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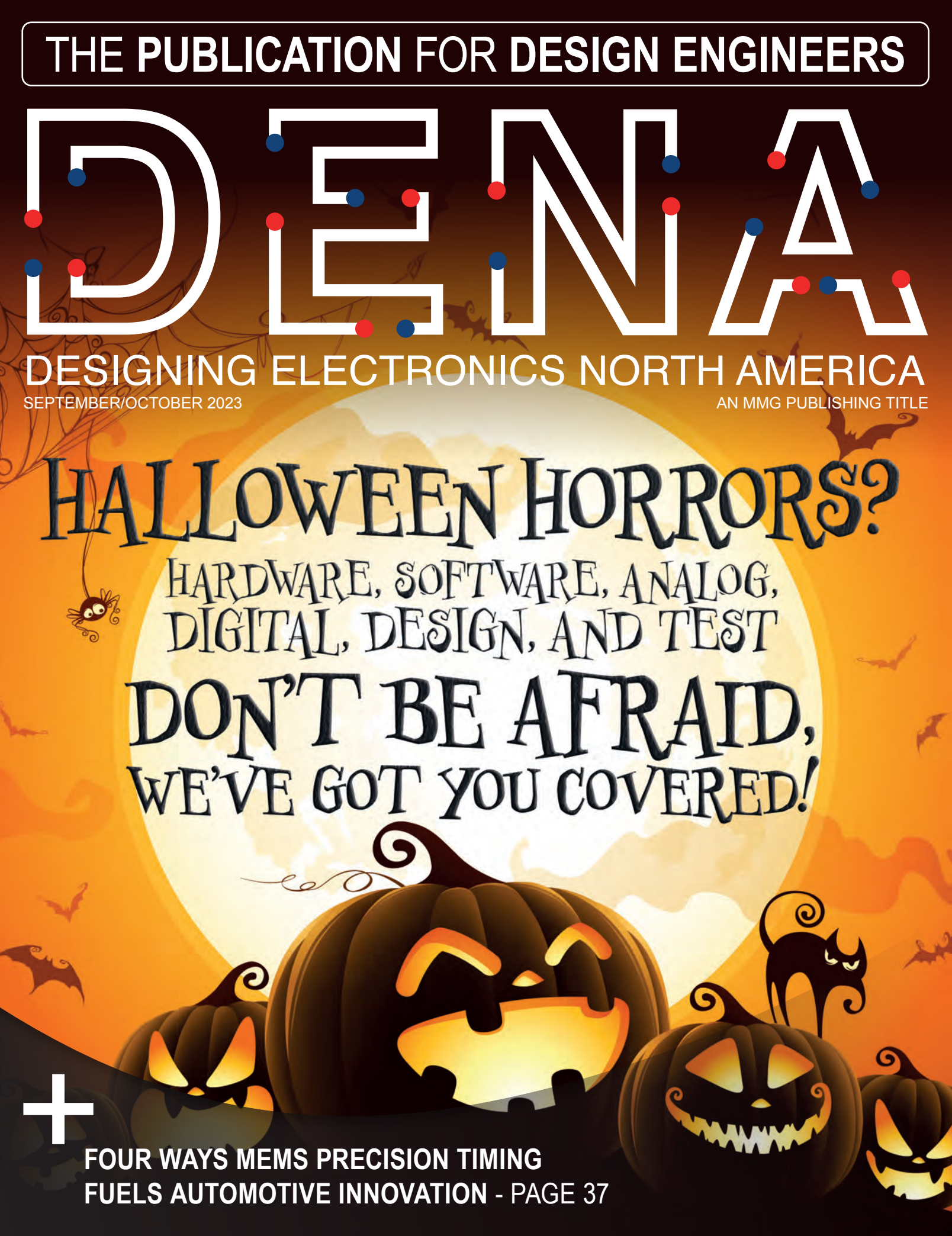

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FOUR WAYS MEMS PRECISION TIMING FUELS AUTOMOTIVE INNOVATION - PAGE 37

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EDITOR'S WORD

Scary, scarier, scariest

It's getting to be a scary world out there, and not only because we are in the season of Halloween. As it is said in a traditional Scottish prayer: "From ghoulies and ghosties and long-leggedy beasties and things that go bump in the night, Good Lord, deliver us!"

On the one hand, for example, generative artificial intelligence tools like ChatGPT offer the promise of making our jobs easier, helping with architectural evaluation, design, verification, and decision-making tasks. On the other hand, many people are becoming increasingly concerned that these tools may ultimately take our jobs away.

Personally, I'm a glass-half-full type of guy. Having said this, I'm reminded of the little boy who tells his dad, "I'm an optimist because my glass of milk is half empty." Chuckling, the father replies, "That's not the way it works, son. If you see the glass as being half empty, then you're a pessimist. If you're an optimist, you see the glass as being half full." The boy looks meaningfully at his dad and says, "It all depends on if you like milk… and I don't!" (You can't argue with logic like that.)

We are living in interesting times. The best we can hope is that they don't become too interesting. But turn that frown upside down into a smile because—no matter what the future holds and however scary it gets—all of us at DENA are here to help guide you on your way.

Max Maxfield

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TOP STORY

New current sensing resistors for automotive, consumer, and industrial markets

Littelfuse has announced the launch of its new Current Sensing Resistor (CSR) family. These new CSRs offer a more cost-effective solution for measuring current within circuits, enabling voltage monitoring, control, and power management of functions such as battery charging and motor speed, while also providing overcurrent protection.

The new Littelfuse CSR family of products extends the company's circuit protection solutions portfolio, deepening its current and voltage monitoring focus. Each CSR is either a metal foil, metal strip, or metal plate resistor ideal for measuring currents in circuits due to its high precision and low resistance rating.

The CSR family provides a more cost-effective solution than competing technologies like Hall Effect sensors, current transformers, flux gate sensors (DC only), and Rogowski coils (AC only). Additionally, CSRs work in AC and DC circuits without requiring additional power or equipment to enable measurement.

This means that the CSR series is a game changer for anyone who requires precise current and voltage monitoring for their advanced technologies. These devices are ideal for numerous applications, including automotive electronics, electric vehicles (including 2- and 3-wheelers), home appliances, consumer electronics, and industrial automation.

www.littelfuse.com

UL-recognized Female, Quick-Fit PCB terminals on continuous reel

Keystone Electronics is a leading manufacturer of THM and SMT terminals and test points, as well as battery and fuse hardware, along with an extensive array of electronic interconnects and hardware. Application engineering services are also available to meet special product modifications or custom designs with active stamping, machining, and assembly support.

Keystone has introduced a new packaging for its diverse selection of Female Quick-Fit, PCB Receptacles. These female terminals are specifically designed on a continuous reel (strip) to be used with standard automated insertion equipment, thereby reducing assembly and processing time.

www.keyelco.com

DIGISTOR moves closer to full CC certification and CSfC listing

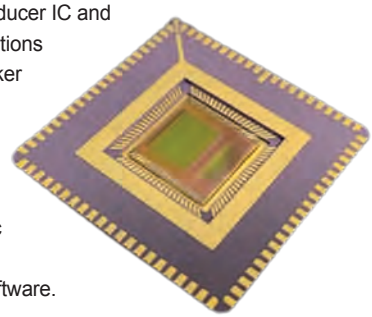
Securing data at rest (DAR) in a zero trust architecture (ZTA) is important to preventing cyberattacks and keeping information safe. DIGISTOR is a leading provider of secure DAR storage solutions. The creators of secure systems use DIGISTOR's Citadel C Series self-encrypting drives (SEDs) to prevent unauthorized access to sensitive data in laptops, desktops, and other endpoint devices.

Now, DIGISTOR has announced that the pre-boot authentication (PBA) portion of its Citadel C Series SSDs (powered by Cigent) is listed on the National Information Assurance Partnership (NIAP) Common Criteria Products in Evaluation List. NIAP is responsible for the US implementation of the international Common Criteria set of data security standards. The evaluation and full NIAP listing for the Cigent PBA is expected later this year. This means the Citadel C Series secure SSDs will have both NIAP-listed SSDs and PBA, making it perfect for critical infrastructure companies, industry, and military and government agencies requiring the highest data security levels.

www.digistor.com

Senseeker offers low-noise digital readout IC for SWIR applications

A US owned transducer IC and cryogenic test solutions company, Senseeker specializes in the design of state-of-the-art digital imaging sensors, cryogenic test equipment, electronics and software.



Most recently, Senseeker has announced the availability of the Neon RD0033, an advanced digital readout integrated circuit (DROIC) with low-noise performance, triple-gain modes and a 10µm pitch pixel with a capacitive transimpedance amplifier (CTIA) front-end circuit.

The Neon DROIC was developed for low-light applications such as short-wave Infrared (SWIR) and low-current detector technologies such as quantum dots-based detectors. It has been designed for use in high-operating temperature conditions.

The Neon RD0033 is in production now and is supported by an electronics kit and a thermoelectric cooler sensor test unit that, together, enable testing and evaluation of Neon-based focal plane arrays.

www.senseeker.com

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METCASE's TECHNOMET instrument enclosures now with flat or sloping front panels

METCASE's premium TECHNOMET desktop/portable instrument enclosures are ideal for medical and wellness devices, industrial control, test and measurement, peripheral devices and interfaces, switchboxes, communications, and laboratory equipment. These highly attractive cases can now be specified with or without a sloping front for easier viewing.

These advanced aluminum enclosures feature a modern and cohesive design. Diecast aluminum bezels at the front and rear fit flush with the main case body. Snap-on trims hide the case and front panel fixing screws. The anodized front panel (accessory) and removable rear panel are both recessed to protect keypads, displays, connectors and switches. The internal chassis is pre-punched for three, five, seven or nine PCB guide rails: circuit boards slide in and out for quick and easy installation, inspection, and maintenance. There are also four M3 PCB mounting pillars in the base. All case panels are fitted with M4 threaded pillars for earth connections.

In addition to standard sizes, METCASE can supply TECHNOMET fully customized. Services include custom sizes (height, width and depth), custom front panels, CNC machining, fixings and inserts, painting/finishing, and photo-quality digital printing of graphics, legends and logos.

www.metcaseusa.com

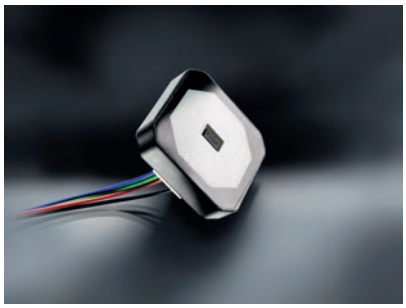
Melexis ToF sensor supports functional safety applications

Melexis is a world leader in advanced sensor devices and technologies. With its physical 307kpixel spatial resolution, the MLX75027RTI VGA resolution time-of-flight (ToF) sensor is aimed at inclusion in safety critical systems where ASIL or SIL certification is required. Key use cases for this sensor are dynamic airbag suppression (so that airbags are not deployed unnecessarily), driver attention monitoring, and close-range exterior LiDAR. It can also be employed to provide safety perimeters for industrial cameras, for supporting the control of robots' movements and for enabling more advanced machine vision.

The new MLX75027 is available in both automotive and industrial variants. The MLX75027RTI is designed for automotive usage and features a –40˚C to +105˚C temperature range, while the MLX75027STI is for industrial applications with a –20˚C to +85˚C temperature range. Another important feature of the MLX75027 family is its proven sunlight robustness, meaning the signal quality is not affected by the external environment.

www.melexis.com

New touchless switch is concealed behind surface



SCHURTER has introduced an innovative touchless hidden switch (THS) series employing optical sensor technology that can be concealed behind any surface without the need for mounting holes. A small opening in the user interface is all that is needed to allow the time-of-flight (ToF) sensor to actuate.

Equipment and appliances used in public areas have created demand for non-contact switches to replace conventional touch-activated switches. The THS is a touchless switch that provides an excellent hygienic solution to prevent the spread of pathogens. It not only serves its practical purpose as a momentary switch, but also adds an element of design for out of the ordinary sleek and sophisticated custom user interface design.

www.schurter.com

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Creating safer roads for autonomous vehicles

Autonomous vehicles require widespread enhancements to road networks

Autonomous vehicles are driving significant and exciting technological developments, with advanced sensors and neural networks being prime examples. But the technology needed to enable autonomous driving goes beyond the vehicles themselves. The roads on which they operate can also benefit from those same advances, bringing about new levels of safety and navigation. This is an area that's gaining increased prominence, although not from all stakeholders.

For example, in 2021 the US Department of Transportation published policy guidance for self-driving cars. Although this guidance outlines a comprehensive plan for manufacturers to ensure the safety of their vehicles, it doesn't provide any data for road builders or the drivers themselves. This narrow focus is perhaps understandable given that semi-autonomous cars still represent only a tiny fraction of all vehicles on the road and forecasts don't see this balance shifting any time soon.

However, questions remain. Should governments spend money on smart roads that benefit a minority of users, and is it possible that such technology might even make the roads less safe for human drivers?

While this debate continues, those designing and building autonomous vehicles are actively pushing for enhancements to the road networks themselves, and some governments are responding.

Lane markings need to improve

Vehicle manufacturers

Brian Santo for Mouser Electronics

suggest starting with an improvement that should be free of controversy, which is to simply mark roads correctly following governmental standards.

In 2016, the mayor of Los Angeles, Eric Garcetti, boldly stated that the city would be preparing its roads for the forthcoming growth in autonomous vehicle numbers. During that press conference, Garcetti got into a self-driving Volvo, which had difficulty driving itself. According to then-president of Volvo North America, Lex Kerssemakers, who was sitting alongside the mayor, this was because the car's cameras couldn't pick out the faded road markings.

Kerssemakers is not the first autonomous vehicle maker to call out the condition of the roads. Tesla's CEO, Elon Musk, showed reporters two sets of overlapping lane markings on a freeway near Los Angeles. The duplicate lines could cause Tesla's autonomous cars to track the wrong markings and consequently move out of their lanes. To mitigate that problem, Tesla mapped each lane in advance, negating the need to rely on sensors.

Smart roads and infrastructure

Another key issue for self-driving vehicle manufacturers is the lack of consistency when it comes to signs, signals, and markings. Cross a state or national boundary, for example, and the design and format of these critical elements can change dramatically.

Beyond simply improving conventional road elements, we're also seeing a shift toward smart solutions, such as embedding sensors in roads and traffic signs. The push to create smarter roadways dovetails neatly with proposed communication standards, such as automotive LTE and dedicated short-range communications (DSRC). These technologies enable vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, both part of the broader vehicle-to-everything (V2X) umbrella.

V2V systems are similar in concept to the Traffic Alert and Collision Avoidance Systems (TCAS) used in aviation to alert pilots to potential collisions. Following a campaign lasting over ten years, the US National Highway Traffic Safety Administration seems close to gaining political approval for mandatory transponder-based V2V systems.

While V2V and V2I were originally envisaged as driver-assisted technologies, both can also be applied to self-driving vehicles, complementing sensor data and sharing it with other vehicles on the road. Researchers in Baidu, China, have suggested additional benefits. For example, the hand signals made by a police officer to a stream of oncoming traffic cannot currently be interpreted by a self-driving car; the human driver would need to take control to follow the instructions. Baidu has outlined how V2X technology could help overcome this issue by providing traffic control officers with beacons that send instructions to the traffic via V2I networks.

What does this mean for human drivers?

The push to alter roads for the benefit of autonomous vehicles could result in controversial outcomes. For example, it's possible that we could end up with roads optimized for self-driving vehicles but with reduced safety for human drivers. Take this a step further, and you could have a situation where human drivers are forbidden from driving on certain roads.

Consider the fact that autonomous vehicles could have a greater awareness of their surroundings and can react faster than humans. Roads for such vehicles could be narrower, thereby reducing costs and freeing up valuable real estate. Cars could also travel faster and with less space between them, while V2I technology could eradicate the need for road signage and traffic lights. But all of this would rely on removing humans from the autonomous equation.

Gradual changes

The idea of changing our roads for the benefit of self-driving vehicles will likely remain a contentious issue to which we may never get a definitive answer. More likely is that smaller-scale alterations will happen bit by bit, without specific intervention from governments.

www.mouser.com

"Those designing and building autonomous vehicles are actively pushing for enhancements to the road networks themselves, and some governments are responding"

Relays for EV and charge point testing

Reed relays enable high voltage and insulation resistance

Electromechanical relays (EMR), solid state relays (SSR), and reed relays can all be used to electronically switch a high voltage.

EMRs are a popular and trusted technology but—because their contacts are not in a vacuum or inert gas—a large contact gap (and consequently large relay body) is required to achieve a high stand-off voltage.

With SSRs, there are no physical contacts as the switching element is a transistor. However, SSRs have a relatively high leakage current, which can be an issue when used in a leakage detection circuit. Also, SSRs may fail such that there is crossover between the control and switching sides of the device.

Reed relays have very low leakage currents (down to 1nA), very high standoff voltages (up to a few kV) and can be delivered in small packages. Another benefit of reed relays is that the switch contacts (the reeds) are hermetically sealed, so the contamination/oxidation issues that occur with EMRs do not occur with reed relays. Because of their small form factor and high isolation, reed relays are the logical choice for EV testing applications where safety is a priority. Reed relays can also switch AC, whereas semiconductor-based SSRs cannot.

Pickering Electronics has an extensive range of high-performance, high voltage isolation reed relays that are ideally suited for use in current leakage monitoring applications. Furthermore, with device footprints starting at just 46mm^2, many relays can be accommodated on a single PCB. The following series are particularly recommended:

Series 67 & 68 reed relays feature switching voltages up to 7.5kV and minimum standoff voltages up to 10kV. Maximum switch current is 3A (at up to 200W) and maximum carry current is up to 5A. Optional electrostatic screening is available.

Series 104 relays have switching voltages up to 1kV and minimum standoff voltages up to 4kV. Maximum switch current is 1A (at up to 25W) and maximum carry current is 1.5A. Optional electrostatic screen is available.

Series 119 devices have switching voltages up to 1kV and minimum standoff voltages of up to 3kV. Maximum switch current is 0.7A (at up to 10W) and maximum carry current is 1.25A.

Series 131 parts are the industry's smallest HV reed relays. They feature switching voltages up to 1kV and minimum standoff voltages up to 1.5kV. Maximum switch current is 0.7A (at up to 10W) and maximum carry current is 1.25A.

The relays recommended in this article are all instrumentation grade and the reed contacts are plated with either rhodium or ruthenium to ensure a long life (typically up to 5x10^9 operations). This is necessary because RISO faults can be intermittent, so current leak detection tests should be performed several times a day.

Pickering reed relays are of a former-less coil construction, which increases the coil winding volume, maximizes the magnetic efficiency, and enables for the use of less sensitive reed switches, resulting in optimal switching action and extended lifetimes at operational extremes.

Internal mu-metal magnetic screening enables very dense side-by-side PCB-mounting, saving significant cost and space. SoftCenter technology cushions and protects the reed switch, minimizing internal lifetime stresses and extending the working life and contact stability. Free relay samples are available, and a full customization service is also available with samples available in as little as two weeks.

www.pickeringrelay.com

"Reed relays have very low leakage currents (down to 1nA), very high standoff voltages (up to a few kV) and can be delivered in small packages"

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Analog compute for Edge AI

Back to the future with analog compute and why you should care

In 1964, Texas Instruments introduced the SN5400 TTL logic family and so started the six-decade dominance of digital logic in compute applications. From early ALUs to today's multithreaded CPUs, digital logic is pervasive. Digital logic is relatively cheap, it scaled according to Moore's law (up until recently), is easy to design with, and has been an efficient solution for most applications, until now. Artificial intelligence (AI) has changed the game, especially at the Edge.

Edge AI enables exciting new use-cases in many market segments like smart mobility, augmented reality/virtual reality (AR/VR), wearables, and health technology. Many of these applications are portable, battery-based, consumer-oriented products, which places severe requirements on energy efficiency, heat dissipation, physical size, and cost.

The reemerging field of analog compute

Highly sequential Von Neumann digital processors rely on Moore's Law to deliver increasing improvements but have presented a serious power problem for Edge applications. Always-on voice, audio, and image processing are compute- and power-intensive for digital processors. The compelling alternative approach to digital for Edge AI is analog compute, which draws inspiration from the evolution of brain power.

Work smarter, not harder

Brains are the ultimate analog computers. The most impressive model is the human brain, which has 100 billion neurons, 1 quadrillion (10^{15}) synapses, and runs on only ~12 watts of power. By comparison ChatGPT3 implementations, using GPUs and memory, have been estimated to consume ~260 MWh/day (that's ~3kW of power every second), resulting in a solution over 250 times less efficient than the human brain just to perform language processing.

To mimic the brain and close the efficiency gap, we need to move from classical digital compute to an ultra-low power approach, such as all-analog processing. All-analog bio-chemical compute is still in the domain of research, but electronic based analog compute is real, and the results being achieved are impressive. Blumind, a leader in analog compute for Edge AI, achieves <1µW power for always-on key word detection and about twice that for visual trigger detection vs. 100s of µW to mW for the rest of the industry.

Less is more

In digital systems, power consumption has two aspects: static power associated with leakage and dynamic power associated with the capacitive charging/discharging of internal nodes. Every time a digital circuit switches, only one bit of information is processed using the entire power supply domain, leading to huge power inefficiency.

Power for digital rail-to-rail transitions is $\frac{1}{2}CV^2F$ (where C=capacitance, V=voltage, F=frequency). Digital systems are power intensive because, in addition to bit-wise processing energy inefficiency, they are clocked at high frequency to achieve results in an acceptable time. By comparison, analog compute is performed at lower voltages and process 10s or 100s of bits of information per transition, thereby leading to orders of magnitude improved power efficiency. In addition, analog compute is inherently highly parallel resulting in low latency for real-time classification.

All analog

True all-analog solutions avoid analog-to-digital converters (ADCs) and digital-to-analog converters (DACs) in all areas of the architecture, including system input and output interfaces (where possible), thus eliminating unnecessary power overhead and digital processing. Using analog input sensors gives greater data precision, which is particularly useful for time series data like audio processing. By avoiding digital quantization of the analog inputs, the analog neural network produces more accurate classification results for audio/voice. Further, the efficiency of analog compute reduces thermal concerns, chip size, and cost. Analog compute is low power, fast, small, and cheap; so why is it not more pervasive today?

The challenges to analog compute are many. Reaping the benefits of analog compute whilst avoiding the pitfalls is an engineering challenge.

Compute in memory

A common analog compute approach centers on the use of specialized (and costly) memory to store and multiply the weights for the neural network. Using NOR Flash, RRAM, MRAM or other specialty memory is being

Roger Levinson, co-founder and CEO at Blumind

Continues on page 14 >

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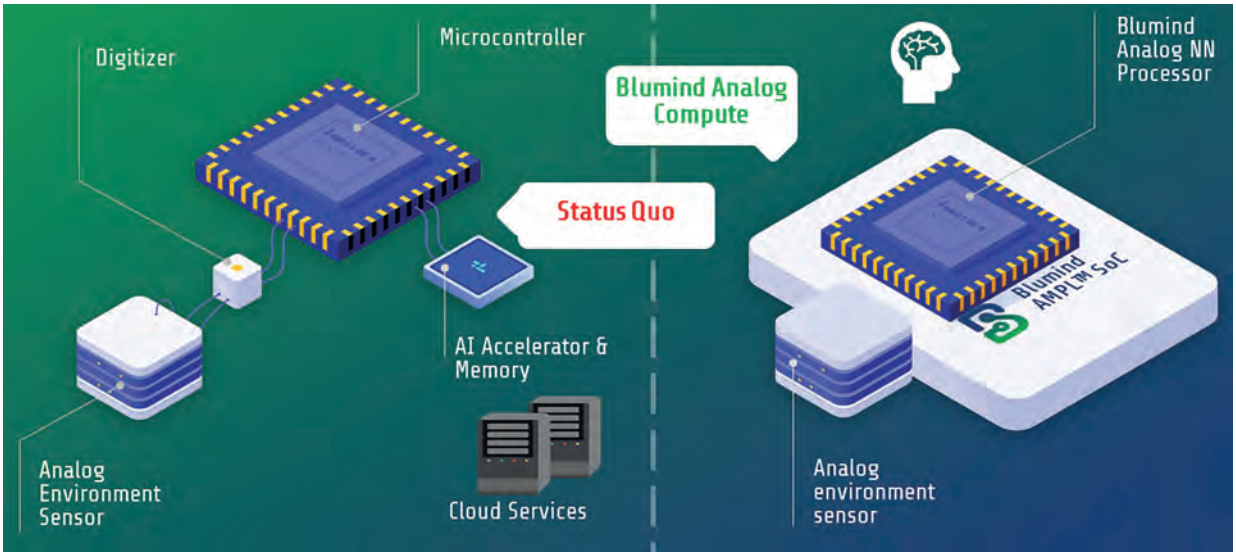


Digital compute inherently limits efficiency

pursued, but challenges ensuring reliable programming and long-term drift are common. Beyond programming and drift, specialty memories have two additional fundamental limitations:

1. They require expensive specialty processes that add significant cost (a typical NOR flash process adds 9 to 18 masking layers to a 28nm or 40nm process, which equates to ~15-30% additional cost). The complexity also increases cycle time, lowers yield, and hinders time to market and foundry portability.
2. Development and qualification of specialty memory is expensive, complex, and slow for foundries, resulting in limited specialized memory product roadmaps on advanced process nodes. A one-and-done technology node is a limitation for many specialty memory analog compute solutions.

Variation challenges

In analog compute, it's also common to deploy voltage and or current steering architectures. Process, voltage, and temperature (PVT) variation, as well as drift over-time, present challenging calibration and repeatability problems for most analog compute solutions. Additionally, ADCs and DACs with their non-linearities are used in large numbers in voltage and current steering solutions, resulting in a hybrid analog and digital architecture, which is possibly the worst of both worlds.

Blumind's unique solution

At Blumind, great care was taken developing our AMPL analog compute architecture to address the aforementioned limitations. Key architectural consideration include:

- Exploiting device physics on standard advanced CMOS processes with an established road map to advanced process nodes for all aspects of the design, including efficient multibit weight storage.
- Taking an all-analog approach to processing, including sub-threshold design and analog input sensor data (where possible), and by removing the need for on-chip ADCs and DACs.
- Removing high-speed

on-chip clocks and using deterministic event-driven processing.
• Mitigating analog PVT and drift issues with a proprietary architecture and thus avoiding the pitfalls induced by precision voltage, current, and device matching.
• Use a standard software stack, such as PyTorch and TensorFlow, and eliminate complex compilers.

These novel architectural techniques, implemented on low-cost standard CMOS trailing nodes, have been proven in our recent silicon results with ultra-low latency and low power, unmatched in Edge voice/audio and vision applications.

System solution advantages

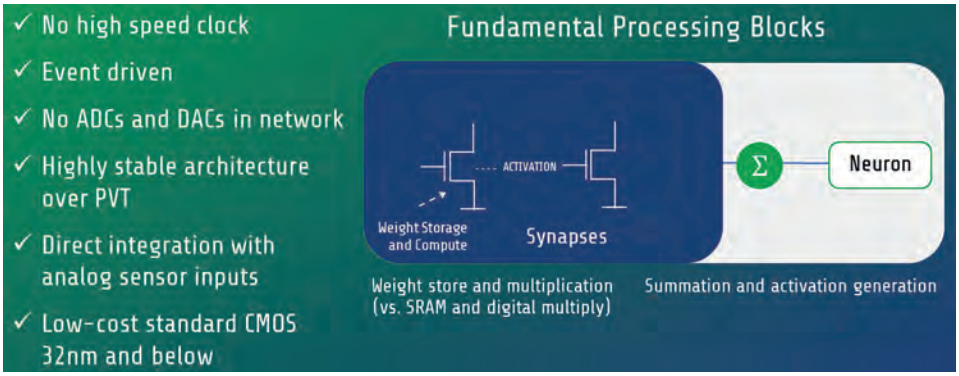
For always-on keyword detection (KWD), the name of the game is battery life, and that comes down to the total system power for the always-on solution, including the microphone and the intelligent processor.

Blumind's audio/voice solution can work with a MEMS analog or a digital microphone. Both microphones are available in standard packages from many vendors, so commodity sourcing is available for both options. However, using an analog microphone is typically 25% to 50% cheaper than similar digital microphone solutions and the power advantage is significant. Analog microphones use a lower supply voltage (typically 0.9V +/- 10%) and consume <20µW of active power vs. digital microphones that consume ~200µW, which is an order of magnitude higher.

Total system-level power consumption for Blumind's always-on KWD solution is <30µW, including the analog microphone and advanced features like a 2-second integrated audio buffer (in always-on KWD applications the 2-second audio buffer is required to validate the key word and follow-on commands by subsequent natural language processing engines).

Compared to other implementations, which typically do not include the required buffer, the Blumind solution demonstrates a 20X total power advantage, meaning battery life can be extended from a day to nearly a month!

www.blumind.ai



Blumind's all analog AMPL compute core

Understanding noise in analog circuits

There are various strategies to minimize noise effects

Analog circuits are at the heart of many electronic systems, providing accurate and precise signals for various applications. However, one of the challenges that design engineers face is dealing with noise and electromagnetic interference (EMI) in these circuits. These inconsistencies can disrupt the output signals, negatively affecting the pursuit of reliable, noise free circuits. In this article we will explore types of noise and discuss practical strategies to minimize their effects.

Sources and types of noise

Various factors contribute to noise in analog circuits, such as thermal noise, shot noise, flicker noise, and electromagnetic interference. Each type of noise affects different circuit components, and understanding these sources is crucial for effective noise mitigation.

Flicker noise, also known as 1/f noise, presents a low frequency phenomenon resulting from irregularities in the conduction path and bias currents within transistors. At higher frequencies, flicker noise is less noticeable because of the dominance of white noise, hence the "1/f" nomenclature. Although internal flicker noise cannot be controlled, system designers can minimize this effect by selecting the proper amplifiers for their application.

Shot noise, or Schottky noise, arises from imperfections in the conduction of charge carriers. As electrons encounter barriers (such as imperfections in metals), potential energy accumulates until the electron surmounts the barrier in a sudden "shot." Shot noise is directly associated with current flow, so less current means more shot-noise voltage. By raising the current, the proportional impact is reduced, enhancing the signal-to-noise ratio.

Thermal noise is present in all circuit components, active or passive. Elevated temperature causes electron movement to intensify, which introduces a stochastic element to their motion that translates to noise. Thermal noise is like shot noise in that it has a Gaussian probability density distribution.

Techniques to reduce noise

There are multiple techniques that can be used to reduce noise, including the following:

Proper component selection: Choosing components with low noise figures and high immunity to interference is crucial for noise-sensitive designs. High-quality op-amps, voltage regulators, and precision resistors can contribute significantly to noise reduction. Look for op-amps with lower voltage noise density (nV/√Hz) and current noise density (PA/√Hz).

Incorporate bypass and filtering: Employ bypass capacitors at the power supply pins of the op-amp to reduce high-frequency noise from entering the amplifier. Additionally, incorporate passive filters (low-pass) at the input or output to reduce noise at unwanted frequencies.

Optimize grounding and layout: Proper grounding and layout techniques are crucial to minimize noise gathering. Separate the analog and digital ground planes, eliminate the ground loops, and keep high-current and noise-producing traces away from sensitive analog traces.

By optimizing grounding techniques, incorporating bypass and filtering, and selecting appropriate components, engineers can ensure that their analog circuits deliver accurate and reliable performance in the face of noisy environments. Apex Microtechnology offers a wide variety of low-noise amplifiers that meet the current and voltage requirements of various high-current and voltage industry applications.

www.apexanalog.com

Chandler Porter, Marketing Communications at Apex Microtechnology

"Each type of noise affects different circuit components, and understanding noise sources is crucial for effective noise mitigation"

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How oscillator advancements impact smart cities

New packaging method enables longer life, higher reliability, and lower costs

The idea of smart cities really began when communication of information between individuals became commonplace. It wasn't until the IoT took off that the idea of smart cities gained traction along with applications justifying infrastructure change.

There are many practical applications that can improve quality of life and municipal operations, such as optimizing traffic patterns and improving safety in the form of natural disaster response and criminal investigations. Other improvements might include applications to increase energy efficiency by way of lighting, distributing grid power, and even energy generation.

Timing must also be considered. The GPS location of an asset, transactions, utility meter readings, self-driving cars, etc. all require a temporal reference for the information to be meaningful during analysis. A smart city will require sundry wireless nodes (consider V2X communications), sometimes operating in harsh environments or presented in small packages, and critical to these modules will be oscillators.

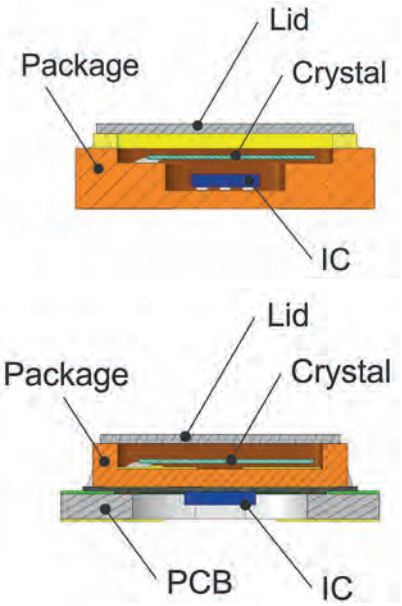
In the case of conventional structure oscillators that are being used by many suppliers today, the quartz crystal and associated integrated circuit (IC) are both housed in a ceramic package sealed with a metal lid. These devices typically range from EIA Metric 7050 (7mm x 5mm) to 2016 (2mm x 1.6mm) case sizes. This means that for every case size in-between, there is a unique ceramic package, crystal, and IC interface that must be accounted for in the design to resonate reliably at a given frequency. These designs are all well and good, but there are benefits to removing the IC from the proximity of the crystal, so long as there is packaging and crystal processing proficiency to maintain frequency performance.

A new and novel packaging method for the quartz and IC of an oscillator—known as a "platform structure oscillator"—will enable longer life, provide higher reliability, and reduce costs, possibly lowering processing costs as well.

Using this approach, only the crystal is housed within a 2016 case size ceramic package, which is also known as the "head unit." This allows for a high-temperature annealing process that would not be possible if the IC was present. The main purpose of the annealing process is to enhance the aging characteristic of the crystal, but this process also prevents packages from having contamination that may lead to failures.

The ceramic package is then soldered to a PCB (the "platform") that contains the IC. The 2016 case size of the package doesn't change, which makes it cost effective from a manufacturing viewpoint, while the PCB can be any size from 2016 to 7050 as a drop-in replacement for conventional oscillators or to provide an option for future size reductions while using the same head unit. The PCB platform also absorbs any coefficient of thermal expansion (CTE) mismatch from the ceramic package to the circuit board.

Advancements in crystal formation, processing, and cutting allow for a wide range of designs in smaller sizes. Packaging advancements contribute to a solid interface from the package to the IC that reduces leakage currents, which will be a big parameter for all components when considering the sheer number of smart city modules. Component innovations like these will enable the creation of modules with longer, more reliable lifetimes that can endure harsh environments as efficiently as possible.



Conventional structure for oscillators (top) vs. new platform structure oscillator (bottom)

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KYOCERA AVX is a leading manufacturer in developing cutting edge crystal products such as crystal units and crystal oscillators by utilizing the full capability of quartz crystals.

KYOCERA AVX has experience supplying a wide variety of crystal devices globally contributing to the evolution of IoT era.

Powering satellite systems

Unleashing the potential of FPGAs with Hi-Rel power supply designs

Kiran Bernard, Product Line Marketing, Renesas Electronics America Inc.

Field programmable gate arrays (FPGAs) have emerged as a game-changer in space applications. From satellite communications to on-board processing, FPGAs have earned their popularity due to offering unmatched versatility and adaptability in commercial bus and payload systems. While FPGAs are attractive from a performance per watt perspective, there are unique considerations when integrating them into a bus satellite system including their radiation tolerance and power requirements.

FPGAs offer high performance computing capabilities while consuming relatively low power. This is due to their inherent ability to run algorithms in a massively parallel fashion, as opposed to serial execution in a traditional processor. This also means that—from input to output—their propagation delay is typically in the nanoseconds range. An FPGA's ability to perform complex computations at a reasonable power consumption makes it an optimal choice for satellite systems that rely on solar panels and batteries for power.

Unlike application-specific integrated circuits (ASICs), FPGAs are reprogrammable. This allows any satellite that uses FPGAs to adapt to unexpected scenarios, changing mission parameters or receiving updates without the need to replace hardware. This ability to remotely reconfigure the FPGA from Earth minimizes the cost and risk of satellite maintenance, thereby extending its total useful life.

Space environments are harsh, filled with ionizing radiation, solar flares, and cosmic rays. It's important for an FPGA to be able to withstand all of these and function reliably within the mission parameters. FPGA manufactures employ special radiation hardened (rad hard) and radiation tolerant design techniques to ensure uninterrupted operation despite exposure to radiation.

FPGAs typically have multiple power rails, each having unique voltage deviation and sequencing requirements that must be followed to maintain reliability. To determine the worst-case voltage deviations for a power supply, one must look at the product datasheet for specs that control the overall regulation for initial accuracy, operating temperature, radiation, and end of life. This can often be a challenging task on its own as some manufacturers do not provide all the data necessary to make the necessary calculations.

To properly budget the error sources for a power supply it's good to list what the possible error sources are. The sources are voltage reference (V_{REF}) accuracy, error amplifier voltage offset (EA_{VOS}), feedback resistor tolerance, line and load regulation, output voltage ripple, load transients, and radiation effects. Typically, the V_{REF} and EA_{VOS} are lumped together at around ±1% with the feedback resistor, line and load regulation, and output ripple taking ±0.25% each. Load transients take up the largest portion of the budget (±2%) due to the types of capacitors available in the space market. Total Ionizing Dose (TID) and Single Event Effects (SEE) are the main concerns for radiation and can be allotted another ±2%.

The power sequencing requirements are important as they prevent high current latching scenarios. Since satellite systems operate on solar panels and batteries, unnecessary dissipated power is a huge concern. Power-on sequencing can be achieved easily with a power-good to enable (P_{GOOD}-to-EN) daisy chain. Here, the P_{GOOD} from one regulator is tied to the EN pin of a subsequent regulator to ensure the downstream regulator does not power up until the upstream device has achieved regulation. There are downsides to this method. If a regulator in the daisy chain encounters a fault during start up, the sequence does not progress and could potentially hold the system in an indeterminate state. It also does not account for power-down sequencing, which is equally critical.

It's tempting to use another FPGA to sequence the power supply for the primary FPGA, but this results in a chicken-and-egg situation as the new FPGA will likely have its own power/sequencing requirements. This means it is better to use an event-based power supply sequencer that can account for both power-up and power-down sequencing while also providing voltage monitoring capability. This helps mitigate any indeterminate system states when one power supply in the sequence fails to power up for whatever reason.

While designing a complete power supply for an FPGA can be a daunting task, Renesas' portfolio of high-reliability (Hi-Rel) reference designs take the guess work out of power supply design with robust parts from a manufacturer that has been serving the space community reliably for more than 70 years.

www.renesas.com

"An event-based power supply sequencer can account for both power-up and power-down sequencing while also providing voltage monitoring capability"

Sensors are Everywhere but R&D Costs are Rising Too

Engineers are designing more sensors into a widening set of products across multiple market applications, pushing up sales but also adding pressures for differentiation.

Intel Corp. co-founder Gordon Moore did not mention sensors in his 1965 seminal paper in which he laid out the contours of one of the semiconductor industry's guiding principles and what has since become known as Moore's Law. A quote from the document published by Electronics Magazine that year would seem to apply to sensors, though. "Integrated electronics will make electronic techniques more generally available throughout all of society, performing many functions that presently are done inadequately by other techniques or not done at all," Moore wrote. "The principal advantages will be lower costs and greatly simplified design payoffs from a ready supply of low-cost functional packages."

Sensors are designed to ferret out information and they today play an increasingly important role in electronic designs. They perform sensitive information retrieving tasks and are deployed often to help OEM products work more efficiently, enhancing safety, productivity, visibility, and creativity. Sensors are also versatile and have been used in almost all segments of the economy by manufacturers, service providers and even ordinary citizens looking to gather information about their products and environment. Observers say the utility of sensors is almost universal, stretching from cold to hot and other applications. "Sensors are used in practically every industry vertical," said Data Bridge Market Research, in a report. "However, they are commonly found in consumer electronics, followed by automotive, IT, and telecom. Sensors such as the accelerometer, gyroscope, ambient light sensor, proximity sensor, and temperature detectors are built into smartphones to keep track of characteristics and give a centralized system for autonomous control."

With such a wide footprint and with growing adoption of electronics by many economic sectors, the application of sensors in non-traditional settings are likely to expand over the next years, contributing to the expected surge in demand for semiconductors through the end of this decade. Forecasters are projecting strong growth in semiconductor sales through 2030. They estimate global chip revenue will top $1 trillion by then, climbing from $574 billion in 2022. Although analysts predict a decline in sales growth this year, the industry will continue to follow the dictates of Moore's Law with unit shipments steadily climbing and pricing moderating following stiff increases during recent shortages.

Although Moore did not put his observations in such strict terms, over time, many observers have condensed the core of the semiconductor principle that bears his name simply to the concept that "the number of transistors on a microchip will double every two years." Moore's Law drove a great deal of the innovations that have pushed the semiconductor industry into a core part of the global economy today. Sensors, in all their variations and applications, are essentially one branch of the semiconductor world that has continued to track Moore's Law over decades.

In many ways – without intending to – Moore did identify more than 60 years ago the critical roles sensors were destined to play in many electronic designs today. As prices drop in general and applications surge, sensors are going into more devices and a widening section of the economy. In industries such as access and security, aerospace, automotive, communications, defense, farming, medical, and industrial segments where sensors have in recent years made major inroads, manufacturers are adding to the variety and number of the devices in their products, according to observers.

"Sensors are used in everyday objects like elevator buttons with touch-sensitive (tactile) functions, and lamps which dim or brighten by touching the base, besides countless applications that most people are unaware of," said Market Data Forecast, in a report released earlier this year. "These sensors have found their way into many platforms such as health care, agriculture, and automotive, among others. Furthermore, factors like advancements in sensor technologies, improvements in the automation sector, rising usage of smartphones and other electronic devices, increase in demand for sensors in the development of smart cities, and the surge in IoT technology, are further fueling the growth of the global sensor market."

Key market drivers

The automotive industry was an early adopter of sensors and has grown into one of the main markets targeted by chipmakers with innovative products. Analysts say the number of sensors in vehicles – and therefore the size of the automotive sensor market – has grown exponentially in the last decade. The average vehicle today has up to 70 sensors performing all kinds of functions. Luxury vehicles have many more with some high-end cars having as many as 200, according to researchers. These include pressure sensors, oxygen and temperature sensors as well as sensors in wheel columns. They provide information about engine performance and other functions inside and outside the vehicle, including safety applications. "By integrating a greater quantity and variety of sensors into vehicles, OEMs address the growing demand for enhanced safety, comfort, and efficiency," The Yole Group said, in a report. "Initially reserved for high-end models, sensors are now set to conquer the entire automotive industry and pave the way for autonomous driving."

The market research firm estimates the market for automotive sensors will shoot up to $14 billion by 2028, driven by demand for advanced driver assistance systems (ADAS), airbag safety systems, stability control and entertainment systems. "5.4 billion sensors for the automotive market were shipped in 2022 globally, generating $7.8 billion in revenue," said Pierrick Boulay, senior technology & market analyst, Photonics and Sensing Division at Yole Intelligence. "And with a strong 10% revenue compounded annual growth rate (CAGR) between 2022 and

2028, we expect it will grow to $14 billion in 2028 with 8.3 billion sensors shipped worldwide."

OEMs are using sensors for more than safety and security. Other automotive applications include navigation, touch sensing for instrument control, driver monitoring and situational awareness. With the growing adoption of electric vehicles, the number of sensors in cars will increase, further expanding the size of the market. Continental AG, one of the top suppliers to the automotive market, puts the types of sensors in EVs into five unique groups. They include "sensors specifically designed for electrified mobility to protect essential components of the BEV (Battery Electric Vehicle) by detecting harmful impacts, monitoring important parameters, and ensuring efficient operation," the company said in a statement.

Industrial

The industrial sector is one of the fastest growing segments of the sensors market. The applications are numerous and interest in sensors for this segment of the economy has increased in recent years as companies focus on precision, safety, security and the gathering of data and accurate intelligence. Sensors are used by companies in a wide range of fields, including oil and gas, energy and power, mining, chemicals and pharmaceuticals. They are also used by cities, municipalities and other government regulatory or service providers to monitor systems. Researchers said sensor usage has proliferated in areas such as "environmental monitoring, flood and water level monitoring systems, traffic monitoring and controlling, energy saving in artificial lighting, precision agriculture, animal tracking, equipment fault diagnostics and remote system monitoring."

As manufacturers have embraced internet of things (IoT) and other connectivity tools in a bid for improved productivity, the size of the market for industrial sensors has increased, they said. Industrial sensors suppliers such as Honeywell, Texas Instruments, NXP, Amphenol, Denso, STMicroelectronics, Bosch, Siemens and First Sensor now sell into markets as varied as home appliances (fans, heaters, refrigerators. thermostats, cameras, and doors), motion control, programmable controllers, healthcare, training and safety instrumentation systems, drones, robots, smartphones and AR/VR. "Based on the sensor type, the market for industrial sensors is segmented into temperature sensors, pressure sensors, position sensors, gas sensors, level sensors, image sensors, force sensors, and humidity & moisture sensors," analysts at Precedence Research said, in a report. "Pressure sensors accounted for the largest market share in 2022. Pressure sensors are used in numerous industrial applications, including pneumatics and hydraulics, mobile hydraulics, water management, pumps and compressors, off-highway vehicles, plant engineering & automation, and air conditioning & refrigeration systems."

The expansion of the usage of sensors will keep demand for industrial sensors strong for years with growth remaining strong through the end of the decade, according to the research firm. Sales are expected to more than double by 2032 to $54 billion, from a projected $25.5 billion, in 2023, growing at a CAGR of 8.5 percent, according to Precedence Research. "Industrial applications for wireless sensors are becoming more and more necessary due to the industry 4.0 revolution, in which machines are becoming more sophisticated and creative," the researcher said. "The new instruments can track their performance, failure, and usage independently and are made more adaptable, safe, and reliable. Therefore, the demand for sensitive sensors is increased by these applications. Another significant driver propelling the market's expansion is the growing acceptance of IoT."

Rising development costs

Rising demand for sensors and expansion into new economic segments have driven innovations at suppliers seeking to differentiate themselves in the marketplace. Manufacturers are pouring money into technological innovations due to the need for data and sensing accuracy, they said. The performance of the equipment many sensors measure, and the environments being monitored are often so sensitive that the components require extreme finesse to gather accurate data. Also, sensors are being pushed into hardy environments of either intense heat or freezing cold conditions. Sensors that measure air quality, for example, must be able to detect subtle changes in environmental conditions, according to researchers. To ensure efficiency, suppliers are intensifying work on the development of ultra-sensitive and yet robust sensors, they said.

In addition to hardware, manufacturers are also funding research into software to ensure smooth data transfer and upgrades. Earlier this year, for example, Renesas Electronics Inc., said its latest firmware would enable engineers "configure the sensors to support various green air quality standards for commercial and public buildings." The company introduced the new firmware in response to changing requirements for air quality standards and to assure autonomous operation of the system, it said. With the upgrade, Renesas' sensors would be able to "detect harmful gases in indoor spaces," it said. "Environmental sensors are a vital tool for ensuring the health and safety of occupants in public and commercial buildings," said DK Singh, senior director of the Sensor Solutions Business, at Renesas. "By using our AI-enabled hardware and firmware platform, customers can easily implement advanced sensors that comply with various building air quality standards to provide a safer and healthier environment for people around the world."

Specialized products like sensors will help boost semiconductor sales to the $1 trillion projected for the end of the decade, Yole Group said. But the landscape remains tough, and suppliers must deepen their R&D activities to manage the demand-supply imbalances that have long plagued the industry, the consulting firm noted. "The technology trend is no longer single-threaded," it said, in a report. "The industry is, therefore, actively exploring innovative solutions through More than Moore (MtM) approaches. NAND memory is headed full steam into 3D stacking, while Advanced Packaging has become vital for all leading players. Many innovations trends are driving the semiconductor industry; wide bandgap compound semiconductors, photonic integration, quantum computing, and neuromorphics will play their role in expanding the industry to serve a growing diversity of semiconductor device types."

Adapting EV battery testing to rapidly evolving battery technologies

Russ Gaubatz, Senior Applications Engineer, EA ELEKTRO-AUTOMATIK

How can battery cycling and test systems keep up?

Each new generation of EVs works to address consumers' concerns of extending vehicle range and recharging time. This need is driving advances in Li-Ion battery technology and alternative technologies like solid-state, zinc-air, graphene batteries, and many others.

Regardless of the technology, EV battery systems must undergo rigorous testing for operating voltage level, charging rate, rating, and use case, both while under development and in the battery manufacturing process. They also are tested during the EV manufacturers' production testing.

A typical battery cycling and test system in use today employs a rack of programmable power supplies and loads ("Cycler") and another rack with an industrial PC, test equipment, and communications systems. The battery packs are cycled while operating at a controlled temperature prescribed by the specific test protocol. Depending on the type of power supplies employed, a cycling test may require interruption to allow the instrument to change range as the battery pack voltage ramps up or down.

An alternative is to use an adaptable cycling and test system that is much lighter on its feet and can easily adjust to whatever changes are required in the fast-changing battery technology environment.

Key elements of an adaptable battery testing and cycling system include:

- Bi-directional, Regenerative, Auto-ranging Power Sources
- Adaptable Testing Software
- Integrated Power Control and Measurement

Bi-directional, regenerative supplies essentially "borrow" the utility power by using an internal synchronous inverter to return most of the power used in the test back to the grid.

Auto-ranging adds flexibility to the entire system. Compared with "conventional" power supplies that provide maximum power only at the rated voltage and current, auto-ranging allows for maximum power to be delivered over a wide range of conditions. For example, a conventional test system configured for 400V battery packs would require the replacement of the power supplies to be reconfigured for 800V batteries. With auto-ranging, the maximum power output would be delivered without any reconfiguration.

The EA-BCTS 10300 system includes adaptable testing and cycling software offering a full range of pre-programmed test protocols and simple means for implementing user-defined tests such as capacity, four seasons, pulse, and imported battery cycling. Built-in drive cycle simulations include FUDS, SFUDS, GSFUDS, DST, and ECE-ICL.

It also integrates "Power Control and Measurement" in the form of an operational interface between the battery packs being cycled and tested and the programmable bi-directional power supplies.

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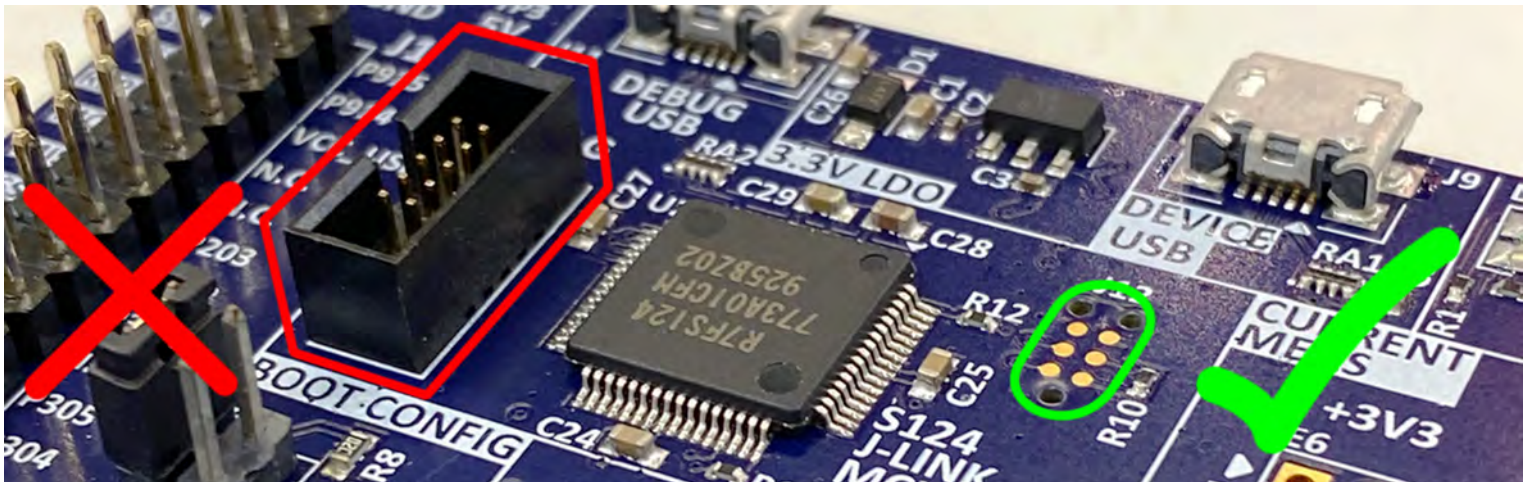

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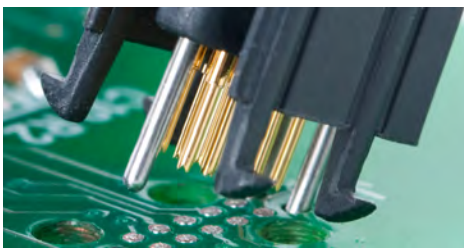

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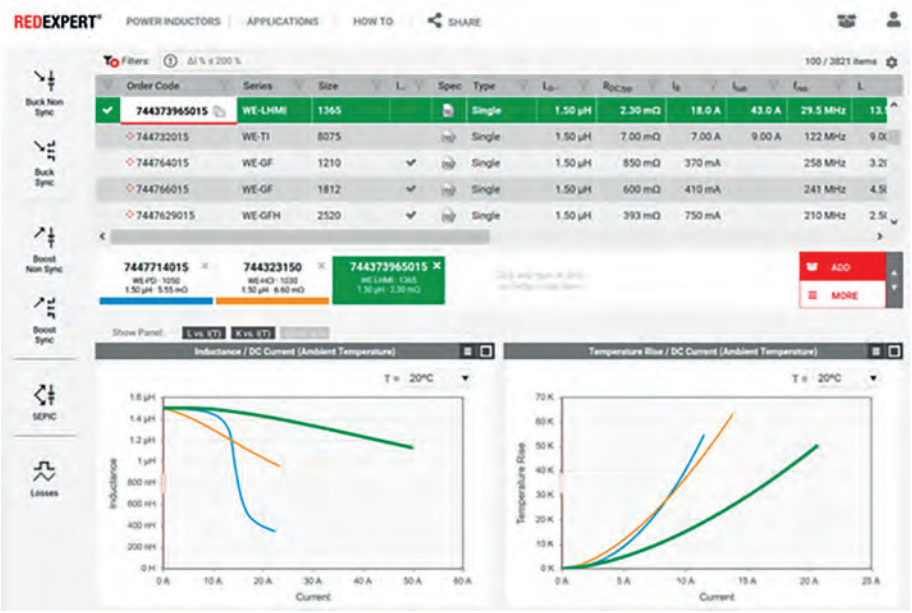
Supporting power supply designers with real data

REDEXPERT allows designers to make smart determinations without complex calculations

In today's world of electronics, the trend has been to make things smaller and smaller, the assumption being that—if they are smaller—they will be more convenient and more readily adopted. But is this true? The first iPhone was truly a marvelous tiny phone that combined features unheard of to that point. But today's version is nearly twice the size—not because of technology, but because people demand something they can see and use. The flat screen television has taken a similar route. The incredibly thin screen has only resulted in making the viewing area much larger. A feat that could not be achieved with a cathode ray tube (CRT)-based product.

Following this trend, magnetic components like inductors have also been shrinking. Remembering our physics, that inductance is based on volume, shrinking the volume reduces the inductance. This has been countered by using higher switching frequencies. To date, no phone or tablet on the market has a bulge in the back because the magnetics were too large. Cameras are a different topic. All components have inefficiencies that result in power losses. These losses result in heat that must be dissipated by either conduction, convection, or radiation. As components get smaller, their surface area decreases, meaning they must have lower losses to match otherwise they will overheat. In magnetic materials, as the operating frequency increases, the losses increase exponentially. On the winding side, a rectangular wave excitation contains many high frequency harmonics that result in skin and proximity effects within the coil, increasing its effective resistance. You get the picture, smaller hotter parts with less cooling area. So, how is an engineer to decide on an inductor?

Tables and charts in REDEXPERT allow quick and accurate comparison of inductors



George Slama, Sr. Application and Content Engineer, Würth Elektronik

What is needed is a method that accounts for each inductor's real-world losses. However, this is complicated by the fact that each application is unique in both its electrical, mechanical, and thermal constraints. Furthermore, each magnetic components manufacturer uses their own unique tests to define product performance, thereby making it difficult to compare parts on an equal basis. This is particularly important for rated current and saturation current.

Standard testing of rated current

The fact that every inductor vendor uses their own method to determine the rated current is complicated by how the inductors are mounted and the thermal conduction the mounting provides. With small inductors, the mounting can provide useful heat sinking, reducing the operating

temperature and extending the current carrying capacity. Put another way, this allows the winding to carry more current, increasing the energy storage capacity, provided that the core does not saturate.

To help our customers, Würth Elektronik has added testing in accordance with IEC 62024-2, “High frequency inductive components – Electrical characteristics and measuring methods – Part 2: Rated current of inductors for DC-to-DC converters.” This standard provides a transparent and recognized method to determine rated current. To distinguish the new measurements from historical values, the new result is called “performance current.” Würth Elektronik datasheets now contain both values and provide notes as to which specific “class” of the standard each inductor was tested under.

The designer now has a more complete picture of the inductors’ capabilities which include the inductance without bias (L), the currents where the inductance drops by a specified percentage due to bias ($I_{SAT,30\%}$), and the currents that cause a 40°K temperature rise under typical (I_R) and performance conditions ($I_{RP,40K}$). However, numbers are hard to visualize, and the heating conditions are based solely on DC currents.

Simulation based on real-world measurements

Real applications have high frequency AC ripple currents that increase losses beyond the DC bias. The impact of these ripple currents on the winding and core losses is difficult to predict accurately by calculation. To address this problem, Würth Elektronik has measured its inductors under real-world conditions in a buck converter circuit over a wide range of frequencies, duty cycles, and bias conditions.

By measuring total losses this way, all the influences of construction and material are considered. The result of this rich data set is available through the online tool REDEXPERT. The user simply enters the basic operating parameters, and a list of suitable inductors appears complete with losses under those conditions based on measurement. This includes charts that show the inductance roll-off as bias increases, as well as temperature rise under a selected ambient temperature.

Sliders on the charts allow the user to obtain intermediate values along the curves. The charts can show the characteristics of many inductors making it easy to compare several potential devices to each other. Engineers often need to document their choices and share them with others. A simple click provides a URL that can be sent to colleagues, allowing them to reproduce the same results. Obtaining samples involves only a simple click-and-drag operation.

Backed by real data, the versatility and convenience of REDEXPERT allows designers to make smart determinations with confidence in the results and without complex calculations. That’s the goal and purpose of support from online design tools.

www.we-online.com/redexpert

How smart sensors are revolutionizing communication applications

Jon Holder, Supplier Marketing Manager at TTI, Inc.

Smart sensors integrate the processing step into the data collection device

Sensors have always played a vital role in communication applications by collecting information from various sources. By integrating microprocessors with the sensors to create smart sensors, the collection and transmission of real-time data are more efficient and accurate than ever.

Contrary to how it may seem, the world does not run on data. The world runs on *how* data is produced and transmitted between the creator and the receiver. In other words, the application of data communication is what enhances our lives. And with the ever-increasing pace of change, shortening the time from data collection, processing, and response has never been more critical.

This desire for more efficient communication has transitioned the industry from discrete data collection, processing, and actuation to smart sensors that integrate the processing step into the data collection device.

Smart sensors transform communication in several ways, explained below.

Efficient and accurate communication

The most apparent way smart sensors enhance communication is by increasing data transmission efficiency. With embedded processing, there is less physical travel distance with fewer interconnections in the transmission circuit.

Another benefit is improved data accuracy. The sensors read and detect inefficiencies like noise and interference while monitoring signal strength. They can delineate undesired characteristics to allow communication devices to maintain stable, accurate connections with lower data loss. This benefit enhances data accuracy along with network efficiency.

Data security

Increased amounts of data raise the likelihood of a security breach. Sensors' continuous data collection enables near real-time performance monitoring, quickly alerting engineers to a potential issue. Many current internet of things (IoT) sensors also can encrypt network traffic, which adds a protective layer to data communication to protect sensitive data transmission.

Another way to ensure data security is by employing IEEE-compliant sensors. The IEEE has adopted four IoT sensor standards to define acceptable communication interface geometry, performance, cyber/physical interfaces for virtual reality/augmented reality (VR/AR), and medical device specifications.

Integrated communication channels

Smart technology and the IoT aims to connect systems (and industries) together. Sensors, in particular, are essential for the seamless integration and data exchange of communication technologies like wireless networks, satellite communications, and IoT devices. They collect data from the surroundings, organize it, and transmit it to other channels for seamless transmission.

To ensure these channels communicate properly, sensors can:

- Help to manage frequency allocations
- Utilize the optimal segment of the frequency spectrum
- Reduce interference, a benefit that helps the channels "fit" together well
- Improve precision and accuracy of positioning and tracking in satellite communications

Communication protocols

One way these channels achieve smooth integration is through communication protocols, of which there are three primary types:

1) Network management
2) Network communication
3) Network security

These protocols include transmission control protocol (TCP), internet protocol (IP), and the combination of these two (TCP/IP) to connect network devices. This combination is the most common protocol connecting the networks together.

Other communication procedures exist, such as hypertext transfer protocol (HTTP) and its secure (encrypted) counterpart HTTPS, post office protocol (POP), simple mail transfer protocol (SMTP), and file

transfer protocol (FTP) to share various data forms. HTTP transfers text between two or multiple systems. It establishes the connection between the data sender and receiver and sends the data once the receiving server acknowledges the send request.

POP (POP3 being the most recent) allows a user to receive an email, regardless of platform, and SMTP is its analogous send-mail protocol. FTP allows the implementation of file transfer between machines. This protocol benefits large data transfers that may not be permitted over email.

Smart, adaptive communication

Dynamic reaction is where smart sensors excel. They enable intelligent and adaptive communication implementation by adjusting frequency, power, and modulation based on the ambient conditions the sensors observe and user requirements.

An example of this dynamic response is automatically switching a wireless data transmission path to a less congested one to improve performance and signal quality. Another application is that the sensors could dictate a change to a satellite's position due to deteriorating weather conditions that would reduce the performance.

Engineers can equip the sensors with clear guidance on the optimal state and variables available for adjustment to enhance data communication. Defining these elements lets the technology iterate to a converged optimum much faster than a human operator could.

Enhanced user experience

Finally, the enhanced capability of smart sensors enhances user experience through advanced communication features like gesture recognition, voice commands, proximity sensing, and ambient light adjustment.

These features allow the user to interact with technology more naturally. In doing so, the technology becomes part of the environment and lets the user interact with it in the way they are most familiar with.

Voice commands allow the user to talk to their device, and proximity sensing can brighten or dim a screen depending on the ambient lighting it senses. Proximity sensors can optimize battery life through adaptive dimming and enable facial recognition to enhance security without time-consuming multi-factor authentication (MFA) steps.

Conclusion

Smart sensors are a powerful and robust method to collect and analyze data. They are the connective tissue of the IoT, enabling data communications between the user and technology and between systems themselves.

Leveraging IEEE standard sensors and communication protocols already in place will accelerate IoT utility, further connecting systems and integrating this transformative technology into our daily lives.

Follow TTI, Inc. on LinkedIn for more news and market insights (http://bit.ly/2Z5jqq1)

www.tti.com

"Smart sensors are the connective tissue of the IoT, enabling data communications between the user and technology and between systems themselves"

Introducing the NoISA processor

The NoISA processor is smaller, faster, and lower power than an ISA-based processor

For as long as there have been FPGAs, there have been people who wanted to use them for computing. The traditional model of FPGA-based compute is to hard code an algorithm and then load the full bitstream once for each program.

The problem comes when loading a new algorithm. Even with partial reconfiguration (PR), the result is like the tortoise and the hare. The FPGA can rip through whatever algorithm is loaded like a hare. By the time a new bitstream is loaded, however, the tortoise wins in most cases.

By comparison, CPUs and GPUs continue to outshine FPGAs in the arena of changing behavior with their ability to simply execute a different program.

Dark configuration

FPGAs have what I call the "dark configuration" problem. Only so many configuration bits can be set at a time, or the voltage rails are pulled down and configuration bits are lost. As FPGAs get larger, they require more configuration. These days, a large FPGA may require over a billion configuration bits.

Even partial reconfiguration cannot save the day. The goal now becomes to try to change the behavior of the FPGA without changing the bitstream that configures the FPGA.

The NoISA processor

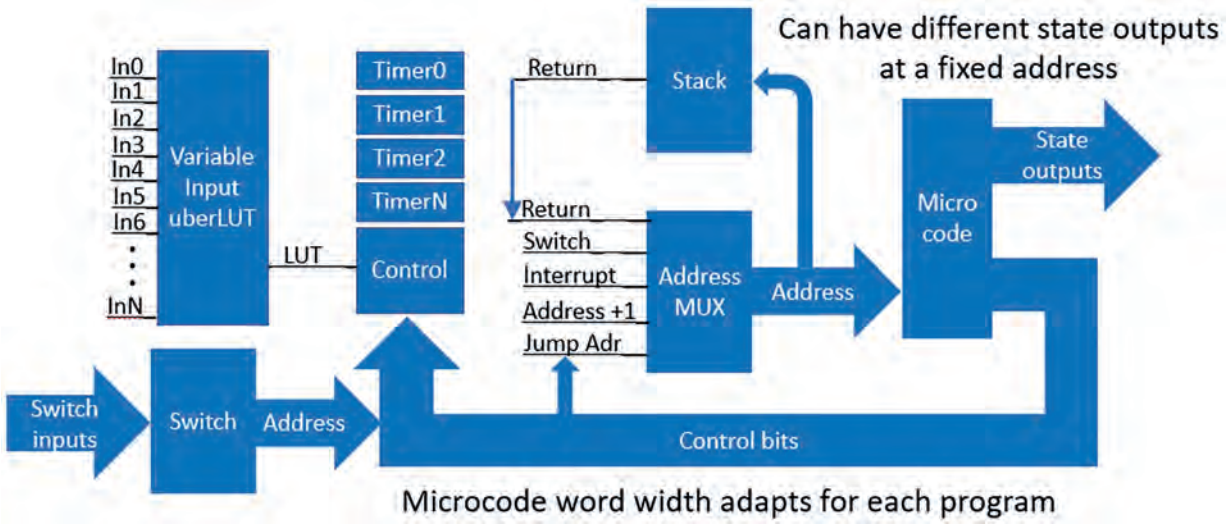
The motivation for the NoISA processor is the observation that current instruction set architecture (ISA)-based processor systems use a fixed ALU, a fixed register file, and a fixed hardware controller. These three units divide the data and control planes into small "chunks" called "instructions." The fixed hardware controller implements the instruction decoder of a fixed ISA and the data orchestration of the program.

By comparison, a NoISA ("No ISA") processor is based on the Hotstate machine plus some HDL. In turn, the Hotstate machine is an advanced C programmable, runtime loadable, microcoded algorithmic state machine that implements the same functionally as the fixed hardware controller of a processor for any arbitrary hardware architecture.

Steve Casselman, CEO, Hotwright Inc.

The Hotstate machine has advanced abilities, including a stack for functions, as many timers as needed, a switch offset table, a

Feature	*ISA*	*NoISA*
Smaller	✗	✔
Faster	✗	✔
Lower Power	✗	✔
Lowest level of access	*Bare metal*	*Microcode*
Programing model	*Multiple languages*	*Bit level "C" plus HDL*
Operating System	✔	✗



The Hotstate runtime loadable microcoded algorithmic state machine

large lookup table for input bits, and an interrupt that responds in one clock cycle.

The state outputs are qualified by a corresponding mask bit and captured if appropriate. The mask bit and state bits are used to create the new state output (state[i] = new_state[i] if mask[i] = true else old_state[i]). The number of possible state outputs at any one address during run time is $2^{(n-m)}$, where **n** is the total number of states and *m* is the number of states used in that line of code. As a result, the Hotstate can express more complexity than a standard state machine (a traditional algorithmic state machine has one state output vector per address).

NoISA vs. ISA-based processors

The NoISA processor is smaller, faster, and lower power than an ISA-based processor. The programmer has a lower level of access with a NoISA processor since it's built around runtime loadable microcode. The NoISA processor does not yet support an operating system, but that can be an advantage with respect to the speed with which the processor can handle real-time events.

The size of the Hotstate machine depends on the size of the code. The compiler reads in the code and passes parameters to the Hotstate module. This is different to high-level synthesis (HLS), which compiles down to hardware. Those designs can't change their behavior unless a new configuration file is loaded. I feel HLS jumped the shark by not using NoISA principles. This is why HLS tools are stagnating because they went down a dead-end path evolutionarily speaking. Adopting the NoISA philosophy can change that.

To create a NoISA processor, implement the data flow design in an HDL, then run all the mux selects, FIFO controls, overflows, underflows, and any other control pins into the Hotstate machine. Now, a little C program runs the architecture. Reloading the Hotstate machine at runtime ensures more software can fit into the hardware (see the tutorial and videos on our website to see how easy it is to create and use the Hotstate machine).

Save time and money

The NoISA processor is a system that can be used with any hardware architecture. It's the ultimate "Napkin" design system. Draw out the data flow architecture and then run all status and control into the Hotstate machine. Designs get done quicker using this method than traditional designs methods. It's different enough to be useful but not so different as to be hard to use. Also, the Hotstate machine is portable among FPGA vendors that support SystemVerilog.

Use cases

There are many use cases for NoISA processor, some of which are as follows:

- Use a NoISA processor when a softcore CPU takes up too much area or runs too slowly.
- The NoISA processor uses less energy than a softcore CPU, so use it on the IoT Edge where power matters.
- NoISA processors make great controllers. Use them to quickly create small controllers and C-programmable state machines.
- NoISA processors are small and fast and the perfect choice for systolic arrays.
- NoISA processors are great for changing the behavior of an FPGA without changing the FPGA itself.
- NoISA processors change their behavior by reloading powerful microcode instead of little instructions.

It's time for a change

It's hard trying new things. It stretches the mind and changes the way one perceives the world. But it's worth the effort. ISA-based processors were invented when computers had vacuum tubes and hand-wound memory cells. Can anyone believe that if Von Neumann had a billion transistors instead of a thousand tubes, he would have come up with the ISA processor-based computer?

Try the NoISA processor. It will be well worth your time. Remember: "Don't be a slave to the ISA."

www.hotwright.com

The future of FPGAs is model based!

Adam Taylor, Founder, Adiuvo Engineering & Training Ltd

Model-based design reduces development time and increases quality

The meeting as always was dragging on but slowly concluding. The changes requested at a late stage in the development process had been made to the FPGA. The root cause at the system level which led to the change request was understood and the method of implementation was judged by independent FPGA experts as acceptable. Crucially, the full verification suite had been run both on the FPGAs and on the system. This was important as—in the not-to-distant future—these FPGAs will be blasted into space to help search for new planets.

All that remained was to reflect the changes across the documentation, but this is where the issues became apparent. A small change to the requirements has a massive ripple-on effect with respect to the documentation used to capture the system's definition, analysis, verification, and validation. This small change would require a raft of documents to be updated, a not inconsiderable task when deadlines are approaching. The meeting concluded with actions on the system and FPGA design team to update the documents, issue them for review, and schedule a delta qualification review.

Increasingly, the number of documentation artefacts that are generated as part of the program is an issue with the development of complex projects. A documentation-centric approach has several limitations. The information from systems engineering activities is contained within a series of documents. This makes analysing data difficult and often means the understanding of it can vary due to human interpretation. A documentation-centric approach also means there can be duplication of data across documents, which makes maintenance difficult and can lead to conflicting information.

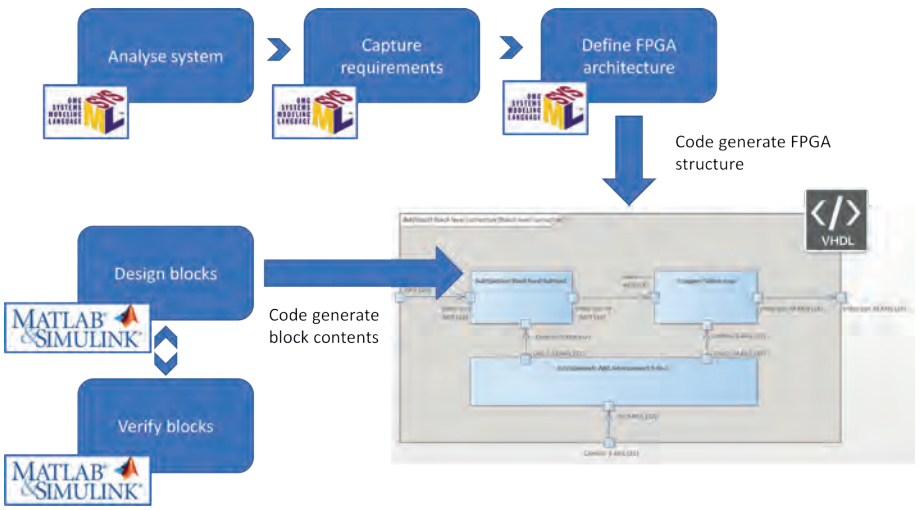
What is model-based design?

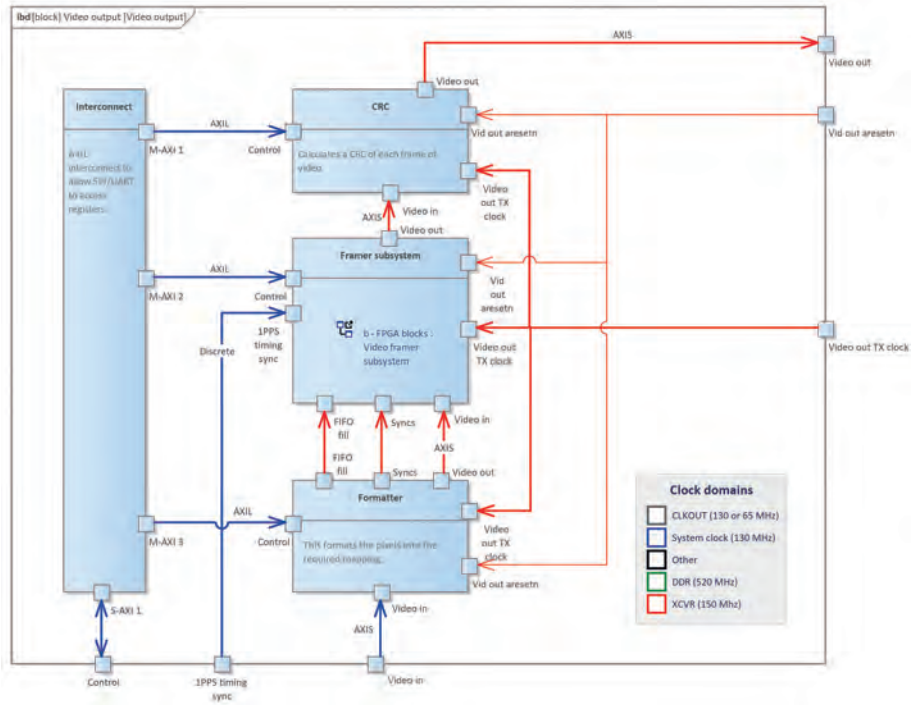
Model-based design (MBD) is a formalised application of modelling to support system requirements, design, analysis, verification, and validation. This starts at the conceptual phase and continues throughout the remainder of the engineering life cycle.

Model based design therefore takes much of the data that would be traditionally have been included in documents in a documentation-centric flow and moves it into a model. These models are often built around a data base, which allows information to be shared and reused across different visualisations of the model. A single source of truth ensures that each element of information is created only once and then reused as required. Using a model therefore gives the engineering team a solution that can be analysed much easier than a disparate set of documentation.

In situations like the one presented in the introduction to this column, a change requires we find all impacted documents and update them. By comparison, since information is linked together in a model-based flow, it is much easier to make changes as any modifications are automatically propagated though the model.

Process flow for model-based design





Example enterprise architecture FPGA structure

Another significant benefit of a model-based approach is standardisation. Engineers often communicate information via diagrams and walls of text. A model-based approach introduces standardisation in the way information is presented though the use of specific diagrams. An even greater advantage of model-based engineering is the ability to create computer programs that can read the model and automate key tasks.

MBD and FPGA development

The example presented in the opening paragraph was based on a previous FPGA project implemented using a traditional documentation-centric flow.

More recently, our FPGAs and projects have been developed using a model-based engineering flow. In this flow, we use MBD tools to capture the system. In the most recent case, this model captures both the FPGA and microprocessor along with their interactions.

To achieve this, we used an industry standard tool, Enterprise Architect, which enabled us to capture the technical baseline of the project. By means of this tool, we captured the requirements and behaviour diagrams, which demonstrated the desired functionality. We were also able to capture the internal architecture of the FPGA design.

Within this internal architecture, we are able to define the functional blocks, their interface classes (e.g., AXI, AXI Stream, or custom) along with the clocking architecture. This structure diagram shows the architecture of the FPGA design including the interconnects used to connect the modules together.

From this structure diagram, Adiuvo has internally developed automation tools that are able to process the model and generate a VHDL netlist of the structure. Along with this netlist, register maps and integration information such as interface control diagrams and C/Python functions are also generated.

This automation tool automatically pulls in elements from our Adiuvo IP library, which contains commonly used modules such as AXI interconnects, FIFOs, direct memory access (DMA) etc. The tool also generates stubs to which any custom modules to be developed will be attached.

In the same way the model-based approach enables the level of abstraction for the FPGA to be raised, we also raise the level of abstraction (where appropriate) for the development of the modules. To do this, we leverage MATLAB and Simulink along with the appropriate toolboxes to enable hardware description language (HDL) generation.

Simulink is well-suited to FPGA design as we can model not only signal processing but also state machines and combinatorial logic. Along with developing the functionality in Simulink, we can also use it to develop the test bench and test cases, thereby enabling a single environment for modelling and verification.

This model-based approach—which combines Enterprise Architect for most of the model-based design with Simulink models for detailed functionality—enables the development of an FPGA from a single source of truth, cutting down on the documentation and its maintenance while enabling development at a higher level of abstraction.

Using this approach, Adiuvo recently developed a large video processing FPGA for a space application. The design drives a high-end scientific CMOS image sensor and processes the video before outputting it over gigabit serial links. The entire design consists of approximately 100,000 lines of VHDL, most of which was generated automatically using either Enterprise Architect or Simulink.

Conclusion

By deploying a process that focusses on the front-end of the lifecycle, employing techniques such as model-based design and continuous integration, we can significantly reduce our overall development timeframes. Furthermore, this approach produces the high-quality designs mandated by the most challenging of applications.

www.adiuvoengineering.com

Hardware-anchored AI security is reshaping data centers

Rising cybersecurity threats demand innovative solutions

Data centers are prime targets for cybercriminals because they are treasure troves of critical data. Knowing the information they store is coveted, data center operators implement robust security measures and protocols to protect against attacks and ensure the privacy of client data. Despite advances in security technology, however, ransomware and other types of attacks are increasing, proving that today's data centers are not impregnable.

So many tools, so much time

Cybercriminals have a wide array of tools at their disposal. Distributed denial of service (DDoS) attacks can overload a data center's servers, causing them to crash and render the data inaccessible. Malware can be used to gain access to a data center's systems, stealing data, or damaging infrastructure. Threats from within an organization by employees or contractors with access to the data center's systems can intentionally (or accidentally) harm the data or infrastructure.

Social engineering attacks such as phishing can unwittingly trick employees into divulging sensitive information or providing access to data-center systems. From the initial breach, malware continues to attack the targeted system through the paths of least resistance, after which it may either infiltrate the data center immediately or lie in wait for days, months or even years until conditions are right for exploitation.

Trust nothing, verify everything

With so much at stake and with hackers continuously changing their digital camouflage like chameleons, the cybersecurity industry has come to realize that current generations of applications are inadequate. One solution is to use cybersecurity best practices anchored in Zero Trust, a premise that reverses the assumption that anything or anyone inside the network can be trusted. The Zero Trust mantra is "never trust, always verify."

The protocol assumes that every attempt at a potential connection must be verified before it is allowed to communicate with a network device. Even when access is granted, it can be revoked should the user fail a re-authentication test. A new generation of the approach makes extensive use of artificial intelligence because the threat landscape continuously changes.

AI algorithms can process massive amounts of threat intelligence data in near real-time and then add them to a threat library. This AI processing can be performed with a single device called a trust platform module (TPM) within the control plane of the server. The TPM uses AI to authenticate the identity of credential holders before approving their access to documents. Frequent authentication is achieved by issuing encrypted keys designed to verify user identity.

A prime example of this hardware-anchored, AI-driven approach to platform security is Axiado's trusted control/compute unit (TCU). The TCU has four domains, each dedicated to a specific function set that collectively provides protection for the most common threats: ransomware, side-channel attacks, network-level attacks, and anomalous behavior.

Breach containment

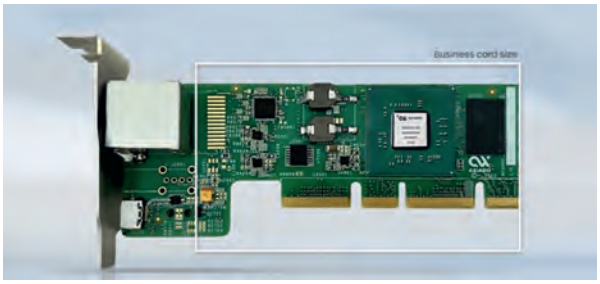
According to IBM Security's most recent annual Cost of a Data Breach Report, the average cost of a data breach reached a record high of $4.45 million in 2023. The report concluded that AI technology had the greatest impact on accelerating the speed of breach identification and containment. In fact, organizations that fully deployed AI cybersecurity approaches typically experienced 108-day shorter data breach lifecycles and significantly lower incident costs (on average, nearly $1.8 million lower) compared to organizations without these technologies.

Tareq Bustami, Senior Vice President of Marketing & Sales, Axiado

The ability of a hardware-anchored, AI-driven security platform to continuously monitor and perform run-time attestation of cloud containers, platform operating systems, and firmware creates efficiencies that help reduce time spent investigating potential threats. A hardware solution that integrates AI into a chip can analyze behaviors and CPU usage. That allows it to immediately investigate anomalies in user activity.

With this approach, networks can no longer be infiltrated because of software

The Axiado Smart Secure Control Module (Smart-SCM) features the Axiado TCU



vulnerabilities or porous firmware. AI technology enables heterogeneous platforms that include root-of-trust (RoT) and baseboard management controllers (BMCs) to offer hierarchy and security manageability. By deterring cybercrime at the hardware level, the industry can finally address the long-standing shortfalls of online security.

Cybercriminals often target BMCs to execute their schemes to steal data for ransom, implant malicious code that can cause users to reveal passwords and other sensitive data, or bring down an entire network to cause chaotic service disruptions. These vulnerabilities usually emerge when a third-party program or firmware is installed in a device that allows arbitrary read and write access to a BMC's physical address. The BMC is a key target for cybercriminals because it is the first processor to run on a server, even before a main processor like the CPU and GPU. As such, hacking a BMC's firmware can affect every other firmware or software application that runs after it.

Hardware-Anchored, AI-Driven Security

Hardware-based detection involves specialized hardware devices that monitor system behavior and detect signs of an attack by monitoring CPU usage, disk activity, and network traffic. Network packet behavior anomaly detection involves monitoring network traffic and analyzing packets to identify unusual patterns or behaviors that may indicate an attack. Hardware-based anomaly detection enables system administrators to detect and prevent ransomware attacks before they cause significant damage.

CPU performance monitor counters detect attacks by identifying unusual CPU usage and identify unusual patterns so system administrators can forestall damage. AI engines significantly enhance detection by identifying advanced attack patterns that traditional techniques may not detect. Analyzing large amounts of data and identifying subtle patterns are an integral attribute of AI-based hardware security.

External root-of-trust monitoring provides an additional layer of security against attackers. The RoT entity can monitor system performance and detect any attempts by attackers to tamper with or bypass the monitoring mechanisms. The RoT also can be used to securely store the cryptographic keys and certificates necessary for ransomware detection. By storing these keys in a secure and tamper-proof manner, the RoT can prevent attackers from compromising the keys and using them to evade detection.

The RoT entity can also provide secure boot capabilities, ensuring that the system boots only from trusted and verified sources. This prevents attackers from installing malicious software during the boot process, which can bypass the ransomware detection mechanisms. By incorporating an external RoT into the ransomware detection solution, system administrators can provide an additional layer of protection against attackers and ensure the integrity and confidentiality of the monitoring mechanisms and cryptographic keys.

OCP Takes the Lead

Attacks pose a growing threat to data centers and the traditional methods of addressing these attacks are not enough. To address this need, a modular solution offered by the Open Compute Project (OCP) aims to integrate server management, security, and control features from a typical motherboard into a module.

The module solution consists of a daughter card called the data center secure control module (DC-SCM), designed in vertical or horizontal form factors that can be used across various data-center platforms. By adding intelligence to the DC-SCM platform, the solution can replace all the SoCs on the motherboard, including the BMC, RoT, trusted platform module, programmable FPGA/CPLD, and management local-area network (LAN). This approach provides an integrated solution that fits the unique needs and levels of security of different types of servers. It also allows users to tap into the momentum behind the broader open-source hardware community through groups like the CHIPS Alliance, OpenPOWER, and RISC-V.

The OCP predicts that 20 to 30 percent of systems coming to market in 2023 will incorporate a DC-SCM card, with 100 percent adoption expected by 2024. By embracing the OCP's modular solution and adding intelligence to the platform, the industry can take a significant step toward mitigating the impact of ransomware attacks and reducing the costs associated with system replacement.

Summary

With an emphasis on cybersecurity coming from the highest levels of both government and industry, the safety of networks has become a leading priority for all organizations. The next generation of hardware-anchored, AI-driven security platforms can create a more robust Zero Trust architecture for data networks, enabling a more rigorous approach to secret key storage and management. Ultimately, more effective Zero Trust practices will secure the future of data centers and give peace of mind to our digital communications for years to come.

www.axiado.com

Make haptics easy and accessible with the Titan Core dev board

Haptic solutions are notoriously difficult to develop; this new product provides a solution

The word haptic, from the Greek *haptikos*, means "tactile, pertaining to the sense of touch." Haptic technologies (also kinaesthetic communication or 3D touch) can enrich user interfaces, creating an experience of touch by applying forces, vibrations, or motions to the user.

These technologies can allow users of smartphones to receive tactile feedback from their devices. They can also be used to control virtual objects in a simulation and to enhance remote control of machines and devices. Haptic devices may also incorporate tactile sensors that measure forces exerted by the user on the interface. Simple haptic devices are common in the form of game controllers, joysticks, and steering wheels.

Haptic technology is an unsung hero of our modern electronics experience. Almost any consumer device you interact with today, be it your smartphone, smartwatch, or video game controller features some form of haptic actuation to improve the user experience and deepen immersion.

Unfortunately, as it turns out, haptic applications are notoriously difficult to develop solutions for. Haptics are tactile and personal, which makes them hard to quantify and methodically design. While there is some science behind the field, a lot of haptic solution design requires a process of trial and error accompanied by a lot of subjectivity.

The state of the industry

Developing haptics is made even harder by the lack of development tools available to designers. There are a handful of different types of haptic actuators, dozens of brands that make each type, and even more companies that produce the supporting circuitry surrounding haptics.

Haptic developments require a confluence of choosing the right motor, the right driver, and developing the control scheme that creates the natural and intuitive tactile sensations you desire. With few solutions available to support development, the result is that progressing a haptic solution to market takes much longer than it should. This stifles growth and limits the industry severely, which is problematic for a technology as ubiquitous as haptics.

Introducing TITAN Core

At TITAN Haptics, we are addressing this challenge with the introduction of our TITAN Core haptic development kit.

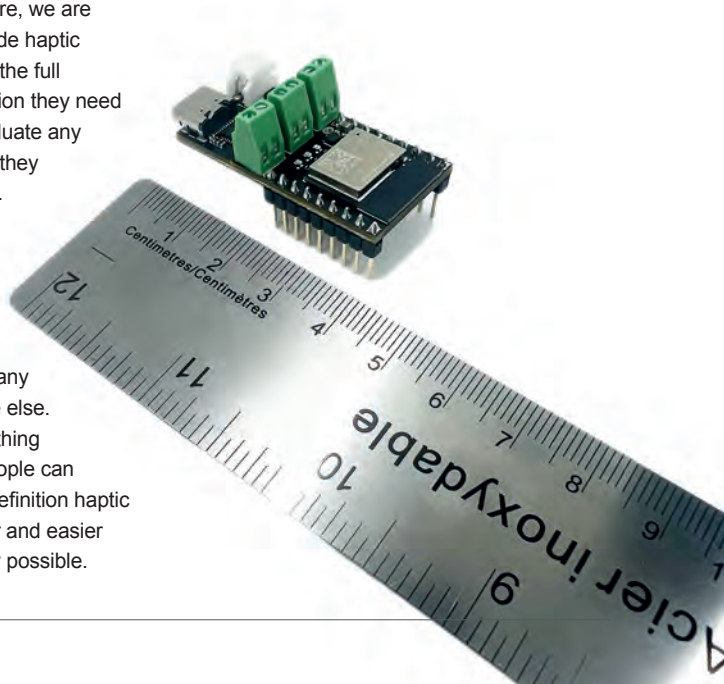
TITAN Core is a compact haptics development board that also doubles as a production-ready module. This solution consists of a fully contained haptics PCB core and ESP32 chipset designed to make haptics integration easier and more seamless. Each Core offers three discrete haptics channels, a 3W dual-channel Class D amplifier + Dual H-Bridge, and onboard power management with LiPo charging via USB-C. To make things even easier, we also offer Wi-Fi and Bluetooth connectivity, along with a plethora of GPIO such as 2 DACs, 2 ADCs, and SPI, I2C, and serial communication support.

With TITAN Core, we are aiming to provide haptic designers with the full hardware solution they need to test and evaluate any haptic solution they are developing. The product is totally motor agnostic, so you can test motors from our company or from anyone else. The important thing to us is that people can develop high-definition haptic solutions faster and easier than previously possible.

Kyle Skippon, Head of Engineering at TITAN Haptics

We truly believe that TITAN Core offers the fastest means possible to a full-production haptics solution. Designers can even take the TITAN Core directly into production, making the product a true plug-and-play way of integrating high-definition haptics into their upcoming projects.

www.titanhaptics.com



Four ways MEMS precision timing fuels automotive innovation

MEMS enable advanced communications technologies in today's vehicles

MEMS-based precision timing solutions are transforming the automotive industry by providing resilient, high-stability, low-power timing references for demanding in-vehicle applications. Developers have relied on quartz-based timing devices for decades until the recent advent of MEMS-based alternatives. Here are four ways in which MEMS precision timing is fueling automotive innovation while providing a superior alternative to quartz technology.

#1: Enabling faster in-vehicle interfaces

Advances in automated driving technologies are driving increasing numbers of sensors deployed in vehicles, providing data streams up to 20TB per hour for automated driving systems. This data flow requires numerous high-speed interfaces such as PCI-Express, 10GB Ethernet, FPD-Link, or MIPI A-PHY.

MEMS precision timing solutions play a critical role in ensuring these interfaces function at their highest potential. By reducing jitter and delivering high-performance clocking, clocks and oscillators based on MEMS technology enable faster data transfer, improve system performance, and enhance the overall in-vehicle experience.

#2: Enabling better connectivity to the outside world

Vehicles today are not just transportation mediums but interconnected mobile devices that communicate with the outside world, from vehicle-to-vehicle (V2V) communication to vehicle-to-infrastructure (V2I) and vehicle-to-everything (V2X). MEMS-based timing components are robust and resistant to the environmental stresses encountered in vehicle operation such as shock, vibration, and temperature fluctuations. As MEMS timing devices can reach the ±0.1ppm frequency stability required by the V2X standard, they are a key element enabling advanced communications technologies in today's vehicles.

#3: Improving reliability and safety metrics

MEMS precision timing solutions not only ensure the smooth operation of electronic systems within vehicles but also play a vital role in maintaining safety. Standards such as ISO 26262, an international functional safety standard defining the development of electronic systems in road vehicles, have been created for this purpose. MEMS timing contributes to the high reliability of digital components within electronic systems, ensuring they perform accurately and safely under different operating conditions. The high reliability of MEMS timing devices helps improve system-level safety metrics for automotive applications. Oscillators are typically single points of failure. By using MEMS oscillators, a better single point of failure metric (SPFM) is achieved. In addition, MEMS timing enables a lower system-level probability metric of hardware failures (PMHF).

#4: Making the supply chain more resilient

In an industry where supply chain disruptions can cause significant issues, the ability to create a more resilient supply chain is crucial. MEMS precision timing solutions leverage the benefits of silicon-based technology. Both MEMS wafers and CMOS wafers used in manufacturing MEMS precision timing devices are sourced from scalable suppliers. Multiple Assembly and Test vendors ensure no bottleneck exists within the production flow. MEMS timing devices are ideally suited to respond to surges in demand with short lead times.

Sumeet Kulkarni, Director of Product Marketing – Automotive at SiTime

MEMS—The driving force behind automotive innovation

MEMS technology is the unsung hero of the automotive industry's transformation. Automotive system designs are steadily transitioning from quartz to more reliable and robust MEMS-based timing technology. By enabling faster in-vehicle interfaces, improving connectivity and communications, enhancing reliability and safety, and providing greater supply chain agility, MEMS precision timing solutions are driving the future of automotive innovation.

www.sitime.com

Why design engineers are replacing ICs with discretes

Kevin Parmenter, FAE Director Americas, Taiwan Semiconductor

Due to the scarcity of proprietary ICs, designer engineers are turning to discrete technologies

This time, it's different

Although we are used to cyclical downturns in our industry, the persistent semiconductor shortages we have been experiencing are unprecedented. The causes are many: the pandemic, the Russian invasion, too much demand vs. too little capacity, wafer shortages, and so on. The difference with this downturn is that it's finally effecting real change in the behavior of design engineers.

For years we have been taught that the best design approach is to implement a minimum-parts-count solution using highly dependable ICs. Today, designers are seeing the benefits of using older discrete technologies that have lots of sources. For example, you might immediately think a ramp generator, differential amplifier, buffer, or gate driver should be integrated circuit implementations. But suppose your amazing proprietary gate driver takes up to 99 weeks lead time, which means you won't ship your product until you can get them.

While it's understood that your four-core 32-bit ARM processor SoC can't be implemented discretely, you might be able to use discrete devices—with backup sources—for your less sophisticated circuit functions. That way, if someone decides to stop making, say, MMBT3604s and MMBT3906s, there are plenty of other suppliers left to choose from.

Discrete devices can be used to switch and amplify; you can use them to create oscillators, buffer I/O lines and more. It is also possible to use small-signal discrete devices like 4148 switching diodes, Zener diodes, small signal MOSFETs, or bipolar small signal devices.

Again, it is impractical to make a microcontroller with discretes, but new designs can contain dual layouts. In this case, only one layout on the PCB is populated and the other is not. If a part becomes unavailable, you can simply populate the alternate layout. This approach is, of course, more expensive—but it's cheaper than not shipping products for two years.

Industry challenges

Component suppliers must figure out a way to make their supply chains more robust. In general, they are doing a poor job, which has forced customers to find alternative options.

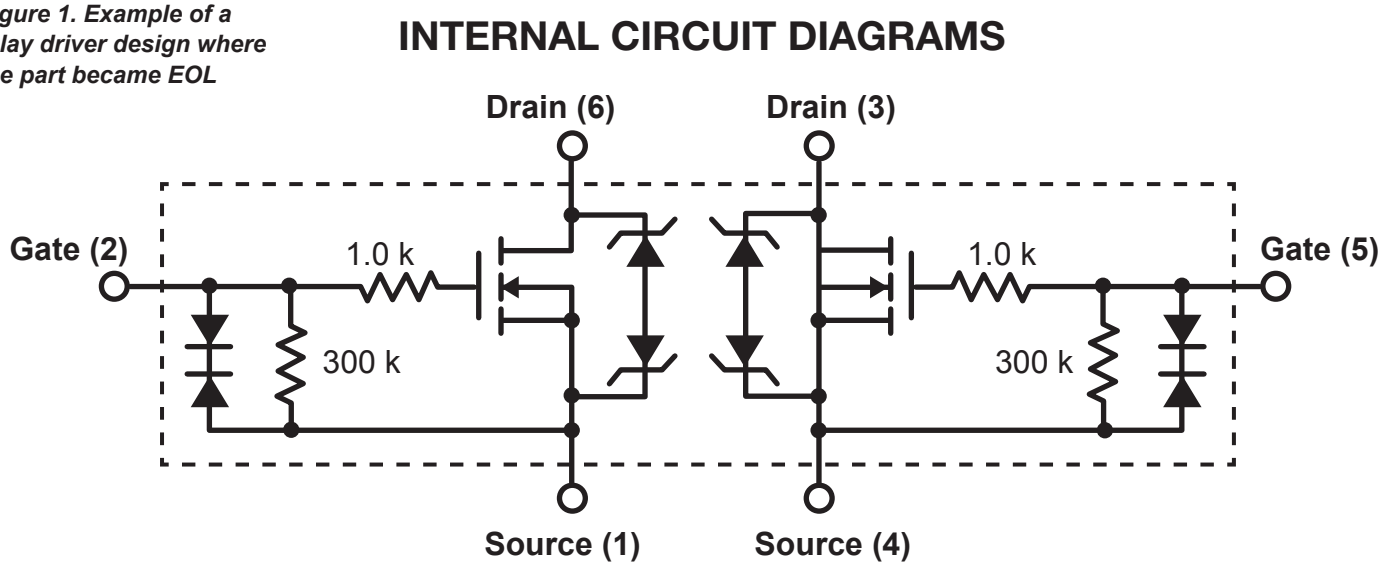


Figure 1. Example of a relay driver design where the part became EOL

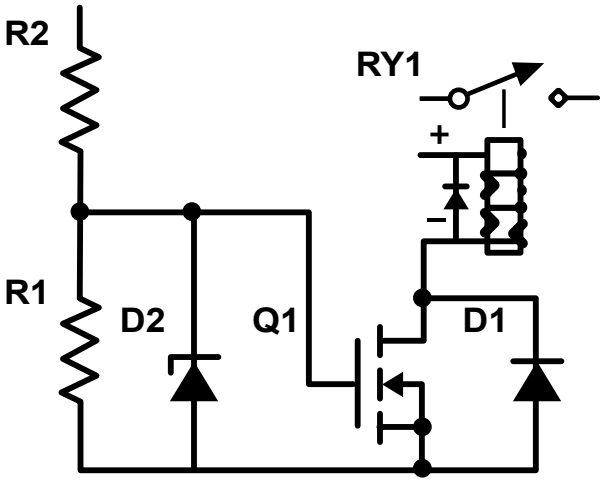


Figure 2. Redesigned circuit from Figure 1 using discretes

While suppliers are fixated internally on tracking data and dashboards and so forth, customers are figuring out ways to avoid being "hung out to dry." They might even resort to designing their own ICs and having them built in foundries themselves.

Another challenge is that many suppliers are not committed to customer orders. When your backlog goes away after waiting out your 22-week lead time, only to see it suddenly turns into 99 weeks, it means that the supplier sold your parts to a more favored customer. (Nice, just wait some more.)

Problem: "Getting semiconductored"

Imagine a proprietary IC that is integral to your design suddenly disappearing. A VP at a semiconductor company, for instance, might decide to kill proprietary products because they are not meeting the right "dashboard metrics" for the investors. Or because of how they read an algorithm and big data. Whatever the reason, your part is gone. This is called "getting semiconductored."

Figure 1 is an actual example of this problem. It shows a relay driver coil that was used in a cooling system driving a 75mA contactor. This single part offered many types of protection with one insertion in production and no external parts were needed. Then, with little notice, this nice, compelling part went EOL. (Whoops! Redesign time!)

Solution: Using discretes

What do you do now? Maybe change the design using what you should have used in the first place: discretes. How about a 2N7002? Lots of people make those. And we can add some 1N4148s or 1N4004s and TVS devices, as needed, to clamp the inductive EMF that could damage the device.

The solution is to rebuild the circuit in Figure 1 with "common household items"; that is, the tried-and-true discrete parts we know so well.

Figure 2 shows the discrete design. **Q1** is a 2N7002. **D1** and the back EMF diode of the relay coil can be a 1N4148 or 1N4004, while **D2** can be a BZT52B9V1-G, a P4SMA9.1, or similar. **R1** can be approximately 100KΩ, however, it's not critical. **R2** can be 100Ω depending on the logic switching signal applied to its "input" (it's just there to protect the gate of the **Q1**.)

And now you have a future-proof design that is built to last. None of the components are critical and they don't need to be precision devices. Simply build the circuit, times two, and you have a replacement for the original sole-source part. Are there any downsides to this design? Probably not with space or cost. Maybe with board insertions (if you keep score on that), but this is a small price to pay for not getting shut down.

Using this solution, no singular component supplier can shut down your production and force a redesign. If you must use a substitute, it's easy to find something pin compatible that provides the right function. Plenty of people make discrete devices, and all of us are really good at making them in massive volumes. So, if a product line manager decides to exit the 2N7002 and 1N4148 business ("dashboard metrics baby—and let's change our logo while we're at it!"), you'll still have 50 others to choose from. (Not all are ones you should buy from, but that's another article.)

Lessons learned

Implementing functions discretely, when possible, means that the circuit, and the overall product, can be produced. You will withstand downturns due to random decisions by executives at the supplier semiconductor company, adverse market conditions, natural and manufactured disasters, and whatever else comes along.

Also, make sure your supplier can answer questions about MTBF and FIT reports, reliability qualification reports, and can provide quality data in production (i.e., AQL levels). If they can't, look elsewhere.

These types of parts have been around a while and they aren't going anywhere, so this approach future-proofs your designs. Use discretes and avoid being semiconductored again. After all, fool me once…

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Obtaining unprecedented signal-to-noise using SigmaSense Sigma-Delta sensing

Self-biased sensing innovation enables breakthrough capabilities for impedance sensing

High sensitivity impedance sensing that delivers high speed data extracted from within a sea of noise is a challenge for every sensing circuit. Concurrent, self-biased sensing delivers superior results that eliminate most design challenges of the past.

Self-biasing background

Self-biased sensing circuits, also known as self-biased current mirrors or self-biased current sources, offer several advantages that make them an essential component in various electronic applications. These circuits use feedback to automatically adjust their biasing, which leads to enhanced performance, stability, and reliability.

Self-biased sensing circuits maintain a stable biasing condition regardless of process variations, temperature changes, and supply voltage fluctuations. This stability ensures consistent and accurate operation, which is crucial in precision applications such as instrumentation, sensing, and control systems. By reducing the impact of external factors, these circuits can provide reliable and repeatable results over a wide range of operating conditions.

Compared to traditional sensing circuits that rely on fixed biasing, self-biased circuits can significantly reduce power consumption. Since they continuously adjust their biasing levels, they only consume the necessary current required to maintain the desired output, minimizing wasted power. This advantage is particularly valuable in battery-operated devices and energy-efficient applications, where power optimization is essential to prolong battery life and reduce overall energy consumption.

Self-biased sensing circuits exhibit a wide dynamic range, allowing them to accurately sense and amplify signals of varying magnitudes. This feature makes them well-suited for applications that require the processing of weak or strong input signals without sacrificing accuracy or linearity. Consequently, these circuits find use in signal conditioning, audio processing, and communication systems where a diverse range of input amplitudes may be encountered.

In integrated circuit (IC) manufacturing, process variations can lead to differences in transistor characteristics, which can adversely affect the performance of traditional sensing circuits. Self-biased sensing circuits, however, are inherently less sensitive to process variations due to their feedback-based biasing mechanism. As a result, these circuits provide higher yield and reliability during the IC fabrication process, reducing production costs and improving overall performance.

Temperature fluctuations can alter the performance of electronic circuits, impacting their accuracy and stability. Self-biased sensing circuits can incorporate temperature compensation techniques that adjust the biasing currents in response to temperature changes. This compensation ensures consistent operation over a wide temperature range, making them suitable for applications in harsh environments where temperature variations are significant.

These sensing circuits can be designed with a smaller number of components compared to traditional biasing techniques. This simplicity not only reduces the overall complexity of the circuit but also results in a smaller physical footprint. This compact size is particularly advantageous in ICs, where real estate is at a premium, allowing for higher levels of integration and more functionality within the same chip.

Shawn Gray, Founder, Chief Innovations Officer, SigmaSense LLC

Self-biased sensing circuits, due to their inherent ability to adapt to changing conditions, are more robust and reliable compared to circuits with fixed biasing. The feedback mechanism ensures that the circuit operates within its desired range, minimizing the risk of component stress, saturation, or other operational failures. This reliability is essential in safety-critical applications, automotive electronics, and aerospace systems, where any failure could have severe consequences.

SigmaDrive

This novel simultaneous drive and sense implementation encompasses all four primary analog and digital functions

(AFE, ADC, DAC, and DSP) integrated into each channel on a single pin! What? No multiplexing? SigmaDrive fundamentally exceeds the capabilities of the customary sigma-delta designs by using self-excitation and self-biasing, as well as a current feedback loop on every channel for concurrent sensing functions.

It's all about Tau

Tau is the time constant of an RC circuit that it takes to change from one steady state condition to another steady state condition when subjected to a step change input condition. Why is this relevant? Electronic circuits are not always in a stable or steady state condition but can be subjected to sudden step changes in the form of changing voltage levels or input conditions. For example, the opening or closing of an input or output switch.

However, whenever a voltage or state change occurs, a circuit with capacitive and/or inductive elements cannot respond instantaneously and will require time to reach a stable state. The change of state from one stable condition to another generally occurs at a rate determined by the time constant of the circuit, which itself will be an exponential value with an exponential decay. The time constant of the circuit will define how the transient response of the currents and voltages are changing over a set period.

Sensor arrays such as switched capacitive touch systems can only run as fast as the system can switch, settle, and sample. The SigmaDrive architecture operates continuously on every channel mitigating the effects of system RC timing constraints providing for higher performance and ease of sensor design. No longer is there need for uniform impedance sensors or equal length traces. Concurrent sensing of all nodes simultaneously enables advanced noise cancellation techniques, further improving signal-to-noise results.

Conclusion

SigmaSense has redefined analog sensing. With the development of a reimagined Sigma-Delta architecture, radical improvements are made in sensitivity and signal-to-noise ratio (SNR). These consequential improvements are a result of a four-fold approach: a redefinition of the Sigma-Delta architecture, removal of quantization noise inherent in Sigma-Delta techniques, aggressive narrowband DSP filtering, and dynamic noise avoidance made possible through spectral analysis. Furthermore, our direct-to-digital frequency domain approach removes the additional power-hungry analog pre-processing circuitry found in typical AFEs leading to a 90% digital chip that is smaller, lower cost, and lower power.

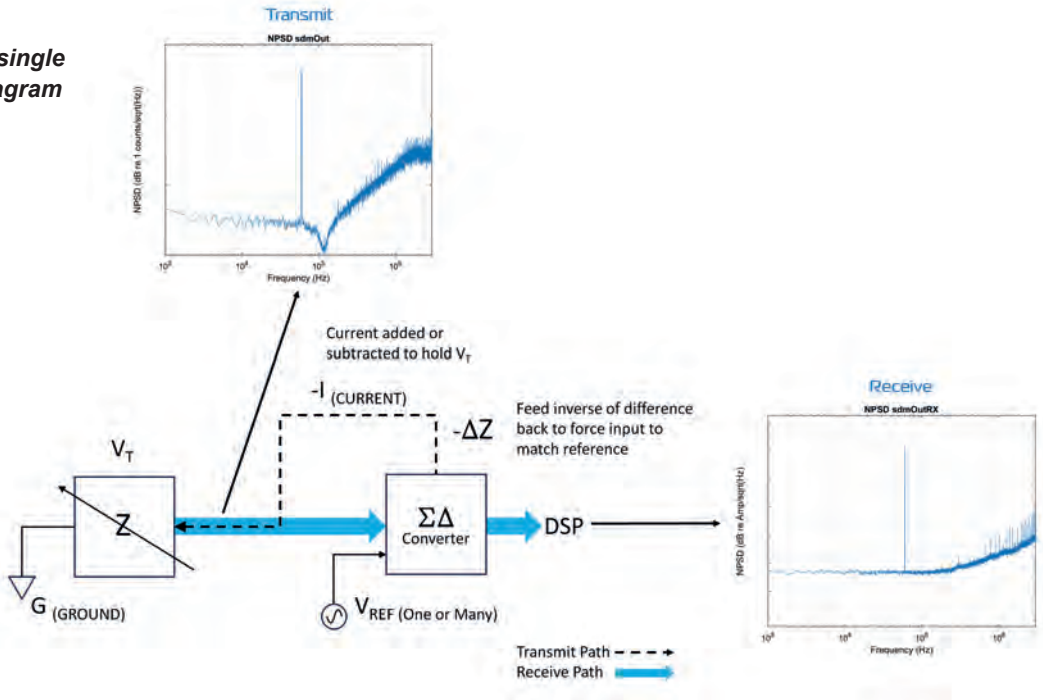
While technologies exist for general sensing applications, manufacturers today need new sensing capabilities to solve difficult problems and enable better outcomes for the manufacturer and the end user. For system designers, sensitivity, noise rejection, high SNR, and low power consumption are paramount. SigmaDrive is the solution to all these challenges.

New user experiences require new sensing features that are not available today. The extensive capabilities of SigmaSense's technology makes possible future devices that deliver on designer needs and facilitate innovative user experiences.

www.sigmasense.com

"SigmaSense's technology makes possible future devices that deliver on designer needs and facilitate innovative user experiences"

SigmaDrive single pin block diagram



Understanding LED life and performance

In this article, CML walks buyers through the life and performance of LEDs, explaining how carefully balancing brightness and current can improve life expectancy

The lifespan of an LED can range from 80,000 to about 120,000 hours depending on materials and manufacturing method. Generally, these estimates are based on perfect conditions. However, in reality the harsher the use the less the life expectancy. Eighty thousand hours equates to a little over 20-years if operating the device eight hours a day. Most products would be obsolete by the time a complete or catastrophic failure occurs.

Increasing demand for brighter LEDs is playing a role in life reduction. More and more we see a drive for daylight visibility in certain ranges of parts, products, and components. If there is one thing directly impacting an LED's life expectancy it is current draw. Operating an LED at reduced current extends its life even further. At significantly reduced levels, an LED can last almost indefinitely. However, should it see current above the nominal rating its life will be much shorter. Unfortunately, the relationship between LED life and current is not linear unlike the relationship between current and brightness.

LED lighting can last a long time. However, that does not mean users should keep the lighting as long as there is not a catastrophic failure. Light output and color will degrade over time, with the application generally determining the level of acceptance.

LED technology has developed rapidly in recent years and should continue to do so. Innovations and improvements occur continuously. Good design and careful manufacturing techniques help increase the life and general performance of lamps.

CML's latest lamp products are available with data sheets that accurately reflect life and performance. They can be requested directly from the customer services team or by contacting CML's list of authorized distributors.

www.cml-it.com

CML Innovative Technologies' commercial manager, Roger Neal

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