. This effect is sometimes referred to as IR leakage.

The glass reflection and the IR leakage make up a major portion of optical crosstalk. Optical crosstalk is any unwanted signal that appears at the sensor during emission. In a perfect system, only reflected signal from the detection

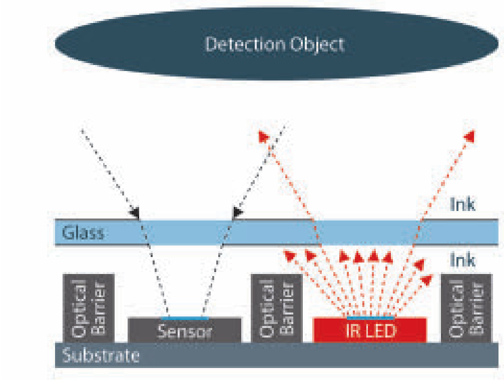

Fig. 4: Inclusion of optical barriers

object will appear at the sensor.

There are several system level physical design elements that can be employed to help mitigate the issues caused by the glass cover and IR leakage. Optical barriers can be placed around the IR LED and sensor to prevent unwanted signal from reaching the sensor. In theory, the optical barriers shown in Figure 4 could extend the complete distance from the substrate to the glass and reduce the reflections off of the glass. However, this is not mechanically practical because the glass will bend during usage and having the optical barriers touch the glass will enhance the possibility that the glass may break or crack. Fortunately, this is another option to help solve the problem. By using non-reflective (absorptive) ink on both the top and the bottom sides of the glass, the amount of reflected light is greatly reduced and makes the issue manageable.

In smartphone designs, power consumption of each system is critical and the same holds true for the proximity detection system. The radiated emission pattern of the IR LED can be narrowed with the addition of a lens which will reduce the amount of wasted light energy. Lowering the amount of wasted light energy means the IR LED can be operated at a lower power level or for a shorter amount of time for equivalent performance resulting in power savings.

The proximity sensor designs in smartphones are very small. Some occupy less than 10 cubic millimeters of space. There are many dimensions that must be tightly controlled. Some of these dimensions are shown in Figure 5 including the XY spacing from the LED to the sensor, the air gap between the optical barrier and the glass, the Z height of the LED and the sensor to the glass, the thickness of the glass and also the distances the LED and sensor are from the optical barriers. In Figure 5, the critical point must be tightly controlled to ensure proper operation of the smartphone. The critical point moves too far from the glass surface, it will not be able to detect objects close to the glass and if the critical point moves inside the glass, the crosstalk will increase significantly. Even a movement of a few tens of microns can completely break a system. Spatially placing components reliably in a high volume environment is a significant challenge for smartphone manufacturers.

Discrete versus Module Solutions

Numerous system issues that must be solved to create a reliable proximity design in a smartphone. Modules offer some inherent advantages over discrete solutions. Modules can make the development effort easier and they can create a product that is easier to manufacture in high volume. For example, with modules, many of the spatial dimensional issues with placement variability are constrained to the point such that it is much easier to model and simulate the overall system. This eases

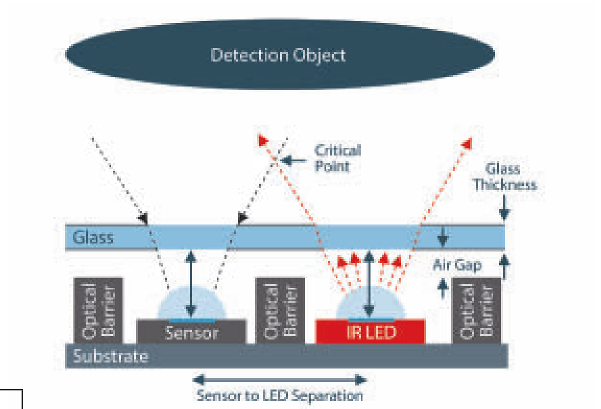

Fig. 5: Complete system with lens showing critical dimensions

and speeds the development effort. Since many of the critical dimensions are contained within the module, these critical dimensions are no longer a manufacturing issue the smartphone manufacturer needs to address. Also, the systematic optical crosstalk becomes a more predictable phenomenon with modules which can be modeled and controlled to an allowable limit. The tighter tolerances modules provide can lead to a more aesthetic smartphone design with smaller holes in the glass.

Modules also offer several other additional advantages over discrete solutions. First, they can be calibrated at the factory to remove the radiated power variability of the IR LED. The power variability can be in excess of 30% and calibration must be performed at some point during the smartphone build to create a reliable system. Calibration at the module level is easier than once the design is assembled into a smartphone. Secondly, integrating the IR LED removes an item (and probably an additional vendor) off of the end users bill of material (BOM) which simplifies the manufacturing process. Also modules solve the issue of selecting the best IR LED to pair with the light sensor. The emission patterns of IR LED vary greatly and so does the detection characteristics of light sensors. For optimal performance, the IR LED and light sensor must be compatible. ECN

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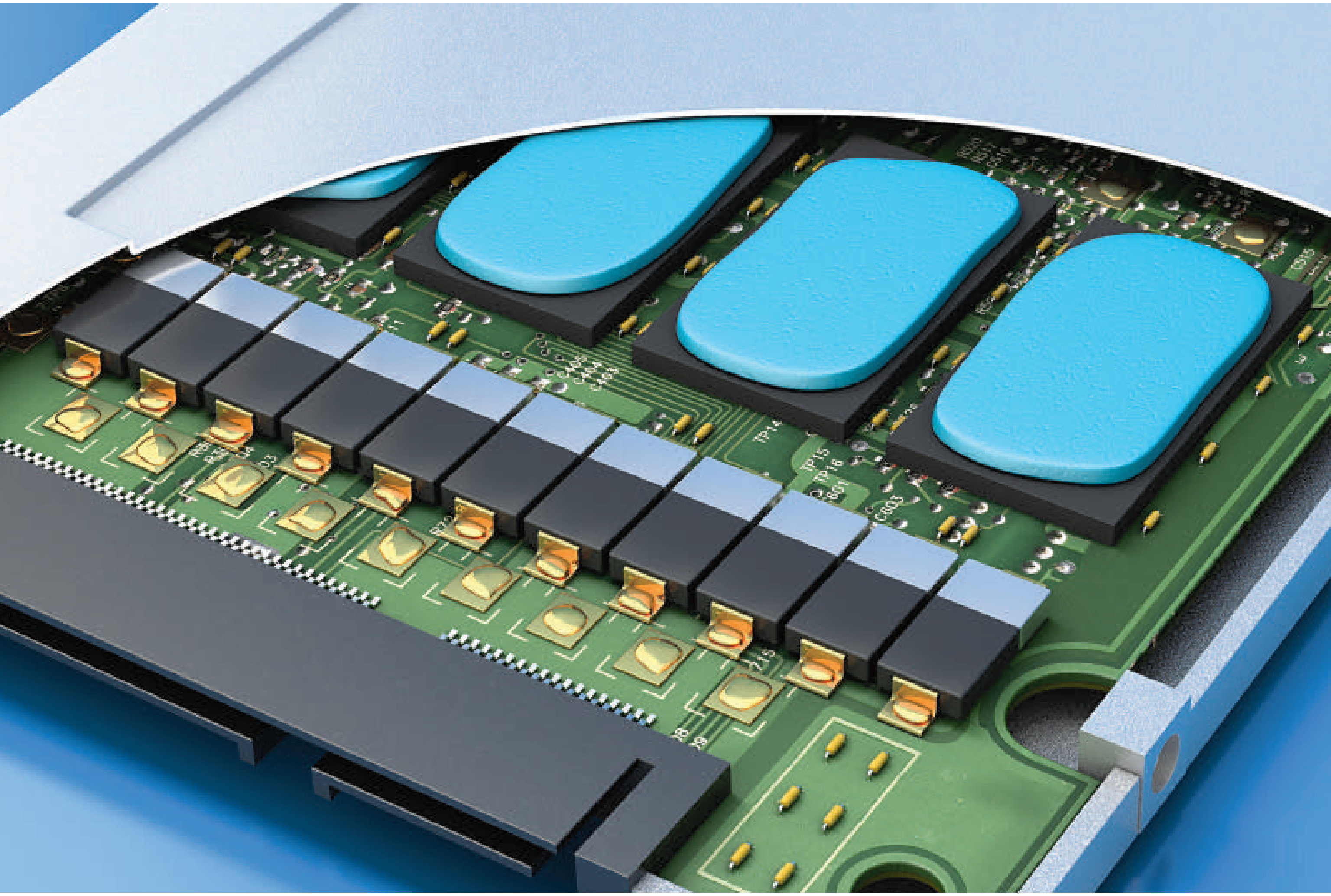

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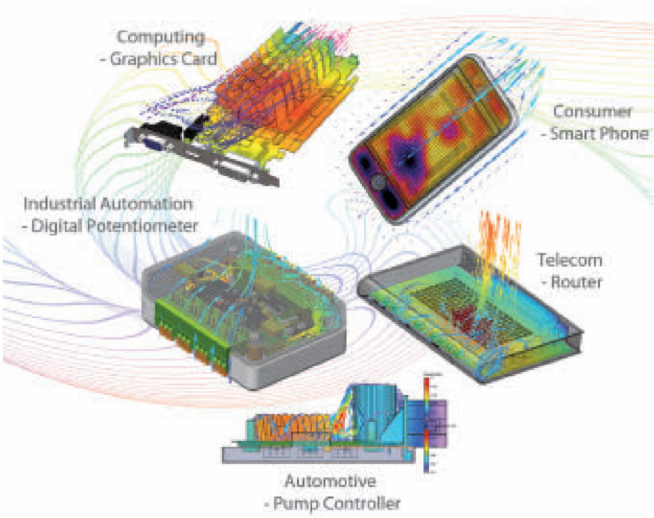
Heat Knows No Boundaries

A multi-discipline and multi-level approach is needed to design electronic products.

By John Parry, Ian Clark, and **Robin Bornoff,** Mentor Graphics

The rapid growth of electronics functionality, and miniaturization, has resulted in the ever-increasing integration of electronic components into a wide-variety of physical products. Yet still these products and their electronic components are designed with different tools (ECAD and MCAD), and they have different constraints on performance, which is addressed through totally different computer-aided engineering analysis solutions, such as for electrical timing and mechanical stress. Bringing it all together into a final seamless product is a major challenge in this situation. The future of technological products is production that connects all the disciplines, mechanical and electrical, from design through to manufacturing.

An area facilitating this approach already is thermal simulation and analysis, with computational fluid dynamics (CFD), because heat knows no boundaries. Heat from closely located active electronic components is additive. It soaks into everything and can affect the reliability of thermally sensitive components. In design, temperature equality is often assumed for timing purposes, which means that actual temperature differences will affect performance. Consequently, the heat has to be removed, as efficiently as possible, so the cooling solution has to be planned in from the start, not only for each component but also for the entire end-product design.



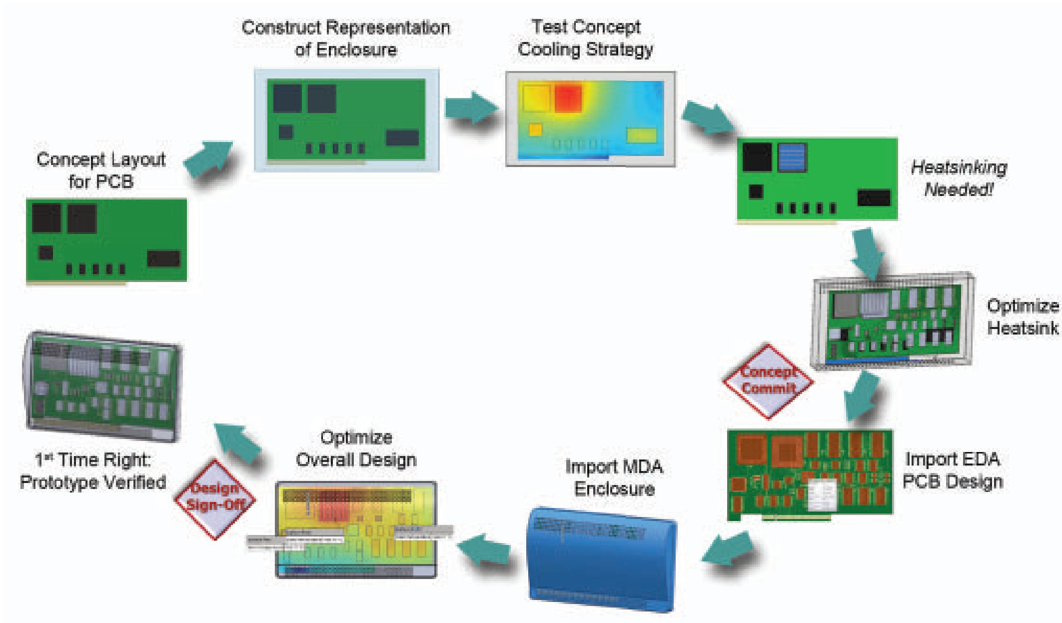
Good heat management is required for all electrical products. (Figures courtesy of Mentor Graphics)

Because multiple voltages are used in a product, the power planes are partitioned, and current is increasing that causes heat to be generated within the electronics board. This means that, in practice, designs can no longer be made based on an assumed power thermal limit; instead, thermal design has to be based on how the product will be used, and power has to be throttled back if the product becomes too hot when used at the limits of its application.

Managing heat is not only a multi-disciplinary challenge, it's also multi-level. An IC package that is thermally optimized does not mean the entire system is good. Effective heat management at the PCB level does not guarantee high reliability. Design and thermal analysis has to be done at multiple levels that include the ICs and PCBs in the product enclosure. Computational fluid dynamics (CFD) software connects these levels and crosses disciplines so that convection, conduction, and radiation heat transfer of the entire system can be considered throughout the design to manufacturing processes.

Optimizing the cooling system for an electronic product involves juggling multiple design variables such as airflow rate, fan, and vent locations, as well as heatsink size and the physical location of boards. Successful design engineers use a comprehensive approach to thermal management, whether they are a single engineer in a small company who is tasked with the entire design and optimization process or several teams of engineers spread around the globe that provide components that fit into a single product.

Mechanical engineers using mechanical design automation software are responsible for all aspects of the physical design of the product except the ICs and PCBs. So they need to collaborate with electronic designers using electronic design automation software. These two domains used to be linked only via en-masse data transfer (through neutral file formats such as IDF), usually without filtering for thermally relevant information. Good thermal design needs accurate electronic design information, such as individual trace geometries to capture their cooling effect and the interaction between components. This resulted in excessive design detail that required the designer to manually simplify the model for CFD simulations



An example of a design process from concept through to final verification using CFD software with tight integration to the mechanical and electrical design tools.

or suffer excessive CFD run times and risky convergence.

However, today's CFD software enables a thermal engineer to simulate and analyze a system until he or she is satisfied with the cooling solution, using detailed design data automatically imported from his or her colleagues' mechanical and electronic design automation tools. With the latest software technology, they can do upfront analysis, determine trends, perform efficient and accurate analysis, and make good progress by solving more problems faster, and, in effect, complement what specialists do at the later stages of verification. This can reduce the cycle time to days or overnight versus multiple weeks. Design engineers can test various options using a design of experiments approach and arrive at a much more competitive or reliable product, or the fast cycle times can be used to reduce time-to-market. Modern fast and accurate thermal analysis tools are useable by both design engineers and thermal experts, bringing together multi-disciplines more efficiently to create a product. ECN

Big Solar For Small Batteries

By Sol Jacobs, Tadiran Batteries

The Ashalim power station, a futuristic solar power station scheduled for construction in Israel's Negeu desert, will use the sun's energy to supply 121 MW of clean renewal energy, enough electricity to meet the needs of more than 120,000 households. Once online, this facility, constructed by BrightSource Energy, Inc, will feature 50,000 heliostats, which are individually controlled mirrors using wireless communication being to actuate motors that rotate and tilt each mirror precisely to concentrate huge amounts of energy towards a boiler that sits atop a tower. The focused energy creates high-temperature steam, which is then used to power a conventional turbine engine that produces electricity.

Critical to each heliostat is a self-contained power supply that provides reliable power to each motor, while also supporting wireless connectivity throughout the network, delivering the critical data needed to support synchronous movement of all. The system needs to be 'truly wireless' with each heliostat having self-sufficient power, eliminating the expense, complexity, and risks associated with running miles of wire and cable.

Industrial grade Li-ion rechargeable batteries were chosen to power the heliostats with each one equipped with a small photovoltaic energy harvesting device along with a small battery pack consisting of six batteries.

The batteries will power the heliostats for up 25 years without replacement. Given that a system-wide battery change-out would be an incredible expense, extended battery life is critically important. Considering the extreme environmental conditions of the Negeu desert, the batteries offer an extended temperature range (-40°C to 85°C), and are more ruggedly constructed using battery cans that are precision welded to create a hermetic seal.

While supercapacitors were also considered in place of the Li-ion batteries, this technology has inherent drawbacks for industrial applications, including short duration power, linear discharge characteristics that do not allow for use of all the available energy, low capacity, low energy density, very high self-discharge (up to 60% per year), and the need for cell balancing for supercapacitors linked in series.

As industrial wireless technology continues to expand and evolve, there will be a growing need for power supply solutions that are truly wireless: providing reliable power that is completely free of wire and cable, delivering a higher return on investment (ROI) while using fewer precious natural resources to promote environmental sustainability. ECN

Programmable DC Power Source With Integrated True Function Generator

Intepro Systems introduces the PSI 9000 2U programmable DC power source, providing a 1-3KW supply with a feature set typically found in higher power 3U systems. The PSI 9000 2U power source features an interactive system with touch panel menu navigation that simplifies set up and storing to test profiles. The high-efficiency (up to 93%) unit includes an integrated true function generator. For user convenience, complex test sequences can be loaded from the system and saved to a standard USB flash drive.

A unique feature of the PSI 9000 2U power source is its auto-ranging output. Unlike competitive DC sources that provide rated power only when maximum voltage is applied to the load, the auto-ranging output stage is capable of delivering a three-times higher output current at reduced voltages. This feature is especially useful when testing products that require varied input voltages while maintaining regulated output power. With auto-ranging, a single system provides a complete test solution, compared to buying multiple sources to address low- and high-voltage/current requirements.

For more information, visit www.inteproATE.com.

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The MPL-03SEUP series is a family of miniature, safety approved, 3W AC/DC power supplies. Designed specifically for space critical board level applications, these power modules are as a miniature single-in-line (SIP). As part of our “Cost Cutter” product series, they are offered at very low cost.

Six standard models operate from a universal input of 85 to 264 VAC; providing regulated single outputs of 3.3, 5, 9, 12, 15, or 24 VDC. They may also be used in high voltage DC/DC applications with an input of 70 to 400 VDC. Standard features include tight line/load regulation, continuous short circuit protection, input/output isolation of 3,000 VAC and over power protection.

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Spectrum Rider Assists Users During RF Transmitter Installation

The versatile R&S Spectrum Rider from Rohde & Schwarz assists users during RF transmitter installation and maintenance and also supports measurement tasks in RF development labs and in service. With its high sensitivity of –160 dBm and measurement accuracy of typically 0.5 dB between 10 MHz and 3 GHz, the R&S Spectrum Rider offers class-leading RF performance.

The frequency range of the R&S Spectrum Rider can be extended via software upgrades – a feature unrivaled in this instrument class. The base model covers the frequency range from 5 kHz to 2 GHz, which can be expanded to 3 GHz or 4 GHz to support applications that require higher frequencies such as measuring radio signals above 2 GHz or signals above 3 GHz in TD LTE bands.

The instrument is the industry's first handheld spectrum analyzer to offer a large format capacitive touchscreen that enables lab users to easily and intuitively adjust settings such as frequency, span and reference level and to set markers. Its large buttons and practical multifunction wheel also make it easy to operate with gloves in outdoor environments. The handheld spectrum analyzer can be remotely controlled via USB and LAN. A built-in measurement wizard automates measurements, reducing measurement times and enabling even novice users and operators with little RF expertise to reliably carry out measurement tasks. Settings and results are saved to a 32 Gbyte microSD card.

For more information, visit www.rohde-schwarz.us.

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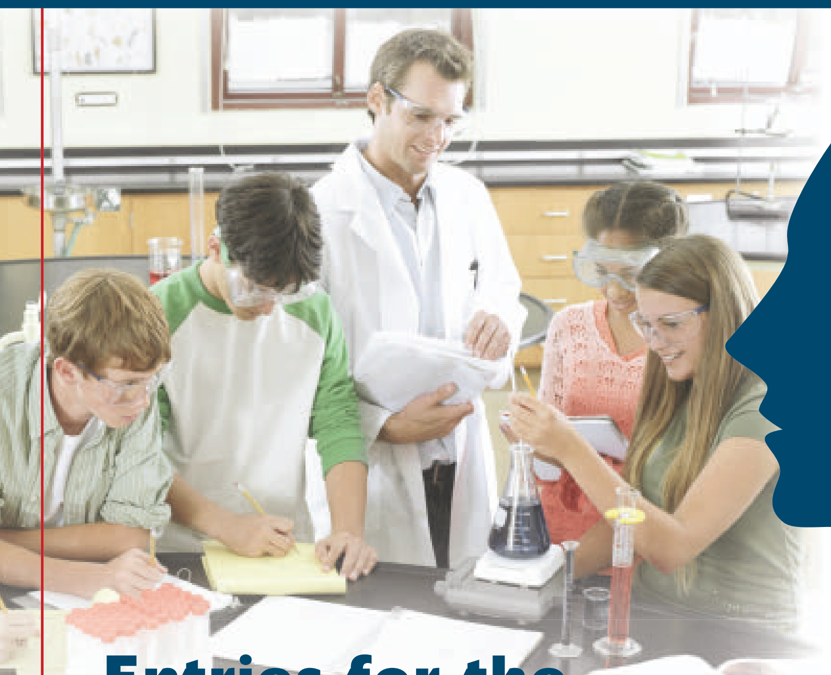

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Entries for the 2nd Annual Awards Are Now Open

Advantage Business Media's **Young Mind Awards** recognize inspired designs in science, technology, engineering, and math (STEM) from the next generation of inventors, scientists, and engineers.

The awards shine a spotlight on these future innovators, giving them the opportunity to demonstrate their passion and showcase their ability to tackle real-world challenges in STEM. It provides an excellent opportunity for educators to add STEM to their curriculum by having their students take on individual or team research projects. And all Middle School, High School, and Undergraduate students are eligible to apply.

A panel of distinguished industry professionals will review all submissions based on the core principles of creativity, comprehensiveness, clarity of expression, and demonstration. Students can submit a project in one of five innovation categories:

- Electromechanical/Mechanical
- Electronic Design
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The New World of Rapidly Configurable AESA Radar

The introduction of a modular building block solution offers greater design flexibility for Active Electronically Scanned Array radar.

By Mark Howard, Chief Engineer, API Microwave Ltd.

To date, AESA radar technology has been largely restricted to customized solutions developed by prime aerospace contractors for use in their own proprietary systems. These systems were relatively costly, required extended lead-time, and could not be easily reconfigured for specialized applications.

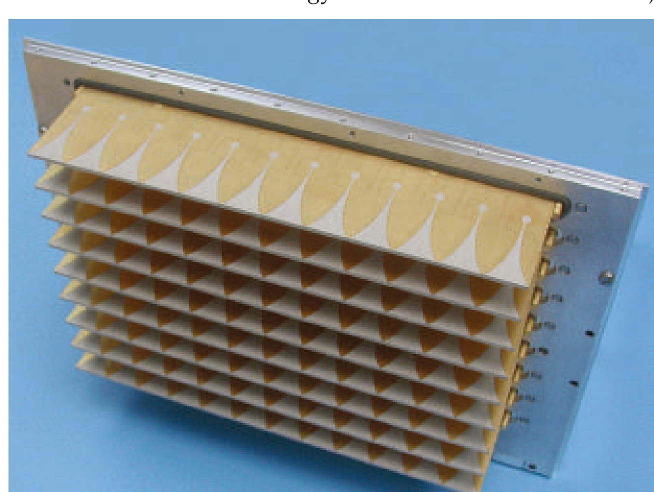
There is a growing need for a modular, stackable AESA radar system that can be quickly configured to a wide variety of applications, including: naval, airborne, vehicle-mounted, and ground-based systems; coastal, harbor, and border security; air traffic control; foreign object detection (FOD) for airport runways; satellites; and data links.

How AESA Radar Systems Work

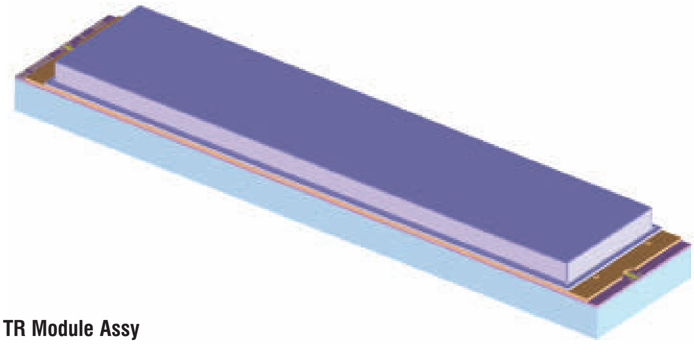
Active Electronically Scanned Array (AESA) radar, or e-scan, is a well-established technology that utilizes numerous transmit/receive modules (TRMs) that transmit and receive high power radio waves of varying frequencies, scanning rates, and radiation patterns on demand to provide highly agile beam steering, which permits multiple targets to be tracked simultaneously.

AESA radar offers greater frequency agility than conventional radar systems, including Passive Electronically Scanned Arrays (PESA), which delivers unpredictable scan patterns that are difficult to detect by radar warning receivers (RWRs), particularly older systems. AESA radar provides high jamming resistance by spreading signals across a range of frequencies, and can be switched into a receiver-only mode to track the source of jamming signals or serve as a radar warning receiver. AESA radar can also provide high-speed data link capability, supporting peer-to-peer networking by combining data from multiple platforms to deliver expanded radar coverage and enhanced resolution.

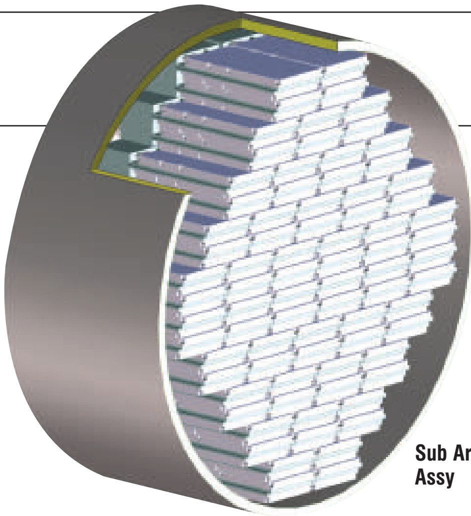
This advanced technology also has certain limitations,



X-Band Sub-Array face. (All images courtesy of API Microwave Ltd.)



TR Module Assy



Sub Array Assy

as the highest field of view (FOV) achievable for a flat phased array antenna is generally between 90 to 120 degrees. Wider coverage can be obtained through multiple antenna faces or two rotating antenna faces. An X-Band array mounted onto the nose of an aircraft can use a mechanical gimbal to expand its FOV.

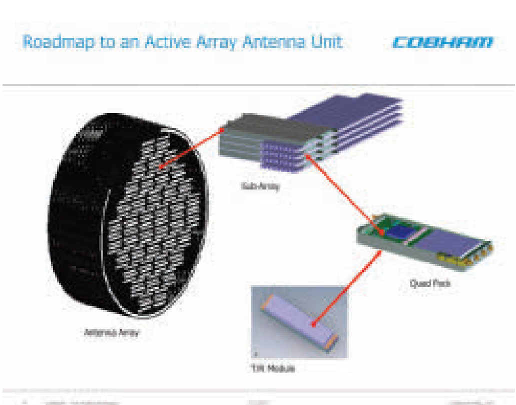
Thermal management is also required to reduce the heat gradient caused by multiple power amplifiers (PAs) distributed across the antenna face. These cooling systems must fit within a limited space envelope between the elements.

Designing The Ideal Aesa Radar System

Application-specific requirements dictate the overall system design, with circuit technology, circuit topology, and the available space envelope being major considerations.

Circuit Topology

The functional building blocks of a typical T/R channel are similar regardless of overall system requirements. For C-Band frequency and above, a MMIC 'core chip'

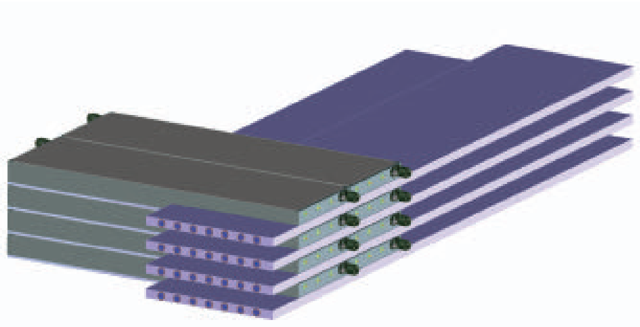


Roadmap to an Active Array Antenna Unit

QTRM Inside

is likely utilized along with a low noise amplifier MMIC in the receive path and a power amplifier MMIC in the transmit path. The MMICs are typically designed as a chip set, allowing the power amplifier to be driven directly from the core chip.

The core chip usually consists of a digital phase shifter and an attenuator, along with low noise and medium power amplifiers that interface directly with the receive and transmit path MMICs. Switches within the core chip allow the attenuator and phase shifter functions to be used in both transmit and receive paths and thus form a common leg circuit. Minimum detectable range (MDR) can be reduced by minimizing T/R switching speed, limiter recovery time, and DC supply gating circuit requirements.

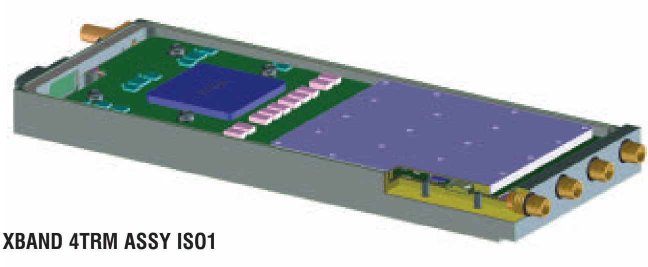


XBAND 4TRM MULTI ASSY

A limiter circuit in the LNA protects the device from high power RF signals generated either from the transmit side or from external sources. The antenna port feed to the T/R channel usually passes through a ferrite circulator, often with a ferrite isolator to protect the power amplifier, or occasionally with a high power T/R switch that can terminate the receive path with a load during the transmit pulse cycle.

Lower frequency designs can utilize a combination of discrete surface mount MMIC devices to realize the core chip functionality, along with discrete high power transistors with external matching circuits for the power amplifier. Combining a low noise receive channel with high output power extends the signal transmission range.

In all cases, adjacent T/R channels will need to be isolated using either channelized grounded cavities or metal covers.



XBAND 4TRM ASSY ISO1

The Circuit Technology is influenced by the frequency band, which dictates the available space envelope. Lower frequency designs lend themselves to a single layer RF pcb design mounted onto a backplane, with SMT packaged MMICs, and drop-in devices such as circulators or packaged discrete transistors.

Higher frequency designs have a smaller space envelope, making it difficult to fit all the required RF functionality and associated interconnects onto a single layer and prohibiting the use of packaged devices. Therefore, a chip and wire approach is required using a highly integrated MMIC chip set. A multilayer approach may also be considered, such as LTCC packaging or a mixed-media multilayer board.

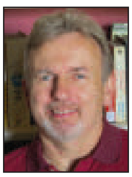
The Available Space Envelope is generally dictated by the need to maintain a half wavelength (or less) antenna spacing to reduce undesirable grating lobes, and by the array configuration, with total power output limited by the module's size, frequency, and the need for heat dissipation. Multiple modules are generally packaged into a single housing -- usually four for the higher frequencies (C-Band and above), and two for S-Band frequencies -- providing sufficient space to incorporate full digital functionality, local power supply conditioning, and a single, all encompassing environmental seal rather than multiple channel-to-channel seals.

Conclusion

A modular, stackable AESA radar system has been developed that offers high levels of agility, flexibility, and functionality to adapt to various radar and data link applications. This modular approach reduces the total cost of ownership by enabling the use of COTS components and MMIC technology, by simplifying installation and integration, by allowing graceful degradation with no single point of failure (PoF), and by permitting in-field TRM replacement (LRU) without having to take the entire system off-line. ECN

Precision Resistor Technology: A Look Under The Hood

By **Paul Pickering**, Technical Contributor



Resistors are seemingly the most mundane of components. The conventional wisdom is that their tolerances are poor; their values change over temperature; they have significant capacitance and inductance; and they cost fractions of a cent in high volume.

But what if you need highly precise parts that maintain their performance over a wide range of environmental and electrical conditions? Now that's a horse of a different color. In this article, we take a look at some of the special design techniques needed to produce highly precise resistors.

Key Resistor Parameters

Apart from well-known datasheet parameters such as nominal resistance, tolerance, and power dissipation, several other specifications are important in comparing precision resistor technologies.

Temperature variations and exposure to high temperatures play an important role in long-term stability; relevant parameters include temperature coefficient of resistance (TCR), self-heating characteristics, and thermal electromotive force (EMF). Other parameters include electrostatic discharge (ESD) protection, long-term stability, power coefficient of resistance (PCR, expressed in ppm/W), and noise.

Precision Resistor Types

Standard carbon-based resistors use a variety of methods to make the resistive element. Carbon composition resistors, now being phased out, use a mixture of finely-ground carbon and a ceramic insulating material. Other carbon-based technologies include carbon film resistors, carbon pile resistors, and resistors printed directly onto PCB substrates. Carbon film devices have tolerances down to 2 percent, a TCR as low as -200 ppm/°C, and stability after 100 hours of around +/- 0.8 percent.

For precision use, several technologies - thick film, thin film, foil, and wirewound - are available, offering tradeoffs in performance versus cost. Table 1 provides a comparison.

Thick film resistors use a screen printing process to deposit a ruthenium, iridium, or rhenium oxide paste onto a ceramic substrate. The resistive layer is around 100 microns thick, a thousand times greater than thin film. Although it's widely used to produce inexpensive, surface-mount components, thick-film technology can also provide higher performance devices (at higher cost, naturally), with tolerances of 0.5 percent.

Compared to thin film resistors, thick film technology can handle more power, withstand higher surge conditions, and give resistance values up to 10 TΩ.

Thin film resistors are made by depositing the resistive material onto an insulating substrate, a vacuum deposition process known as sputtering. This gives a uniform metal

Table 1: Precision Resistor Characteristics

Technology	TCR -55ºC to +125ºC, + 25 ºC ref	Initial Tolerance (%)	End Of Life Tolerance	Load-Life Stability	ESD (V)	Thermal Stabilization	Noise (dB)
Bulk Metal Foil	0.2 ppm/ºC	From 0.005	< 0.05%	0.005 % (50 ppm) 0.01 % (100 ppm)	25,000	< 1 second	-42
High Precision Thin Film	5 ppm/ºC	From 0.05	< 0.4%	0.05 % (500 ppm) 0.15 % (1500 ppm)	2500	> few minutes	-20
Precision Thick Film	50 ppm/ºC	From 0.5	< 5%	0.05 % (5000 ppm) 2 % (20,000 ppm)	2000	> few minutes	+20
Wirewound	3 ppm/ºC	From 0.005	< 0.5%	0.05 % (500 ppm) 0.15 % (1500 ppm)	25,000	> few minutes	-35

(Source: Vishay)

film that is much more stable at high frequencies than thick-film types. Resistances up to several MΩ are possible, with tolerances from ±0.05% after trimming and TCR from ±5 ppm/°C, depending on resistance.

Thin-film resistors are also low inductance. By forming the film on a heat-conducting alumina substrate that is metalized and soldered to a heat-dissipating copper plate tab, it's possible to create low-cost, high-power film resistors in small TO-style packages.

Wire wound resistors, a traditional choice for through-hole applications, consist of a resistive wire wound around a ceramic core. The wire is made from alloys such as NiChrome or Manganin; these have extremely low thermal coefficients of resistance (TCR) and excellent long-term stability. Manganin, for example, was first invented in 1892 and consists of 86 percent copper, 12 percent manganese, and 2 percent nickel. It's an improvement on the better-known Constanan, which is popular for strain gauges.

For tightest tolerances, the wire is tested during manufacturing and trimmed to the exact value needed. Because the wire wound resistor construction forms an inductor, parasitic inductance and capacitance give it the worst high-frequency performance of all resistor types. Various bifilar winding patterns are used to overcome this, including Ayrton-Perry winding, which consists of two separate wires wound in opposing directions around the core and connected in parallel at the ends. This method acts to cancel out the magnetic fields and minimizes parasitic capacitance, but requires four times the length of wire compared to a single winding.

Wirewound resistors aren't available in a true chip package, so applications with severe size and weight constraints must use other options.

Foil resistors offer the highest overall stability and precision. These use a foil for the resistive element, made of special alloy several microns thick. The foil is bonded to the substrate, then photo-etched into a pattern that contains a series of pre-determined trimming locations.

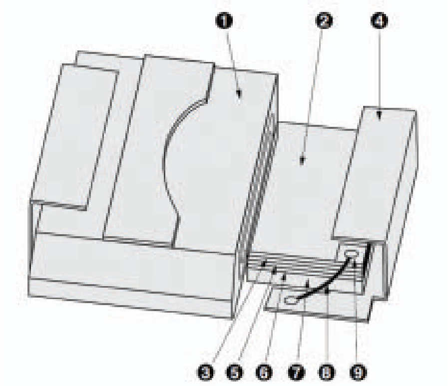


Figure 1: Metal foil resistor construction (source: Alpha Electronics)

Figure 1 shows the construction of a precision metal foil SMT resistor from Alpha Electronics. The outer coating (1) of transfer-molded epoxy resin combines with an extra coating (2) to give high resistance to moisture, heat and solvents. An additional protective layer (3) is above the metal foil (5). The whole assembly is attached with a polyimide bonding layer (6) to a ceramic substrate (7). A gold wirebond (8) connects the resistive element and leadframe (4).

Specialized Form Factors

Some applications call for specialized resistor construction – automotive battery monitoring, for example.

A micro hybrid vehicle includes fuel-saving technology such as a start-stop system, where the engine shuts off automatically while the vehicle is stopped, whether at a light or in a traffic jam. To accomplish this, an automotive battery sensor must determine the battery's state of health (SOH), state of charge (SOC) and other parameters to make sure it can restart the vehicle when needed.

The system must accurately measure battery voltage, current, and temperature over a period days of weeks; battery current measurement requires a resistor with a very low resistance and precise performance over a wide range of environmental conditions.

The BAS family of parts from German manufacturer Isabellenhuette uses a variety of proprietary alloys and is designed to be installed between the vehicle battery negative terminal and chassis ground. The 0.1mΩ device can dissipate 15W of power and handle a continuous current of 350A. The TCR is less than 50ppm/ °C from -40 to +170 °C.

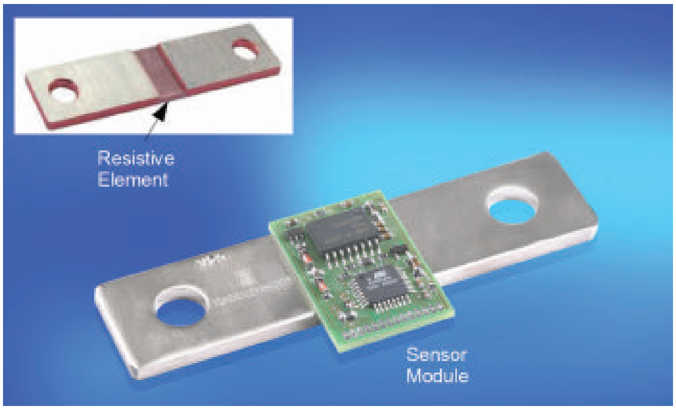


Figure 2: Precision resistor for battery monitoring (source: Isabellenhuette)

Figure 2 shows the component in a typical application. The sensor module is mounted directly to the resistor and measures the voltage across it – and hence the current – by means of solder pads on the bottom side of the PCB.

You Get What You Pay For

The best things in life may be free, but if you want the best precision resistor, it's going to cost you a little bit more. Here's a recent comparison of some Vishay low-power devices from Digikey.

Technology	Value (Ω)	Tolerance (%)	TCR (ppm/°C)	Relative Price
Thick Film	330	5	200	1
Thick Film	330	0.5	50	8
Metal Foil	332	0.05	2	1458

Quite a difference, but less than the difference in performance. That's not always the case – the world's most expensive watch, at $620,000, is arguably less accurate than its $20 equivalent from Walmart.

But who spends $620,000 on a watch just to tell the time? Certainly not ECN readers. ECN

Piezo Mechanisms: Making Advances in Laser Technology

by Stefan Vorndran, Scott Jordan and **Steffen Arnold,**
PI (Physik Instrumente) L.P.

Laser technology is in demand in many high-tech fields, from aerospace and astronomy to precision machining, optics and semiconductors. Fast and precise motion is critical for the advancement of applications in these fields—and that's where piezo mechanics come into play. Piezoelectrics are the gold standard in motion control in terms of speed and precision. Today, using this technology, laser systems engineers have a large tool box of solutions at their disposal, ranging from highly stable actuators for static fine-tuning to fast piezo auto-focusing devices and high-speed, integrated multi-axis beam steering systems based on piezo-flexure mechanisms.

Not all Piezo Drives are Created Equal

Piezo actuators and motors are all based on the same physical principle, molecular level motion with intrinsically unlimited resolution. However, there are a number of commercially available basic designs, specialized for different applications. Piezo stack actuators, for example are short travel devices (<0.2mm travel), providing picometer resolution and high acceleration to 10,000 g's for microsecond responsiveness. They are used for laser cavity tuning/switching and also often incorporated in more complex positioning mechanisms, such as flexure guided tip-tilt steering mirrors,or piezo scanning stages, such as used in laser scanning microscopy. For longer travel ranges, a variety of different piezo motors is available, from high-force, high resolution "piezo-walk" type designs, to high-speed ultrasonic, travelling wave motors, and compact, low cost stick-slip (inertial) drives.

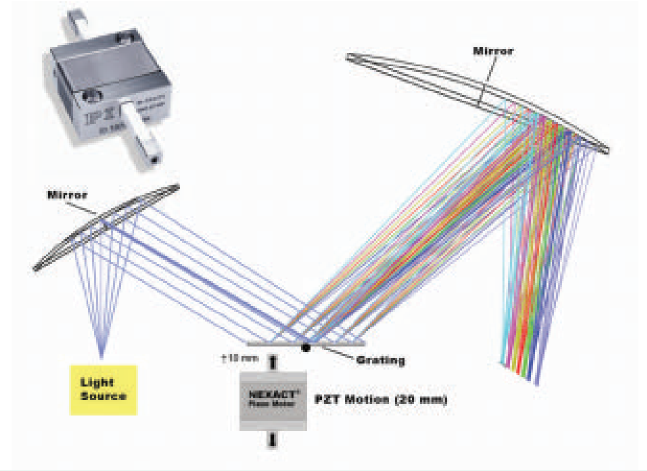


Figure 1. A compact PiezoWalk® motor, optimized for alignment of optics and mirrors provides 10N power-off holding force and smooth motion over centimeters with picometer-class resolution in compact, cost-effective format. (Figures courtesy of PI L.P.)

Maintenance Free, Mars-Rover-Tested Technology

Piezo devices are maintenance-free, vacuum compatible, lubricant-free, and do not have gears and moving components such as found in conventional positioning devices. This fact allows for very high lifetime and reliability, as well as speed and precision, ideal conditions for the use in laser control applications. Modern digital servo algorithms have further increased the performance of such piezo-based positioning systems making it easy to tune and quickly adapt the mechanics to changing requirements.

Laser Scanning in Fluorescence Microscopy

In laser scanning microscopy, the laser beam needs to be controlled and focused to excite fluorescence in the sample. Galvo scanners have traditionally been employed in the steering part, but piezo scanners have the advantage of being more precise, with faster response, and provide multiple motion axes integrated into a single device. This reduces size and also eliminates polarization rotation effects. Piezo devices are used in most fields of super resolution microscopies (Figure 2) where resolution can be far below the diffraction limit. Piezo-driven tip/

tilt mirrors and platforms demonstrate their advantages here. The S-334 tip/tilt scanner (Figure 3), for example, allows highly dynamic and precise steering motions of an integrated mirror in two orthogonal axes around a common pivot point. The frictionless piezo drives and flexure guides allow higher accelerations than conventional drives. A compact controller was specially developed for this type of mechanism and combines the functions of a multi-channel servo and driver in one.

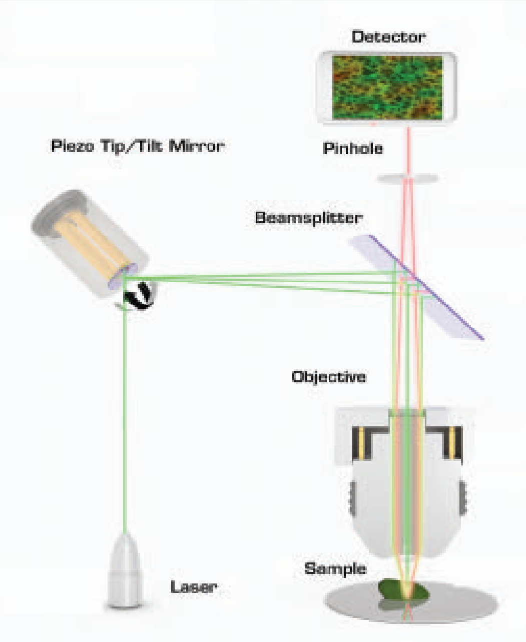


Figure 2. Principle of super-resolution laser scanning microscopy.

Its internal hardware also carries out the coordinate transformation for different mechanical designs to provide pure orthogonal motion of the platform.

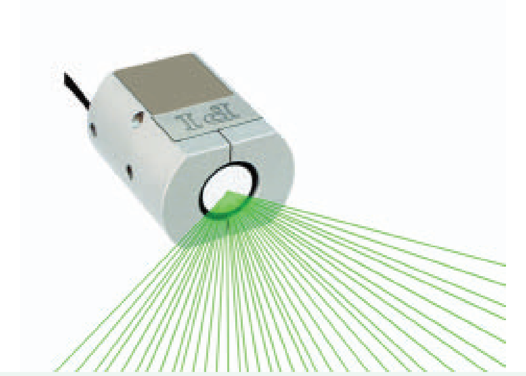


Figure 3. Integrated two-axis miniature piezo-driven tip/tilt mirror provides microradian resolution and millisecond response times.

Telecommunication/Photonics Alignment

Modern telecommunication mostly relies on fiber optic data transmission via laser-light. Bandwidth requirements keep going up, and the need to speed up the production of fiber optical components is on the rise. To align most single-mode fiber optic components, nanometer resolution is required, which is why piezo technology is key. A compact multi-axis piezo mechanism, such as the NanoCube® positioner, together with a fast controller and modern align and tracking algorithms can align fiber optic components in a matter of a few seconds, a task that could have taken several minutes in the past. The piezo scanner provides 100um of fine travel and can be combined with motorized positioning stages for coarse positioning such as shown in Figure 4. Piezo scanners are also used in free-space optical communication to keep laser transmitters and receivers aligned dynamically.

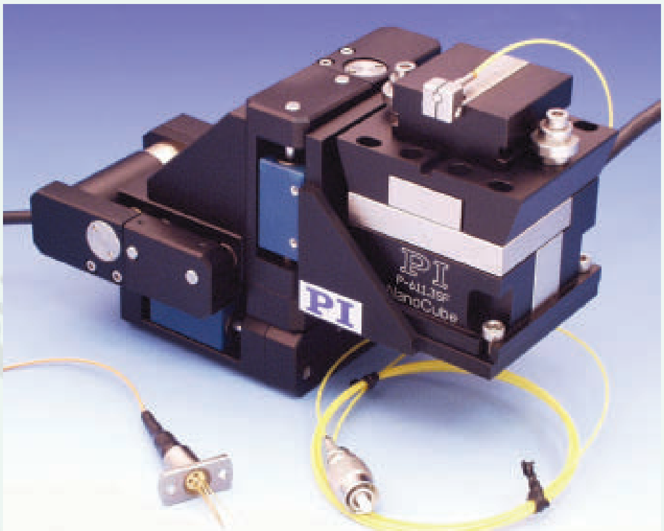


Figure 4. F-131 XYZ coarse/fine fiber alignment system provides 2nm resolution and up to 25mm travel.

Materials Processing

Typical applications for laser materials processing are found in electronics manufacturing, e.g. the production of templates used for PCB coating with solder paste. The precision and speed requirements here are very high; the material must be removed very precisely with exactly defined edges. Time is money and high throughput is essential. Traditional laser-beam deflection techniques such as galvo scanners are suitable, but for two axis motion, two single-axis systems have to be "stacked". This results in different, variable pivot points, beam polarization rotation and increased space requirements. Piezo-driven tip/tilt mirror systems are more compact and provide higher acceleration and bandwidth. Due to their parallel kinematics design (Figure 5) there is only one moving optic with a fixed pivot point, leading to reduced inertia and higher dynamics in a smaller package, while achieving superior accuracy.

Medical Technology: Ophthalmology Benefits from Piezo Drives

Ultrasonic ceramic piezo motors also open up new possibilities for laser applications. They are characterized by extremely high velocities and acceleration. A patented drive principle makes them self-locking at rest without power dissipation. Linear motors for the integration in OEM devices as well as completely packaged and guided systems such as the M-663 miniature linear stage (Figure 6) are both available. This piezo positioner combines compact dimensions with high performance motion. It provides closed-loop velocities of up to 250 mm/sec and ¾ inch travel range with 0.1 μm resolution and very fast settling (Figure 7). A non-contact optical linear encoder guarantees high linearity and repeatability. Its compact dimensions of 15x30x35 mm allow for easy integration into the respective application.

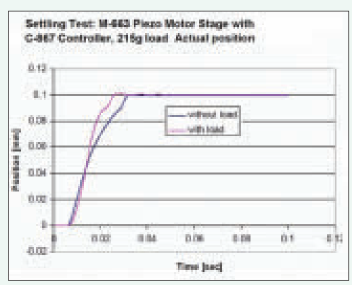


Figure 7. Settling behavior of the M-663 stage shows the rapid response of ultrasonic motor positioning systems.

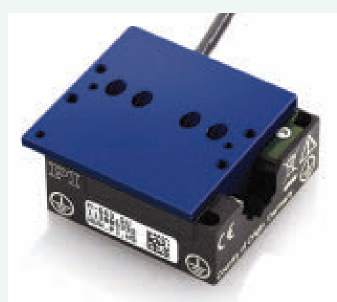


Figure 6. The M-663 miniature linear stage is driven by an ultrasonic piezo motor. It provides rapid acceleration, velocity to 250 mm/sec and locks its position when powered off.

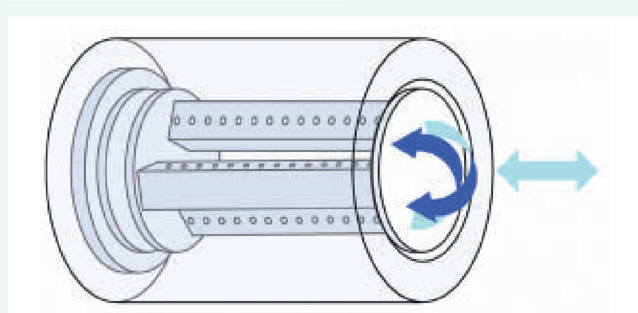


Figure 5. Parallel kinematics 3 axis Z/tip/tilt platform based on 3 piezo stacks. All actuators act directly on the same platform, providing higher dynamics and accuracy, while reducing the size.

Set-and-Forget Laser Alignment Components

In addition to the highly dynamic applications mentioned above, there are a number of "set-and-forget" applications where an optic or mirror in a laser system needs to be tuned occasionally. The focus here is on high stability and very smooth motion. PiezoMike type inertial motor actuators combine resolutions of 30 nanometers with holding forces of 100 N and reliable start-up, even after longer downtimes (Figure 9).

Figure 9. PiezoMike inertial linear motors replace conventional micrometers in a tip/tilt mirror mechanism.

Summary

The field of piezo motion devices for laser applications has expanded rapidly in recent years and today's optical engineers have a wealth of different piezo technologies at their disposal, from small piezo stacks for cavity tuning to tip/tilt platforms and long travel motors with high dynamics and precision.Piezo actuators can even be found on Mars where they help researchers answer the question if there once was life on the Red Planet, based on laser spectroscopy. ECN

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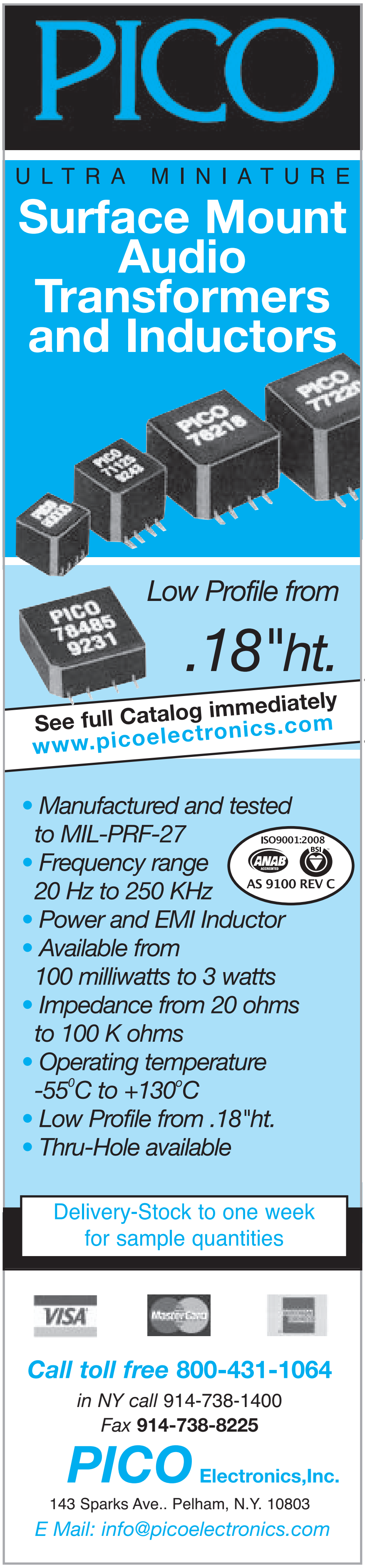


BRAINSTORM

MODERATED BY JAMIE WISNIEWSKI
ASSOCIATE EDITOR

Q: What has the greatest technological advancement been of 2015?

Elly Schietse, Global marketing manager, GreenPeak Communications

2015's greatest advancement in technology has been the recognition of the misconception of the Internet of Things, making place for the Internet of Services.

The concept of the Internet of Things has been around for many years, but has not yet taken off. The market potential was forecasted by analysts to rocket sky-high, volumes and $ estimated in several billions, trillions. And yet, it did not quite happen in 2015 and we are just starting to understand why.

Consumers want applications, solutions and services. Wearing a Fitbit will not make you fitter, but the online coach who motivates you to run more and harder will help you to accomplish your goals. Installing door or presence sensors will not make your home more secure, unless it is connected to an app that sends an alert to your neighbor or the police when you are away for the weekend and an intruder is detected.

Today's connected sensors only provide consumers with the illusion of progress, healthier living, comfort, energy efficiency and security, but the exciting part is in the application behind the sensors that can make decisions for us and can turn off lights when nobody is home, turn off water supplies when a leak is detected or close the back door when we are on holiday.

Today, organizations of all sizes are accelerating business growth with service solutions based on virtualization, collaboration and interconnectivity for the Internet of Services.

Operators and service providers are starting to work with sensor developers, adding cloud application and analytics algorithms to create a service that people need, not a collection of connected sensors. And this is how the Internet of Services can truly become the multi-trillion global opportunity over the next decade.

Tom Griffiths, Sr. Marketing Manager, Sensor Driven Lighting, ams AG

Lighting is about to come alive, and few enough even inside the lighting industry, may understand the implications. The great advancements are straightforward enough: 1) Nano-optic interference filters; and 2) Sensor-fused chip-scale smart lighting management. Combined with the convergence of cloud-based computing, mesh-networking and ubiquitous connectivity we see the groundwork for lighting to become the IoT sensor-hub for our built spaces. An internet of spatial awareness is being enabled, and that will change as much about our interactions with the spaces we occupy as smartphones changed how we communicate, manage and spend our time.

Why does a filter technologies matter so much? Up to now, precision spectral filtering has been pretty vanilla, covering ambient light (lux), subject to variations over time and temperature. It really hasn't been possible for high-precision and stability and calibration "for life" to be delivered cost-effectively enough for any type of mass adoption in consumer items or lighting. Interference filters can be incorporated into standard CMOS processes, and are incredibly stable over time and temperature.

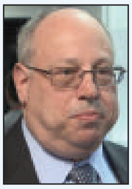
Optical sensing with spectral filtering is entering the $50B sensor world in multiple areas, enabling calibrated sensor fusion into chip-scale lighting management solutions. The need for sensor-driven daylight responsive lighting has opened the door to payback for "smart" lighting, and with the added user benefits (including comfort, productivity and health) that will come from spectrally tunable lighting, intelligence will reign in our lights. Lighting always has electricity available, has a great, high-granularity view of the space, and with embedded intelligence, becomes straightforward to tie in to building management systems and the cloud. It's the perfect sensor hub for our built spaces. And like smartphones, if we build it, the apps will come.

Scott Kipp, President, Ethernet Alliance

The greatest technological advancement of 2015 can be seen in Ethernet. Yes, Ethernet. The most ubiquitous networking technology entered a new era of dominance in 2015 by developing six new speeds in a single year. Selling over 1 billion ports per year, Ethernet is being optimized to deliver more bandwidth at lower cost/bit to seal its fate as the leading networking technology. While Ethernet is continuing to go faster by standardizing 25Gb/s and 50Gb/s and 100Gb/s lanes, Ethernet is also going slower to meet the refined needs of more applications.

Ethernet defined 10 Gigabit/second Ethernet (10GbE) in 2002 and many thought that the industry would convert to 10GbE instead of GbE. The shift to 10GbE has not happened much outside of the data center because of additional costs and power to go that much faster. It turns out the industry is often more interested in low cost solutions that re-use installed infrastructure than going faster. One example of this is the new speeds of 2.5GbE and 5Gbe. To use the billions of meters of installed Cat 5E cabling, 2.5GBASE-T and 5GBASE-T will double and quintuple the throughput over these existing cables. Ethernet is also increasing the bandwidth of GbE backplanes by the same factors to enable cost and power optimized disk drives.

The existing Ethernet speeds (10M, 100M, 1G, 10G, 40G and 100G) are being supplemented with new speeds of 2.5G, 5G, 25G, 50G, 200G and 400G to go faster and broader than existing speeds. A few years ago, most Ethernet aficionados would have thought that only faster speeds like 400G would be standardized, but the industry has changed course and is now standardizing these lower speeds to attack new markets. The large Ethernet ship is proving that is can turn on a dime as well as go faster.



Stuart Lipoff, IEEE Fellow

Autonomous vehicles and advancements in intelligent transportation coming into mainstream society is the greatest technological advancement in 2015.

The US Department of Transportation (DOT) defines level 4 vehicle designation as: "The vehicle performs all safety-critical functions for the entire trip, with the driver not expected to control the vehicle at any time. As this vehicle would control all functions from start to stop, including all parking functions." While the promise of allowing "Level 4 transportation" is not yet commercialized or legal in all 50 states, the technology is ready to be rolled out – only waiting for the law, social comfort, and cost to catch up the technology.

The history of robotic car R&D dates well back in the 1920s, with some significant success toward the level 4 goal in the mid-1980s. However, in the last few years we have seen a variety of the building blocks needed to gain level 4 designation, including; lane following, cruise control, and anti-collision automatic braking.

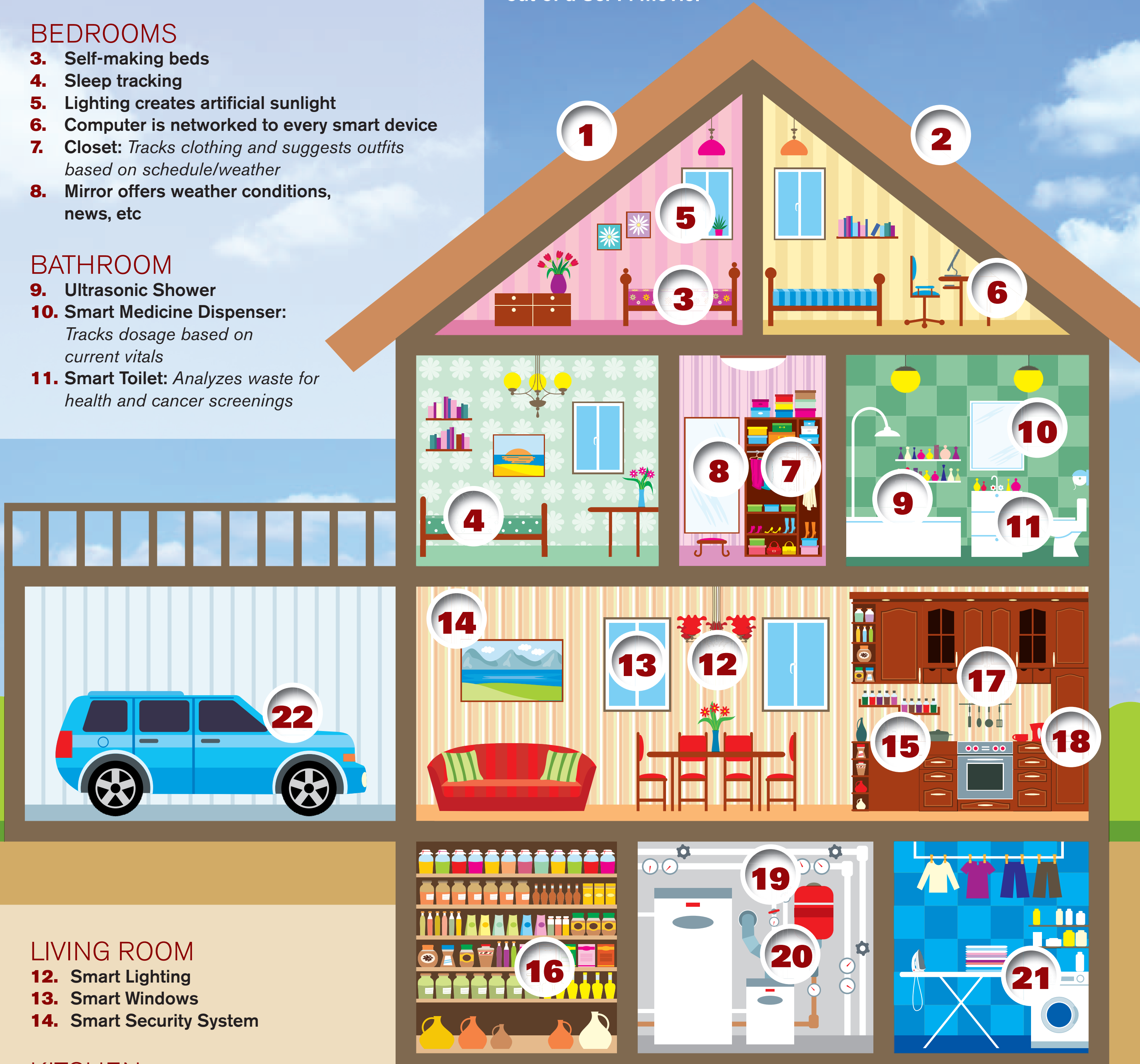
Robotic car technological developments are so significant because of the long list of positive benefits they can offer to improve quality of life. These vehicles will be able to significantly enable or restore mobility and independence to seniors and the disabled, as well as provide assistance to the underprivileged with the basis that self-driving vehicles can facilitate economical vehicle sharing.

Other benefits beyond enabling or restoring mobility are also significant and include a long list of promises such as: reduced accidents, more efficient fuel usage, solving parking problems in congested areas (the car can locate an available space), more capacity on existing highways, etc. ECN

SMART HOME KEY CODE

By Kasey Panetta, Editor

If you could plan your dream home of the future, what would it look like? With the influx of IoT and smart devices, the homes of 2050 and beyond are looking more and more like something out of a Sci-Fi movie.



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4. **Sleep tracking**
5. **Lighting creates artificial sunlight**
6. **Computer is networked to every smart device**
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BATHROOM

9. **Ultrasonic Shower**
10. **Smart Medicine Dispenser:** *Tracks dosage based on current vitals*
11. **Smart Toilet:** *Analyzes waste for health and cancer screenings*

LIVING ROOM

12. **Smart Lighting**
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14. **Smart Security System**

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16. **Smart Fridge/Pantry:** *Auto-restock and track contents*
17. **Smart Appliances:** *Broken appliances will notify the owner/repairman*
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