THE **PUBLICATION** FOR **DESIGN ENGINEERS**

# DENA

## DESIGNING ELECTRONICS NORTH AMERICA

**JULY/AUGUST 2022**

**AN MMG PUBLISHING TITLE**

**Got questions (about hardware, software, analog, digital, and test)?**

# WE'VE GOT ANSWERS!

+

ALSO FEATURED ON PAGE 12 - **New sensor provides humanoid robots with tactile awareness**


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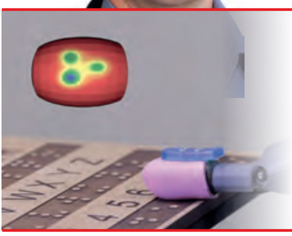

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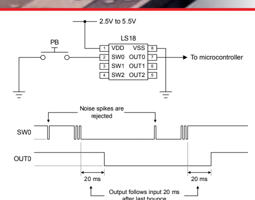


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## EDITOR'S WORD

### Welcome to the future!

I designed my first application-specific integrated circuit (ASIC) in 1980. This little beauty, which was implemented at the 5-micron technology node, contained only around 300 equivalent logic gates and I used each and every one of the little rascals.

My schematics were captured using pencil and paper. We didn't have access to computer-aided tools. Functional verification involved walking the other members of the team through your design, answering impertinent questions like "Why did you do this bit like that?"

Similarly, we didn't have a timing analysis tool. Instead, we identified critical paths based on our knowledge of the design, and then we added the gate and wire delays associated with those paths by hand.

Once my design had been laid out, it was time to perform a step now known as layout versus schematic (LVS). The layout was printed on long strips of paper that were joined to form a 20-foot square, then I went through the design gate-by-gate and net-by-net using colored pencils to mark each element in both the schematic and layout with my fingers crossed that there wouldn't be any "bits left over," as it were.

Things have certainly changed since those far-off days. I look at the tools available to today's designers in wonder. I also look at the components and products being designed in awe. I hope you will feel the same way when you read this issue of DENA.

*Max Maxfield*

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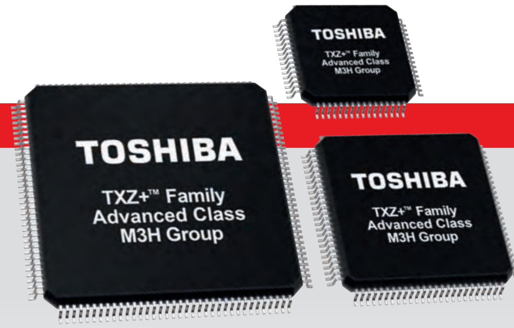
ecia
Connect. Influence. Optimize

TOP STORY




# New microcontrollers optimized for control

Toshiba has started mass production of 21 new microcontrollers in the M3H group, which includes an ARM Cortex-M3 core running at speeds up to 120MHz, integrated 512kB (max.) code flash, 32kB data flash, and 64kB of RAM.

These microcontrollers also offer various interface and motor control options, such as an encoder and programmable motor driver. As a result, M3H group devices are suited for a wide range of applications including motors, home appliances, and industrial equipment.

These new products have enhanced communications functions integrated as UART, TSPI, I2C, and a 2-unit DMA controller (DMAC). Moreover, a digital LCD driver is integrated to reduce the number of components for display function and ensure a flexible board layout.

These devices support a variety of sensing applications with a high-speed, high-precision 12-bit analog/digital converter (ADC) that allows individual sample and hold times to be set for each of the 12 to 21 ADC input channels. In addition, they provide a solution suitable for controlling AC motors and brushless DC motors in combination with an on-chip advanced programmable motor driver (A-PMD) circuit that can operate synchronously with the 12-bit analog/digital converter.

Also included within the highly integrated device is a dual-channel, 8-bit digital/analog converter (DAC) and up to 135 dedicated input/output (I/O) ports. Other peripherals include a remote-control signal preprocessor (RMC) and CRC calculation circuit.

The self-diagnosis functions incorporated in the devices for ROM, RAM, ADC and Clock help customers to achieve IEC60730 Class B functional safety certification. All of the new microcontrollers operate from a voltage in the range 2.7 to 5.5V DC and are housed in high-density 64 to 144 pin LQFP packages.

*www.toshiba.com*

## Mitigating chip shortages

**MicroEJ**, the company that brings the "smart" into smart things, is designed for low-cost and low-power chips used in IoT edge devices from small Cloud-connected sensors to smartwatches to smart appliances. MicroEJ supports all the major chip providers, including STMicroelectronics, Renesas, NXP, Qualcomm, Sony, MediaTek, Sequans, Thales, and many more!

Two years after the start of the pandemic, manufacturers are still impacted by the chip shortages. The latest news from Ukraine does not improve this situation as the country is known to supply more than half of the world's neon gas, vital for semiconductor production.
To enable global electronics manufacturers to mitigate the predicted worsening of this shortage, MICROEJ VEE's virtual software containers allow them to use different processor models for the same product and thus spread their supply sources across different suppliers.

In the consumer electronics market, for example, the MICROEJ VEE application container enables products to be designed up to 3X faster, accelerating the time-to-market significantly. MICROEJ VEE also simplifies dynamic upgrades of new features on products already deployed to meet new user needs.

MICROEJ VEE enables manufacturers to maintain their market presence by diversifying their electronic component suppliers. The additional costs associated with managing multiple suppliers are more than offset by reduced risk exposure, predictable revenue streams, and productivity gains.

*www.microej.com*

## Fiber optics for mission-critical applications

**CDM Electronics**, a premier authorized distributor of electronic connectors and cables, has announced the availability of Commercial Off-The-Shelf (COTS) and custom fiber optic MIL-Spec, harsh environment, mode conditioning and reference grade jumper cables. These multimode and single-mode fiber optic cable assembly solutions target the broadest spectrum of industrial, military, and avionics applications.

Three-dimensional computer aided design, manufacturing, and engineering (CAD/CAM/CAE) software is employed to ensure the integrity of assemblies' performance, speed time to market, and minimize costs. MIL-spec assemblies are comprised of QPL (Qualified Product List) wire and cable and manufactured in an AS9100 certified facility.

Indoor, outdoor, and indoor-outdoor fiber optic cable assemblies incorporate optical fiber, a reinforcement strand for support, and fiber optic connectors. Unlike copper wires which rely on electrical pulses to transmit data, fiber optic cables utilize light

pulses to consistently deliver faster, more reliable data. Their optimized transmission integrity makes them the ideal choice for the full range of mission-critical voice and data systems including Telecom (microwave, dish antenna, and 5G small-cell), SATCOM, in-building DAS, WiFi, along with SCADA networks. Fiber optic interconnects are also suited for installation in broadcast facilities and network operations, GPS, precision timing designs as well as emergent communications technologies.

*www.cdmelectronics.com*

## Facilitating predictive maintenance

**Sensata Technologies** has launched a new asset monitoring solution that enables predictive maintenance for rotary assets and delivers actionable insights to plant managers.

Unplanned downtime related to motors, pumps, and other rotating assets costs plants millions of dollars in production every year. But existing solutions do not provide the real-time insights plant managers need to truly monitor their assets.

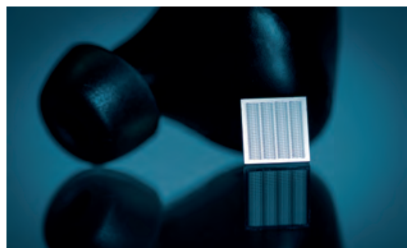
The new wireless 6VW series IoT sensor delivers insights via the Sensata IQ platform and can simultaneously monitor each asset using six sensing modalities: vibration, temperature, acoustic emission, speed, humidity, and magnetic flux. The sensors are designed for easy retrofit into a wide range of existing rotary assets—such as motors, pumps, blowers, fans, or compressors—regardless of brand or manufacturer with no changes needed to the company's hardware or control platforms. The 6VW sensor series is an easy-to-use, self-install solution with a mobile app for device configuration, making setup and installation possible in less than five minutes.

Using powerful AI-driven algorithms explicitly designed for rotary assets by Nanoprecise, a Sensata technology partner, data from the sensor is analyzed at the edge for anomalies and then pushed to the Sensata IQ cloud-based platform for further analysis and data visualization.

*www.sensata.com*

## MEMS micro speaker

**Bosch** is expanding its expertise in MEMS (micro-electro-mechanical systems) micro speakers and strengthening its market position as leading provider of sensing solutions for consumer electronics with its acquisition of Arioso Systems.



The internet of tomorrow will be mobile- and audio-based, both speaking and listening. Components for smart in-ear devices must be increasingly small, light, efficient, and scalable to meet the market's needs. More and more functionalities demand for smaller form factors and expanded battery run time.

Arioso Systems has developed a novel audio transducer technology whereby sound is generated through movement of vertically oriented lamellas inside a silicon chip. Unlike conventional membrane technologies, Arioso Systems technology uses the chip volume rather than surface. Therefore, it is possible to build a miniatured MEMS micro-speaker to generate up to 120 dB SPL (sound pressure level) out of 10mm$^2$ active area. Thanks to the electrostatic actuator of all-silicon MEMS, and thanks to its very low capacitance, the Arioso Systems technology allows battery savings for new sensor applications in demanding hearable devices such as TWS as well as in other wearables devices.

The unique and innovative technology concept from Arioso Systems—combined with the long-lasting experience from Bosch Sensortec to develop a technology to high-volume consumer electronics market maturity—is expected to shape the emerging global MEMS micro speaker market.

*www.bosch.com*
*www.arioso-systems.com*

## 600V super junction MOSFETs

**ROHM** has added seven new devices, the R60xxVNx series, to its PrestoMOS lineup of 600V Super Junction MOSFETs. The R60xxVNx series is optimized for power circuits in industrial equipment requiring high power, such as servers, EV charging, and base stations, as well as motor drives in white goods that are increasingly using inverters to meet the trend towards greater energy savings.


In recent years, as power consumption has increased worldwide along with the need for a more effective use of power, industrial equipment such as servers, EV/base stations, air conditioners, and other home appliances have become more energy efficient, demanding power semiconductors to further reduce power loss. In response, ROHM expanded its existing PrestoMOS lineup with new devices that contribute to even lower application power consumption by offering lower ON resistance than standard products.

The new R60xxVNx series adopts the latest proprietary processes to achieve the industry's fastest reverse recovery time while reducing ON resistance (which is in a trade-off relationship) by up to 20% compared to equivalent products.

In terms of reverse recovery time, the new Super Junction MOSFETs inherit the breakthrough 105ns already provided by existing ROHM PrestoMOS products, making it possible to reduce switching loss by approximately 17% compared to other solutions. With these two features the new devices improve efficiency in various applications.

*www.rohm.com*

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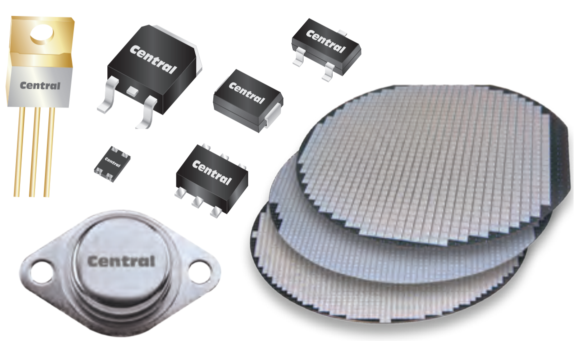
- **Darlington Transistors**
- **MOSFETs & JFETs**
- **Protection Devices**
- **Thyristors**
- **Silicon Carbide**
- **Multi Discrete Modules**



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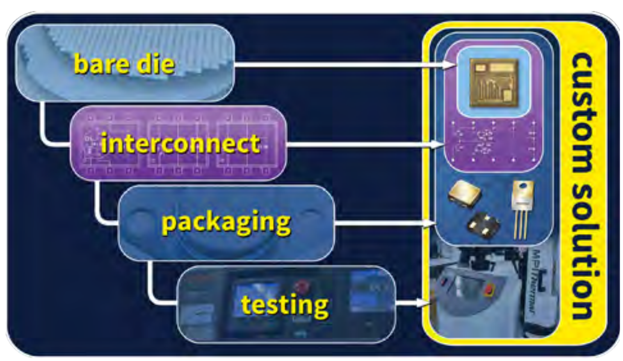


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# New designs brought to light

***Smarter lighting provides new solutions delivering higher levels of energy efficiency, quality, and customer satisfaction for building automation***

Lighting accounted for about 5% of the total electricity consumption in the U.S. in 2021, according to the Energy Information Administration (EIA). The advent of new technologies, such as artificial intelligence (AI) and machine learning (ML), will significantly improve building lighting control and automation. This will result in lower overall costs, a reduction in energy consumption, a decrease in energy waste, and improved service quality and customer satisfaction.

**Smart lighting**

Smart lighting systems have integrated communication and control systems that allow for greater automation and flexibility. Wireless communication aids in covering vast distances. Control flexibility increases because the overall lighting response can get tuned at three primary points: Overall (macro-level), Edge (local level), Particular (device level).

This enables diverse lighting components such as lamps, recessed lights, architectural (indoor/outdoor) lights, signage, and landscape lighting to be coordinated together within one integrated system.

**New technology comes to lighting**

AI is a significant technology disruptor. AI brings learning to smart lighting. Incorporating AI, smart lighting systems can improve their performance in a manner that is analogous to feedback in an electronic circuit. This manner of learning and refinement is called machine learning. ML will enable future efficiencies by sorting through large volumes of available data collected by sensors. It will analyze this data and determine how to enact fine-tuning adjustments that improve performance and reduce waste.

**Adoption**

Organizations with specific knowledge of their smart lighting control and automation parameters will be able to adapt faster than those who have outsourced this duty. An understanding of an existing system's limitations and interrelations will provide specific areas in which to focus and apply AI in building lighting control and automation solutions.

Building lighting control and automation demands are continually changing. The sooner one adopts lighting automation technologies, such as AI, and incorporates them as part of the building lighting control and automation process, the sooner it will reach its optimal decision and response level. Flexibility stays inherently high because the AI has learned what and how to adjust the building lighting control and automation variables in response to deviations from optimal performance.

The result is that after its adoption, the system's overshoot is damped and mitigated. Dramatic changes in usage are also handled. As the system learns from a variety of conditions how to respond, any significant increases or decreases in various inputs are handled in first order based on correct responses, then further tuned based on reinforcement feedback. The upshot is that the AI system provides a well-controlled, self-correcting, fully automated, decision-making tool to control building lighting.

**Shining Example**

A good implementation example is one where the amount of artificial illumination is synchronized with the measured amount of illumination being received from the sun as the position of the sun changes throughout the day. AI helps make lighting more automated, meaning it enables systems to operate while requiring little or no direct human supervision or control. This leads to savings in money, energy consumption, and waste, plus improved service quality and customer satisfaction.

*www.mouser.com*

**Paul Golata, Senior Technical Content Specialist at Mouser Electronics**

# Advanced test equipment enables LED lighting manufacturers to ensure compliance with standards

*This article provides an overview of the relevant industry standards for LED lighting products. It also describes how advanced test equipment helps ensure that LED lighting products meet all necessary parameters for performance, energy efficiency, consumption verification, and safety certification*

## Standard and specification for solid-state lighting

Updated in 2019 (the first time since 2008), ANSI/IES LM-79-19 is the standard and specification for solid-state lighting. In addition to specifying optical measurements (lumens, chromaticity, luminous flux, etc.), LM-79-19 includes stringent system efficacy specifications. For LED lighting, the relevant parameters fall under "AC Power Supply Standards" (sections 5.1-5.3).

The LED driver can be integrated into the LED lighting fixture itself. In this case, the input power coming into the luminaire's LED driver (power supply), as well as its output power, must be measured using test equipment to compute system efficiency.


## Standard and specification for LED drivers

Updated in 2015, ANSI C 82.16-15 is a mandatory standard and specification for the methods and measurement of LED driver input and output parameters.

## Voluntary energy initiatives

In addition to mandatory EIS and ANSI standards/specifications, LED lighting is often tested to meet voluntary national and state certification programs and initiatives that enable energy savings. These national and state programs/initiatives have different objectives and requirements, each with precise measurement and unique submission requirements to assure compliance. Those that deal with LED lighting include:

- Energy Star: EPA/DOE programs. Minimum luminous efficacy (LED power <10W, 50 Lm/W; >= 10W; 55 Lm/W).
- LED Lighting Facts: A DOE program that is mandatory for Energy Star.
- Design Lights Consortium (DLC): Utility-based programs. SSL Technical Requirements V5.1 (80-120 Lm/W, minimum efficacy), decided by product type (LED lamp, outdoor lighting, etc.).
- California Energy Commission (CEC): Mainly energy efficiency. Standby power 200mW or less; PF 0.7 or greater.
- MSSL (Municipal Solid State Street Lighting): DOE program focusing on outdoor lighting (streetlights, parking lots and garages, etc.).

When an LED lighting product completes qualification for one of these programs/initiatives, a label appears on the product packaging to show that the specification has been met (e.g., light output per watt, etc.).

## International standards

The International Electric Commission (IEC) provides international standards that bring together the agreed-upon set of rules, specifications, and terminology that allow manufacturers to have their devices tested for conformity. The following specifications are relevant for testing LED lighting systems:

- **Power consumption testing**
  - The EN50564:2011, which replaces the IEC62301 specification, specifies test procedures for low-power consumption equipment and offers guidance for specifying the measurement equipment, such as power analyzers, used for such tests. It describes how to test products with a supply voltage between 100V

and 250V AC. It may also apply to 3-phase equipment. It may be used in conjunction with other standards for measuring energy efficiency, such as Energy Star and EU standby Power directives.

- **Harmonics testing**
  - EN 61000-3-2 test standard specifies the limits of harmonic components of the input current that may be produced by equipment tested under specified conditions (Class C of the specification is for lighting devices).
  - IEC 61000-3-12 deals with the limitation of harmonic currents injected into a system, such as a lighting system or electronic ballast.
  - IEC 61000-4-7 is applicable to instrumentation intended for measuring spectral components in the frequency range up to 9kHz, which are superimposed on the fundamental of the power supply systems at 50Hz and 60Hz.

## Using test equipment during product development

There are four key parameters for LED products: performance, energy efficiency, consumption verification, and safety. To ensure a LED product will pass UL, TUV, Intertek, and SA testing, engineers and technicians need to analyze these parameters during each phase of product development, from design to final test.

**As shown in the table, power analyzers, electronic DC loads, high potential (hipot) testers, and high voltage switches can be used to check compliance.**

- **Power Analyzers:** Advanced test equipment, such as Vitrek's PA900 power analyzer, can be used to measure LED lighting parameters during the design, production, and verification phases of the product's development. The compact, small-footprint, lightweight PA900 device is easy to handle. It also meets the updated LM-79-19 specification for the higher K=2 accuracy requirements. Examples of the PA900's capabilities are as follows:
  - **LED Driver Efficiency Testing:** The PA900 works as a virtual power analyzer, providing the ability to integrate separate power analyzer functionality into a single instrument. In this way, the power analyzer calculates the output/ input power of the LED driver by showing output, loss, and driver efficiency on its display screen.
  - **Standby Power Testing:** The smart lighting fixture itself can be turned off while its electronics are being constantly energized to communicate over the internet or to an app. To simplify LED lighting compliance testing, the PA900 has the portion of Energy Star's EN50564:2011 5.3.2a specification for standby power built into the unit.
  - **Harmonics Emissions Testing:** The PA900 also has the EN61000-3-2, 3-12 and 4-7 specifications for harmonics built into the unit.

- **Electronic DC Load:** LED drivers (basically, the power supplies) for LED lighting products need to maintain a constant current even if the load increases. An electronic DC load can be used to check performance and energy efficiency parameters for LED lighting during the product's design and production phases of development. Where an LED lighting product is installed, test equipment, such as the DL Series DC load, can be used to detect if the current is stable and luminous intensity (luminous flux) stays within reason even if the load changes.
- **Hipot Testers and High Voltage Switch:** In addition to pre-certification compliance testing, electrical safety (hipot) testers can be used during the final product testing phase to confirm the devices meet safety standards. High-performance testers, such as V7X series and 95X series hipot testers, can perform various tests, including AC hipot, DC hipot, along with insulation resistance, continuity, and ground bond. Additionally, a high voltage switch can be used along with hipot testers during the final test phase of product production, thereby enabling rapid testing of multiple units.

## Summary

As discussed in this article, highly functional, user-friendly test equipment is ideally suited for testing LED products for energy efficiency, performance, and safety compliance. Using advanced test equipment during product development enables manufacturers and engineers to ensure that their LED lighting products will comply with all necessary lighting standards, specifications and initiatives prior to reaching the certifying agency.

*www.vitrek.com*

| Parameters | | Test Phase | Test Equipment |
|---|---|---|---|
| **Performance** | Photometry (lighting measurements): lumens, chromaticity, luminous flux | Design | Power analyzer, electronic DC load |
| | Electrical (voltage, current, power) | | |
| **Energy Efficiency** | Luminous efficacy: the amount of electrical input power vs. the amount of light power coming out on the other end of the fixture | Design / Production | Power analyzer, electronic DC load |
| | Energy efficiency of LED drivers | | |
| **Verification (Consumption)** | Consumption: e.g., hooking up LED lighting device to a power analyzer to monitor power over a certain time period | Production | Power analyzer |
| **Safety Certification** | Shock hazards, fire, and health concerns | Final Test | Hipot tester, high voltage switch |

# Smart fabrics provide new methods for measuring human interaction

***On a mission to create a violin for the 21st century, Keith McMillen developed a smart fabric that can provide humanoid robots with tactile awareness that exceeds the capabilities of human beings with respect to spatial resolution and sensitivity***

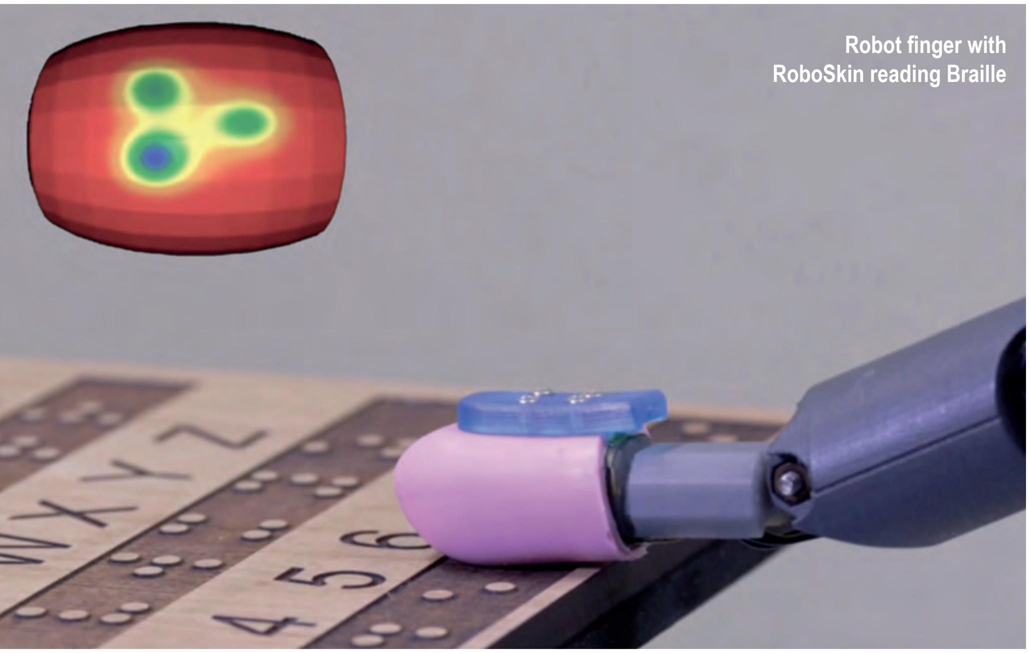
Sensors are fascinating. They are great magicians turning one thing into another. Estimates say the number of sensors on Earth is approaching 1 trillion devices. Hundreds for each of us!

As a kid growing up in Chicago, my first sensor experiments targeted the home thermostat: a flat snail of metal attached to a glass bottle of mercury. As soon as I could reach it, I was in control of that monster of an oil furnace with its arms reaching up from the basement into our home.

The thermostat is considered by many to be the first sensor. Made in 1883 by a guy who still has his company named after him: Johnson Controls. Take that Tom Edison.

When I was nine, my big brother gave me his old Sears electric guitar. Unwilling to leave anything alone, my younger brother's record player got turned into a guitar amp. I wanted to start a band, but I could tell by looking at TV you need a singer and a microphone. Guess what? A speaker is a decent microphone.

Reading "Here, There and Everywhere" last year, I learned that the great Geoff Emerick was using a speaker to capture Paul McCartney's bass at the exact same time. Used on "Rain" and "Paperback Writer" in 1966, the recording genius beefed up Paul's bass sound to great effect by using a speaker plugged into the board at EMI. Outclassed, I'm glad we disbanded.



Robot finger with RoboSkin reading Braille

Repairing musical instruments paid for my degree in acoustics from U of I in Urbana. Every musician since Beethoven wants to be louder. Actually, the Greeks started the volume wars in 300BC with really loud keyboard organs invented by Ctesibius of Alexandria. Used later by the Romans at the Coliseum.

Every acoustic guitarist, violinist and percussionist who wanted to be in a rock band needed a pickup. These were usually single element piezo electric lumps mounted in bridges and bodies. Sounded horrible.

I started making my own violins through my company, Zeta Violins, with a dual element pickup – per each string. A violin string vibrates in the direction of bowing but makes a scraping sound as it returns across the horsehair ready to be pulled again. Stick and slip. The two piezo elements were in a "V" configuration which amplified sound in the horizontal plane but rejected the vertical bow noise.

Zeta Violins grew in popularity, I sold the company to Gibson, and they are still in production today. But I was not done with the bowed strings.

With the growth of computers on stage capable of many times the processing of all of EMI studios, string players wanted more access and expressive possibilities. So, I created the K-Bow, a Bluetooth sensor bow. Tracking X-Y-Z motion with an accelerometer, bow placement with optical and RF sensors it called out for a grip sensor. The violin bow is held by the "stick" in a leather covered area in front of the "frog" called the "grip".

A very intimate cylinder of interface between the player and the played. Now how was I to make an extremely lightweight reliable cylindrical sensor that could be mounted to permanently and be expected to work for decades?

This began my research into fabric sensing. A small piece of non-woven material with conductive particles bonded to the surface of each fiber gave promising results. The outer surface of the fibers of this wildly entangled felt fabric would change resistance as they were compressed. The basic principle was sound. Proof of concept.

It took 3 years of additional work to make this concept into a real sensor through KMI. The conductive particles would not stay in place, coming off on your hand during assembly. Solved.

Changes with time and use? Now stable over millions of cycles of 75-pound hits. (I have sensors out there for over a decade still meeting spec).

Dynamic range? Greater than 80 dB (10,000 to 1). Depending on deployment, measurements from 5 grams to 150 Kg all from the same fabric. Frequency response is flat to 1000 Hz and then rolls off at 3dB per octave.

An easily corrected smooth temperature co-efficient – always a good thing. Spatial resolution – from 1 mm to 10 cm. Tight variable geometry curvature with 1.5mm radii.

You need to source a current into a point on the fabric and measure a voltage nearby to see the piezo resistive behavior. Many methods evolved.

My favorite? Screening conductive inks on both sides of a 100-micron thick TPU (Thermoplastic Poly Urethane) membrane. Add laser punched holes providing vias we now have a double-sided circuit that is waterproof, extremely flexible, and vanishingly thin. Just melt it onto the fabric.

Fabric is a versatile material. Depending on how you mount it you can perceive pressure and location in 3D, bend accurate to minutes, and shear forces. It is possible to do all three with the same piece of fabric.

After the K-Bow, KMI Music proceeded to make a dozen instruments all using smart fabric sensors. Over the last decade, instruments with over 4M sensors are out there in regular use.

We say there are 5 levels of electronic reliability: consumer, commercial, military, NASA and Rock and Roll.

And musicians are hard on their gear. I am blessed with an incredible team of engineers who are artists and musicians. Most have been with me for 8 – 10 years and they carry a sense of pride, knowledge and demands for low latency and repeatability. This is required for a musical instrument that can be loved and depended on.

Due to demand for non-musical devices, we spun out BeBop Sensors, Inc, the world leader in smart fabric sensor technologies with millions of sensors in daily use and 30 patents.

Initial designs included soles for exoskeletons and for human movement and activity. Fabric is comfortable, non-threatening (as are cameras in certain applications) and can sense detail in places where no other sensor could survive.

Such as inside a person's shoe. Now is a good time to talk about the ubiquitous FSR – Force Sensing Resistor. These have been around in one form or another for about 35 years. An FSR consists of two sheets of film, usually PET, with traces on one piece and a conductive material on the other. They face each other and when compressed resistance changes.

There are some applications where this is a fine sensor. It really prefers to be flat and mechanically well supported. Dynamic range is mid 40 dB and they change over time. The inside of a shoe is not the kind of place for FSRs.

Many of our customers have tried to make FSRs behave but all have failed in one requirement or another. There is a lot of fabric in most shoes so why not a little more.

A wonderful challenge for BeBop was making sensors for robots – RoboSkin. On a human like finger, we can sense 80 locations with as little as 2 mm pitch. This is better than human spatial resolution. Forces from 5 grams to 50Kg are reported by each of the 80 sensors.

We welcome our robotic helpers. When Ricky Gervais was asked if he feared being ruled by artificial intelligence, his reply: "I would love to be ruled by any intelligence."

*www.bebopsensors.com*

# Thorough, exhaustive verification and validation of complex SoCs

***Enterprise FPGA prototyping is being used to fill the gap between an emulator's powerful analysis/debug capabilities and the raw performance of a desktop FPGA prototyping board***

System-on-chip (SoC) designers are tasked with completing full system-level verification before mask production. This means thoroughly testing hardware blocks, interactions between those blocks, and the purpose-built software created for end applications before the chip is built.

Hardware emulators and desktop FPGA prototype boards are well-known verification tools used for this task, unlike simulation that dominates in the early design stages and whose use is limited to circuit blocks due to performance. Once full-chip verification begins, greater speed is needed to handle the number of tests required to achieve full hardware coverage, and hardware/software with emulation takes on the bulk of the work. In parallel, when register level code (RTL) code reaches stability, validation of software applications may commence using desktop prototyping boards.

Enterprise FPGA prototyping is now being used to fill the gap between an emulator's powerful analysis/debug capabilities and the raw performance of a desktop FPGA prototyping board. It blends features of emulation and desktop prototyping to address new use cases and offloads emulators. Verification groups can increase their high-speed hardware-based verification resources and optimize total cost of ownership.

Combining emulators, desktop FPGA prototyping boards, and an enterprise FPGA prototyping platform working on the same SoC design ensures thorough and exhaustive verification and validation of hardware and software of a complex SoC.

Emulators provide capacity and debug visibility for verifying large SoCs, including hardware, software drivers, operating systems, and portions of application code.

Enterprise FPGA prototypes provide higher-performance hardware for running emulation regression suites, executing Executing in-circuit emulation (ICE) tests, and verifying application software.

Desktop FPGA prototypes are available to software developers who want more direct contact with their prototypes for local testing. Those tests can move back and forth between the desktop and enterprise units to maximize use of available resources. In addition, developers can ship desktop prototypes to their customers to smooth system integration, verification, and validation.

Differences between the three verification engines (Source: Siemens EDA)

| Main Characteristics | Hardware Emulator | Enterprise FPGA Prototype | Desktop FPGA Prototype |
|---|---|---|---|
| Programmable Core | Proprietary Chip | Commercial FPGA | |
| Scalability | Up to 2.5BG/Rack | Up to 80xFPGAs/Rack | Up to 4xFPGAs/Board |
| Granularity | Board-Level | FPGA-Level | |
| FPGA Interconnect | Re-programmable | Manually Reconfigurable | |
| Multi-User | Yes | Yes | No |
| DUT Memories | SW Models | SW Models | HW Models |
| Compilation | Fully Automatic | Front-End Shared with Emulation | Stand-Alone |
| Deployment Mode | ICE, Virtual, Hybrid | ICE, Virtual, Hybrid | Mainly ICE |
| Debug | Full Visibility | Probe-based | Probe-based |
| Typical Usage | HW Debug & HW/SW Integration | SW & System Validation | SW & System Validation |
| Demo Platform | No | No | Yes |

## Emulation tasks

Emulators are workhorses of SoC hardware verification because they execute orders of magnitude faster

than simulation and test hardware placed on a single chip. Emulator design reflects a balance between performance, the infrastructure required to implement the range of designs, and the instrumentation that allows thorough debug. While they don't run as fast as a final application, they are fast enough to boot operating systems, explore low-level software like drivers and bare-metal programs, and run benchmarks and software workloads.

ICE is another emulator task. By connecting the emulator to physical networks or other hardware to deliver realistic data traffic, it is possible to thoroughly exercise the design under test (DUT) with real-world workloads and unearth deep-seated bugs. Because ICE connections required rate adapters to slow down real-world data rates to match the emulator speed, verification groups moved to virtualized traffic generators instead of ICE.

Virtual traffic generators can replace ICE physical target systems without requiring speed rate adapters, facilitating the unmanned deployment of emulators in data centers, accessible remotely 24/7. Virtualized traffic generators can create realistic workloads for a wide range of applications.

## Desktop prototype boards

While emulators test out low-level software, they're not always the best tool for verifying higher-level application software. Such software must be debugged at the software level where fast speed of execution is paramount and hardware debug unnecessary.

Desktop prototype boards are configured once the hardware design has stabilized with few silicon design changes during the remaining verification cycle. The re-configurable FPGA network allows performance to be optimized as the DUT is implemented and run close to an order of magnitude faster than the emulator.

These boards are distributed to software developers who plug them into their desktop servers to run software tests and quickly obtain results based on the actual hardware design. Because of their speed, it has been easier to connect these boards directly to real-world data sources without resorting to speed rate adapters.

Also, the high performance and portability of FPGA prototype boards makes them unique vehicles as demo platforms for OEM providers of IP blocks.

## Offloading emulators with an enterprise prototyping platform

The emulator has a central SoC-verification role. In addition to hardware debug and hardware/software integration, it can be used for running long regression test suites. As an example, tests that have already passed must be rerun each time the circuit changes to guarantee the DUT's integrity. Executing these regression suites quickly is critical to avoid exceeding the allocated time window. The emulator can meet the challenge while its extensive debug capabilities remain unused. Those debug capabilities are used to trace a bug and determine the root cause of the failure only when a regression test fails.

Complementing an emulator with an enterprise prototyping platform maximizes the investment in hardware-assisted technology. The enterprise prototyping platform can be instantiated in the data center like an emulator and accessed for hardware regression use. Rack-mounted and remotely accessible, it performs at a speed closer to a desktop prototype than an emulator, favoring its deployment for running regression suites and off-loading the emulator. If a regression test fails, then debug resources available on the emulator can be used by moving that test back into the emulation environment for root-cause debug.

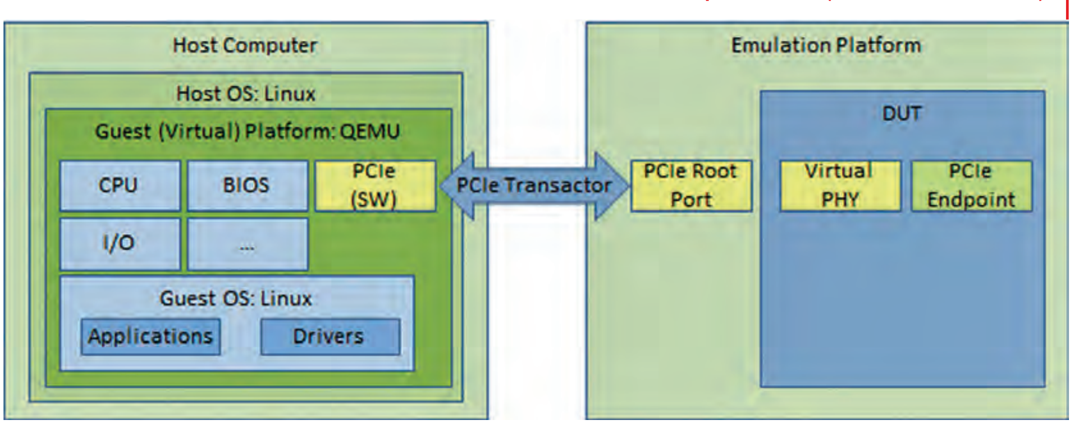
An enterprise prototype performs five times faster than an emulator. With some additional FPGA network optimization work, that gain can be increased up to 10 times for faster regression without bogging down the emulators. It accommodates larger design sizes than the desktop prototype board and is less costly than the emulators.

Enterprise prototypes can be used for ICE, leveraging direct, unvirtualized data-source connections. While physical data sources used for emulation suffer extra transaction latency due to the network connection, a direct data connection delivers that data closer to real time.

Until recently, a full-SoC verification environment featured the emulator housed in a data center with resources accessed over the network and the desktop prototype board located in software developers' offices. The combination of emulation, enterprise prototyping, and desktop prototyping bring an SoC to market faster and with greater confidence in the correctness of the silicon while verification groups reduce overall cost of their hardware verification resources.

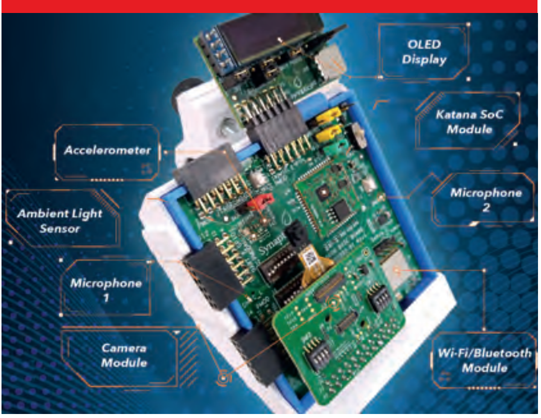
*eda.sw.siemens.com/en-US/*

Traffic generators can be directly connected to the emulator through software drivers for a new PCIe end-point device (Source: Siemens EDA)



# Edge AI SoCs get all the attention, but don't forget the development tools

***Edge AI products built around SoCs represent some of the most sophisticated designs in use, so their development platforms must be as complete as possible***




It seems everything is moving to the Edge. Product developers tout the ability to perform very sophisticated artificial intelligence (AI)-enabled processing at extremely efficient power consumption levels—far from the processing resources of centralized computing architectures. Armed with these solutions, designers are free to create a new wave of low-power AI-enriched solutions targeted at the edge of a network. Now, products designed for both embedded industrial and consumer applications can make decisions locally without relying on a cloud connection.

With this decentralized processing approach, end users benefit from faster response times, enhanced privacy and security, and better use of available wireless bandwidth. It also allows these devices to run off AAA or even coin-cell batteries for extended periods, liberating them from the constraints of line power.

However, this wave of innovation around edge AI has put designers in the position of needing to quickly develop products for a rapidly changing technology landscape. Their designs rely on both the sophistication of AI and its ability to be deployed quickly at the network edge, where it can make intelligent decisions based on data from multiple sensor inputs using accurate and specifically-trained AI models.

## Giving designers a helping hand… and a good night's sleep

Developing AI-infused products can quickly become challenging. A well-thought-out evaluation and design development platform can greatly simplify a development cycle by removing many, if not most, of the time-consuming, headache-inducing steps.

This is especially true for system-on-chip (SoC)-based designs. As their name implies, SoCs combine a range of essential yet previously separate functions into a single, efficient chip. In the case of the Synaptics Katana Edge AI SoC, for example, those functions include advanced processing, connectivity, audio and video input and output, power sources and, of course, intelligence, based on proprietary neural network technology.

This type of complexity clearly underscores the need for comprehensive development tools. Such aids factor heavily into streamlining the design process, saving time and resources, and getting products to market as quickly as possible.

## EVKs simplify Edge AI development

Edge AI products built around SoCs represent some of the most sophisticated designs in use. Because of the diverse applications those devices target, their development platforms have to be as complete as possible. The evaluation kit (EVK) that was recently introduced for Katana, as an example, contains not just the base board with the SoC, a multitude of sensors and a Wi-Fi/Bluetooth wireless connectivity module, but also individual accessory boards for a range of duties, such as a camera, as well as peripheral extensions, and a power source. Cables, batteries, and enclosures round out the EVK.

The AI algorithms in EVKs like this can enable sophisticated features in SoCs, such as person "fall detect" for home healthcare and assisted living monitoring, as well as counting people for applications in smart buildings, theaters, and stadium crowd control.

## The helping hand to transform SoCs from chip to solutions

SoCs at the heart of the edge AI revolution, along with the development tools supporting them, are looking at a bright future. Anand Joshi, managing director of AI analysis firm JD Data observes that SoCs' wide variation in power, size, performance, and degree of functional integration in embedded and IoT systems pose particular challenges to designers. The costly time delays inherent in fragmentation—disparate hardware and software pieced together into a makeshift development platform—can be mitigated, he says, with proven EVKs.

*www.synaptics.com*

# As Analog ICs Evolve, Connections Deepen with New Economic Sectors

This is the perfect time to be an analog semiconductor design engineer. And analog IC supplier. Demand for analog ICs is not just robust – like for most other semiconductor components – but analog chips are enjoying a sort of renaissance with its use now extended throughout all segments of the global economy. Analog ICs are being designed into a wider range of products driven by the growing penetration of semiconductors outside the traditional PCs, communication and networking equipment markets.

Sales of analog ICs are surging at the leading vendors with the Top 10 manufacturers reporting strong double-digit revenue increases in 2021 over the prior year. Texas Instruments was the top supplier last year, controlling just under 20 percent of the market while Analog Devices, the No. 2 vendor, increased its share to 13 percent, according to market research firm IC Insights. The Top 10 companies, including Skyworks Solutions, Infineon and ST (numbers 3, 4 and 5, respectively), together represent more than two-thirds of the market.

Interestingly, the race to digitalize equipment and tools used by manufacturers in fields as diverse as agriculture, industrial, medical and transportation is sparking interest and demand for analog semiconductor components and engineers. Companies that want to increase cost-savings and productivity improvements in their operations are replacing mechanical equipment with electronic products. Industry executives said they are seeing demand for electronic equipment from a widening swarth of the economy, especially in areas that were not traditional consumers of semiconductors.

Areas of growing interest and demand for analog ICs include power management, industrial and motor control, optical data communication and consumer applications, according to IC Insights. These are in addition to areas such as robotics, which is becoming a big part of analog IC vendors' sales due to their use in industrial settings as well as automotive production.

"Analog ICs remain a critical component in nearly all digital-centric systems," said IC Insights in its second quarter Update to the McClean Report issued in May. "The analog market typically grows (and declines) at a more tempered rate than the total IC market, but that was not the case in 2021. The analog market grew by 30% last year, while the total IC market increased 26%. Every general purpose and application specific analog product segment enjoyed double-digit sales growth in 2021. Signal conversion revenue grew 13% last year, but revenue in every other analog IC category jumped by at least 27%."

The forecast is for continued strength in the analog market with sales likely to outpace the general semiconductor market this year. The World Semiconductor Trade Statistics (WSTS) projects chip revenue will increase 16.3 percent in 2022. However, analog IC sales are seen rising 19.2 percent during the same period. Total analog semiconductor revenue for 2022 will increase to $84.54 billion, from $74.1 billion, in 2021, according to technology data provider Statista.

It would seem no segment of the economy is immune to the analog penetration. The transition to electric vehicles, which is predicted to consume more semiconductors, is adding to the demand for analog ICs. But it is not just sophisticated equipment that are seeing rising demand for analog chips. Even hobbyists have joined in the use of electronics, including for personal navigation, home safety, consumer products, health and sporting equipment. Demand for analog design engineers have risen as a result, observers said.

"The use of analog IC in medical and healthcare electronics, green energy management for domestic and commercial buildings or premises fuel the growth of the IC market globally," said Allied Market Research, in a report. "The use of electronics in sophisticated engine and safety controls, navigation, audio/video systems, hybrid electric drives, and LED lighting in the automotive industry is expected to increase the demand for analog ICs."

### Industrial and Robotics

Observers said the global economy is moving into a new cycle, dubbed "industry 4.0" with companies installing equipment infused with wireless and networking capabilities. The long-predicted surge in demand for Internet of Things (IoT) devices is finally here and it is spreading to all economic segments, fueling the growth of the analog market, according to Vincent Roche, chairman and CEO, Analog Devices. In a presentation to analysts, Roche noted that ADI is fielding calls for customers beyond its traditional markets, adding that the company is having to race to support these new buyers.

"The growing scope of our customers' products is dramatically expanding in complexity and pressuring their product development teams and innovation cycles," Roche said. "Our technology is intersecting with our markets. Industries like transportation, energy, telecoms, manufacturing and health care are prioritizing digitalization. This is driving new generations of applications and fueling a host of concurrent secular growth trends."

ADI is putting emphasis on the robotics market because of changes in the industrial market where companies are seeking

> ***"Industries like transportation, energy, telecoms, manufacturing and health care are prioritizing digitalization"***

more automation. The tasks that manufacturers are assigning to robots have increased due to safety concerns and the improved productivity they get from the devices. Advances in robotics have meant robots can be deployed in a wider set of activities and industries, including in the cleaning and disinfection of manufacturing floors, packaging and distribution centers and other areas where companies need greater flexibility. These robots are coupled with and collaborate with human employees, according to industry sources.

"Traditional industrial robots like those seen at auto manufacturers, operate at high speed and often with very large payloads, so they need to be separated from humans using safety cages or light curtains [but] these types of robots are continuing to advance, demand higher precision motion control, improved multi-axis synchronization, and size and power efficiencies," said Nicola O'Byrne, strategic marketing manager for connected motion and robotics, at ADI, in a report. "Collaborative robots (cobots) are also on the rise and are enabling automation of tasks that were previously only possible with humans. This leads to more manufacturers adopting automation where they previously could not afford to."

The chorus across the analog market is that demand for the components will remain strong through the rest of this decade. In fact, the leading suppliers are as a result expanding their production capacity and adding design engineers to support customers. TI, for example, has jacked up its capital expenditure to levels not seen since the turn of the century and plans to spend as much as $30 billion on new fabs over the next years. The company is adding 300mm fabs to gain scale and efficiency, according to chairman and CEO Rich Templeton.

"The real magic of 300-millimeter wafer fab is [the efficiencies gained from the] 300-millimeter fab, not what you paid for it," Templeton said, during a presentation at the Bernstein Strategic Decisions Conference earlier in. "The rates of return that we will be able to achieve, the cost that we will be able to achieve, they are going to be everything that we have ever seen …. We are going to be thrilled with what that looks like."

TI is so bullish on the analog market that the company is not just adding new fabs, but it is also laying out an extensive 15-year plan, which centers on the use of older nodes. The company said its customers will require chips made on 45 nanometers to 130 nanometers for decades and has plans in place to service them using existing and new infrastructure. Even as some companies have been warning of a slowdown in economic activities due to inflationary and energy pressures, TI will continue to hire analog engineers, Templeton said.

"You've seen tech companies talk about slowing hiring, and I get asked, 'are we slowing it?' Templeton said. "It is not like we never sped it up. We are not slowing it. We are going to run it on a very, very steady basis regardless of what revenue does and that really is the right way to think about it."

# Embedded software is eating the world

***App containers have long been used in the IT world. Now MicroEJ extends the concept to embedded and IoT apps running on small MCUs starting at a $1 price point***

Dr. Fred Rivard, MicroEJ's CEO

Since the invention of the transistor back in 1947, the proliferation of electronic devices has been remarkable. Our lives intersect daily with systems containing an average of 200 to 400 integrated circuits. Our smartphones are an obvious example. It is less apparent when we take the elevator or wash a load of laundry that they run embedded software. Powerful processors and small microcontrollers alike are ubiquitous and punctuate the lives of today's increasingly demanding consumers.

While the Fortune 100 names in consumer electronics immediately spring to mind, many more companies of all sizes rely on electronic systems to differentiate their products and increase their performance and overall usability. These companies are exposed to cut-throat competition, which pushes them to accelerate the rhythm of innovation and new product introduction.

## The typical product development process is extremely inefficient

Embedded software is typically a monolithic, single image, executable specific to a single set of electronics, RTOS/OS, drivers, etc. Even with modular design in mind, most of the time, updating even a tiny bit of code requires updating, recompiling, and retesting the entire application. The worst part is that the code you took so much time to write and test is hardly reusable for another product.

Here is a thing to keep in mind: unlike in the PC or Mobile phone industries, where the processor/OS combinations are a handful, embedded developers have the humongous task of supporting many variants. For example, there are about 10,000 different microprocessors and microcontrollers to choose from. There are around 50 different RTOS options, about 100 software stacks (connectivity, communication, human-machine interfaces (HMIs), etc.), along with a wide variety of compilers. On top of this, there are hundreds of device use cases and form factors. All of which translates into a staggering 500 million different possible permutations in this "Matrix of pain."

## App containers open the gate to fast innovations

As the pace of innovation is greatly accelerating, injecting agility

into the development process becomes vital to release products on the shelves faster than the competition. It is now established that modern development methods, such as virtualization and—ultimately—containers, allow for high levels of agility through best practices such as development on simulated devices, continuous development and delivery, and automated testing.

"With containers, it doesn't matter what you are running on. The software layer can be seen as one big brick portable from one hardware to another in a matter of weeks (instead of months with the traditional monolithic approach). Moreover, this huge brick is made of several tiny bricks of software (a.k.a. applications) that can each serve different functions such as connectivity, UI, etc. These apps can be built in different languages by different teams and can be maintained separately. This is exactly how Android works, and so does MicroEJ, except on a much smaller footprint in order to fit in very small MCUs starting at a $1 price point," says Dr. Fred Rivard, MicroEJ's CEO.

## In the embedded industry, "Footprint is money"

App containers have long been used in the IT world. However, diminishing their footprint to fit in small electronics has been very complex, if not impossible, until now, despite multiple attempts from industry leaders such as Android and Oracle, who obviously saw the tremendous value of creating a standard virtualization solution for smart things.

"In the case of MicroEJ, we have created a 32-bit virtual processor unit called MEJ32 with its own unique instruction set architecture (ISA). It has an extremely low footprint (MICROEJ VEE typically requires only 50 KB of memory) and is versatile, since it has been tailored and optimized to run on most embedded systems processors and OS/RTOS commonly used in embedded systems. We have long been working hand in hand with partners such as NXP, STMicroelectronics, Renesas, Sony, etc., to help Fortune 100 clients release their products up to 3X faster by allowing hardware and software parallel development," explains Dr. Rivard.

## The choice of streamlining

Embedded software development has always been complex, but now companies have a choice. They can continue with boutique or homegrown traditional methods, where one risks spending countless cycles trying to reinvent the wheel, or they can move to a streamlined, automated development environment with hardware virtualization facilitating the early validation and rapid prototyping phases.

"Needless to say, in the current context of global chip shortages in every industry, being able to quickly shift from one given set of electronics to another is a 'live or die' situation. We have seen clients compelled to put a stop on entire lines of production due to their reliance on a single chip reference, even for volumes above 1 million units a year," adds Dr. Rivard. "App containers are not only a huge deal in time and cost savings, but they are also a great way to mitigate risks in an unstable international environment."

*www.microej.com*

# Designing through parts shortages

***Is there anything worse than having a complete electronics design that can't be built because one of its components has a 52-week lead time?***

I work for an electronics manufacturer. We've been building small and medium volume PCB assembly runs since 2003. Back in 2018, my company started getting serious warnings from components suppliers about an impending state of extreme shortages. And this was before the COVID-19 pandemic and its accompanying disruption in labor and transportation.

I don't think I've ever seen a components market this messed up. At any given time, there can be a hundred different projects in our factory in the process of being built. I won't give you an exact percentage that are waiting for long-lead parts, but it's a lot.

You may think that, as a manufacturer, I'm just at the end of the cycle and don't have much to say about the rest of the process, but that's really not the case. The sooner you involve your manufacturing partner, the better off you will be, especially for high-volume boards. We, and others like us, can give you thoughts on what to avoid doing and what to do to help navigate messed-up supply chains.

## Avoid questionable substitutions

Be wary of finding subs from the gray market or brokers. When desperation takes hold, the lure of the gray market can be overpowering. Resist this, or at least do as much vetting as you can. I've seen brokers and less than legitimate sellers rack prices up 10X, 50X or even more.

Another problem with sketchy vendors is in counterfeit or re-labeled parts. For example, you may get a completely different component that has been relabeled. Alternatively, you may receive the correct or similar part, but from the manufacturer's reject bin. The first device may test out okay, but how many will later fail in test or in the field?

## "The same, only different," does not mean equal

If you pick a functional equivalent, double check the pinout. This is probably the most common issue we see with last minute substitutions. A good example would be a three terminal voltage regulator issue, as in the LM1085 low drop out (LDO) regulator. It looks, for all intents and purposes, to be a standard three-terminal pin-out part. You'd look at it and assume that it's a direct replacement for any old three-terminal regulator. But, rather than the common In-Ground-Out, the 1085 is pinned as Ground-Out-In.

I ran into another case not long ago with a GPS module. The replacement part was functionally equivalent with the original, but the pinout was mirrored. The only difference in the part numbers was a "C" added to the part number suffix on the version we were given

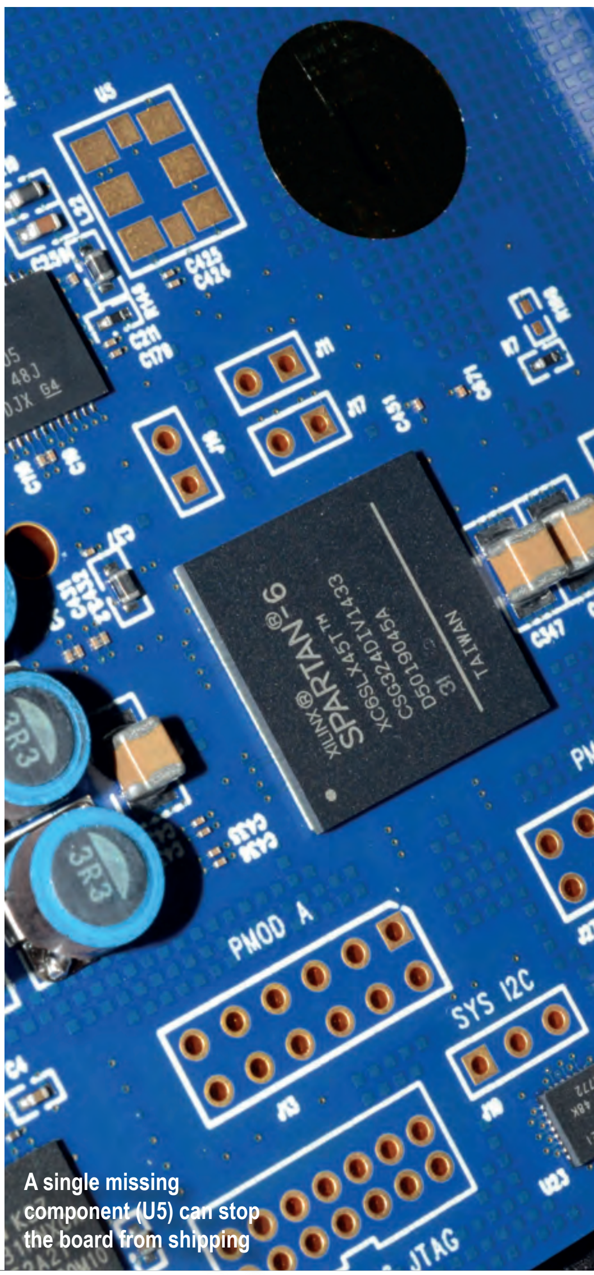
Loaded and ready to assemble PCBs

as a substitution. The parts look identical in form fit and function, but one used top view part numbering, with pin one in the standard upper left, while the other had pin one in the upper left when looking at the part from a bottom view.

### Close may not be close enough

Subs that are close, but not exact, may cause support issues later. I'm a long-time fan of microcontrollers, but there is one aspect that has always bothered me. That's the inability to use a more capable chip in place of a lessor chip without needing to make a change either in the header software, the configuration bits, or both.

A good example would be a Microchip PIC18F43K22. It's got 36 GPIOs, a good set of peripherals, 8K of Flash, and 512 SRAM bytes. That's plenty of code space for the electronic "bubble" level I designed a while back. I built my prototypes with the PIC18F44K22. It's an identical part, except with more Flash and SRAM.



A single missing component (U5) can stop the board from shipping

When it came time to build a higher volume run, the low-end parts weren't available, so I used a variant with more Flash. All of those parts would have been fine, but each required different configuration bits and code header details. That meant that I couldn't just publish a hex file and upgrade any and all of them later. Although this is an easy hardware sub, it may cause software challenges later on.

### Get to know your supply chain partners very well

Manufacturing and components sourcing has never been something that should be isolated from design, but today, with the messed-up supply chain, the sooner an engineer starts looking at parts selection options the better.

The most important thing for you, as a design engineer or project manager, is to become a close partner with the supply chain folks at your manufacturer. Design for manufacturing has long brought the assembly line and design engineering together. Now is the time to also invite procurement into the process.

Your supply chain folks live every day in the world of shortages, alternates, and promised lead times. They will have the best view on lead times and the small and large quantities availability.

### Designing for "wait or change"

Back in the days when "shortage" meant a couple of extra days or weeks, the standard response was to search other distributors or find someone that overbought and had enough extra to get you through. When manufacturers tell you that they won't even accept an expedited request until after the 52 week "standard" lead time has passed, you might need to take a different approach.

If you've got a super long-lead time component without an easy sub, do you wait and hope against hope that somehow it will come in early? Alternatively, do you revise the design to use a different component or component set? This can be especially painful with new chips that consolidate multiple functions or passives into the silicon. Creating a new revision of the design may mean a larger PCB and a higher bill of materials (BOM) line-item count. On the other hand, a rev can mean the difference between getting your product to market next quarter vs. next year. Consider the impact of a year's delay when deciding on a three-component solution vs. a fancy new highly integrated part that you just can't get your hands on.

The supply chain will eventually catch up and allow us to pick parts based on specifications rather than on availability, but we probably have another year or more before that happens. If we all learn to live in this different world, then the process of getting our products out of the door will become a little bit easier and less stressful.

*www.screamingcircuits.com*

# How the latest enclosures are assisting the development of today's electronics

***Standard plastic enclosures are now so feature-rich—so application-ready—that specifying 'off the shelf' is an absolute no-brainer***

Is this a golden age for electronic enclosures? Increasingly it feels that way, and with good reason. Significant advances in development have made it easier to specify standard/customized enclosures that are either highly specialized, incredibly versatile, or even both simultaneously.

What was once the bane of an electronics designer's life—the challenge of specifying elegant enclosures within tight budgets and tighter timescales—is now a breeze. The once-tortuous journey from design concept to finished enclosure has never been shorter. And it all feels very refreshing.

Long gone are the days of designers being forced to choose between anonymous but 'available now' standard boxes and expensive bespoke housings that would take months to create.

Standard plastic enclosures are now so feature-rich—so application-ready—that specifying 'off the shelf' is an absolute no-brainer. Add a few customization tweaks, and a discreet standard housing suddenly becomes uniquely yours: machined, custom branded, and fully finished. It can go straight from your goods-in to your production line, ready for the installation of electronics. Smart, simple, efficient, and effective.

But the huge choice of these application-ready enclosures can sometimes feel overwhelming. No longer is the market trisected into a basic trinity of desktop, wall-mount, and handheld enclosures (with/without battery compartment). Now there are wearables, portables, flush-mounts, IoT/IIoT enclosures, wired housings, modular case systems, and enclosures for mounting on suspension arms.

Standard cases are now more purpose-specific than ever, and yet are still capable of fitting other roles. For example, OKW's SMART-PANEL touchscreen enclosures were created to flush-mount into standard cavity wall boxes, but they can double up as small tabletop housings if required. Similarly, CARRYTEC is an attaché case style electronic instrumentation enclosure, but its integrated handle makes an ideal grab point when the housing is inverse-mounted on a suspension arm.

There have been significant advances in materials too. Acrylonitrile butadiene styrene (ABS) used to be the go-to choice for plastic enclosures. However, this time-honored terpolymer (a polymer synthesized from three different monomers) is increasingly being benched in favor of acrylonitrile styrene acrylate (ASA), or an ASA-polycarbonate blend (ASA+PC-FR), both of which offer greater UV stability.

Previously, enclosures were either plastic or metal (either fabricated or diecast). One or the other. Seldom were these materials used together. But iF award-winning SYNERGY enclosures combine extruded aluminum bodies with ASA+PC-FR tops and bases, all held firmly in place by an innovative pillar-based construction system that conceals the fixing screws.

SMART-TERMINAL control enclosures shake up the cocktail of materials still further by combining aluminum with not one but two plastics. Nestled in the aluminum case body this time are two designer seals molded from soft-touch TPV, and inside those are the ASA+PC-FR end caps. This endcap/seal configuration adds IP 54 ingress protection coupled with a dash of branding panache.

And there's more still to ASA. When specified with a high-gloss finish, it becomes ideal for medical electronics because it's so easy to wipe clean. This is why glossy ASA is standard for STYLE-CASE handheld controller enclosures and wearable BODY-CASE housings for bio-feedback, geolocation, and emergency call applications.

The healthcare sector has always been a demanding environment for enclosures. Hospitals may not be as tough as factories, but they can still be a punishing place for delicate electronics. Intensive 24/7 use by multiple clinicians can take its toll. And, all the while, the enclosures must continue to look good because no patient wants to be treated with tired-looking kit.

Enclosures destined for healthcare and wellness applications must be robust and cytotoxically safe, with ergonomic curves and tamperproof Torx assembly screws.

But it is the IoT/IIoT that has seen the biggest increase in enclosure development in recent years, not least because data-intensive Industry 4.0 applications require different sets of enclosures for their various sensors and associated devices.

The burgeoning enclosure market ranges from small 'clip-to-product' cases such as MINITEC or BODY-CASE (both wearables) to larger wall-mount housings such as square PROTEC, wedge-shaped SMART-CONTROL (for corners), and sleek NET-BOX (for data networks).

There is an argument for design simplicity, given the sheer size of IIoT networks and how many enclosures need to be installed across the average smart factory. Clever design touches make all the difference: OKW's EASYTEC can be fitted to poles, rods, and bars easily and quickly thanks to a curved recess in its base section and installation lugs that accommodate both cable ties and screws.

Whichever standard enclosure you specify, it will need customization: machining of apertures, custom colors, printing of legends and logos... the list goes on. Thus, it makes sense to partner with a specialist enclosures manufacturer that offers a complete range of customization services.

For example, advanced lacquering offers a huge array of finishes, including matt, satin, glossy, metallic, soft-touch faux leather, antibacterial paint, and ESD conductive to mitigate electrostatic discharges. In addition to enabling the printing of photo-quality graphics, digital technology is much easier to set up than traditional screen-printing methods.

As OKW Enclosures, Inc. Vice-President of Marketing Robert Cox says: "Customization technology has taken huge leaps forward in recent years, making fully-finished enclosures available in much lower volumes."

"It's now very easy to specify customized enclosures for extremely niche products. Decor foils for lettering and color design now start in batches of just one unit. Customization doesn't get much more available than that!" he adds.

*www.okwenclosures.com*

# Introducing a 21st century solution to the problem of switch bounce

***When a switch is actuated, the number of bounces can range between 1 to 100+ over the course of a fraction of a second to more than 6 milliseconds***

One of the most common ways of controlling an electronic system is to use mechanical switches. There are many different types of switches, including toggle switches, pushbutton switches, and limit switches, where the latter are operated by the motion of a machine part or the presence of an object. Limit switches, which may also be referred to as microswitches, were originally used to define the limit of travel for a part of a machine, which explains the origin of their name.

It's a sobering thought that—surrounded as we are by the most sophisticated systems conceived by humankind—we continue to predominantly control these systems using a technology that's well over a hundred years old. Pushbutton switches first appeared on the scene circa 1880, while the modern incarnations of toggle switches originally made their presence felt circa 1916. By some strange quirk of fate, 1916 was also the year that educational reformer, social activist, and best-selling American author Dorothy Canfield Fisher warned that "There is a great danger of coming to rely so entirely on the electric button and its slaves that the wheels of initiative will be broken, or at least become rusty from long disuse." We can only wonder what Dorothy would have thought to see us now, surrounded by pushbutton switches—and their cousins—of every conceivable shape and size.

## Switch bounce

One thing about switches is that they bounce. What this means is that when a switch is actuated, its output doesn't simply transition from one voltage level to another. Instead, it may bounce back and forth between the two levels before eventually settling in its new state.

All switches (toggle, pushbutton, limit, etc.) bounce, apart from things like mercury tilt switches, which—ironically—most of us don't use anyway. The number of bounces can range between 1 to 100+ times over the course of anywhere from a fraction of a second to over 6 milliseconds (ms); furthermore, the switch may bounce both when it's activated and when it's deactivated.

Although things can change from one actuation to the next, switches often present a sort of "bounce fingerprint." Some switches will present a lot of narrow bounces close together and then stop bouncing; some may display a smaller number of wider (sometimes widely separated) bounces; and others may offer a combination of effects, such as multiple groups of narrow bounces.

Just to make things more interesting, the *absolute* number of times a switch bounces can vary from activation to activation. Meanwhile, the *average* number of times a switch bounces may be affected by environmental conditions like temperature and humidity; also, it may evolve over time as the switch ages.

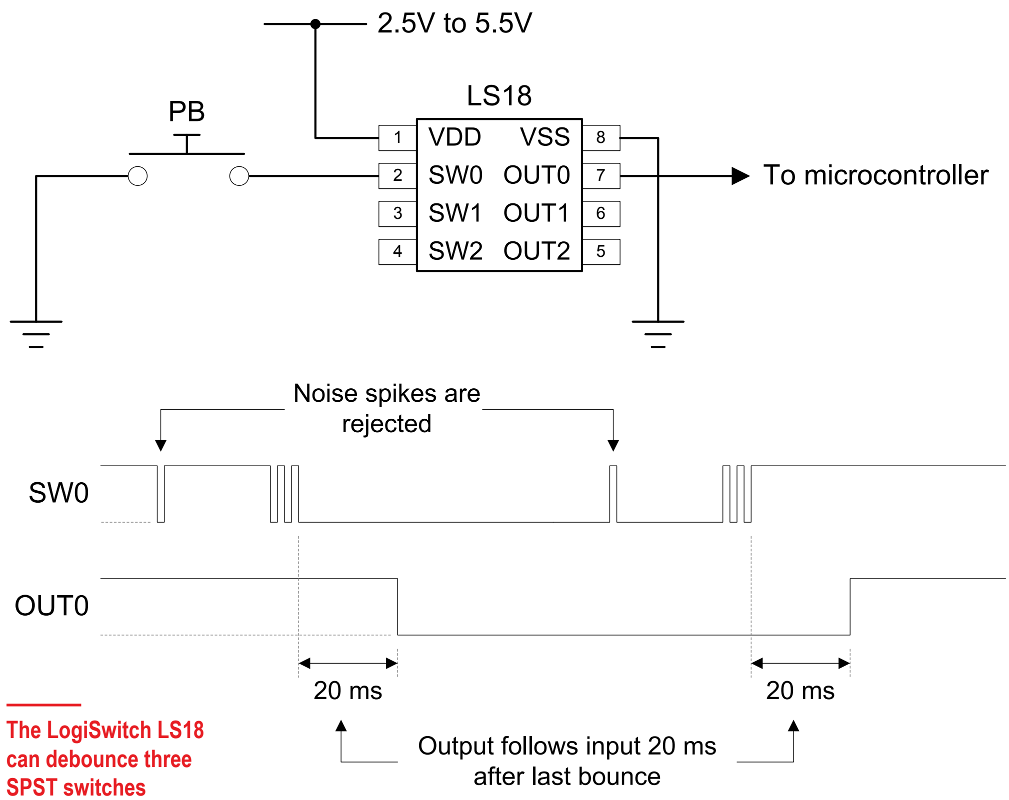
Switch bounce wasn't a problem prior to the introduction of high-speed electronic systems. Indeed, excluding scientists and engineers, the vast majority of people didn't even appreciate that switches did bounce because any such bouncing occurs far too quickly for human senses to detect. The problem arises when a switch is used to provide a control signal to something like a microcontroller whose system clock is running at tens or hundreds of millions of cycles per second. In this case, unless something is done to mitigate the switch bounce, the microcontroller may perceive a single actuation of the switch as comprising multiple events. This may be mildly annoying in the case of the channel select button on a TV controller, but it can be life-threatening in the case of a piece of safety-critical medical equipment, for example.

## Traditional debounce solutions

Switch bounce may be removed in hardware before being presented to the microcontroller, or it can be handled in software after being presented to the microcontroller.

For the purpose of these discussions, we will focus on the simplest—and arguably the most common—type of switch, which is referred to as a single pole, single throw (SPST) device.

Consider a typical hardware debounce solution based on the delay provided by a simple resistor-capacitor (RC) network. Depending on the system's requirements, this may involve a capacitor, two resistors, a diode, and a buffer chip with a Schmitt trigger input. These components—whose values must be carefully selected to match the characteristics of the switch—occupy space on the printed circuit board (PCB), require additional routing resources, and increase the cost and bill of materials (BOM) for the system. Furthermore, this




The LogiSwitch LS18 can debounce three SPST switches

solution must be replicated for each switch, and things become more complex when multiple switches of different types are used because each switch may have its own unique characteristics.

An alternative is to feed the raw bouncing signal from the switch directly to the microcontroller's input and to remove the bounce using software. The idea of addressing switch bounce using software may appear to offer a more attractive solution because it doesn't involve adding any extra components to the board. However, problems may arise if the software developer lacks sufficient switch bounce expertise and relies on incorrect data.

For example, many sources state that a switch will have stopped bouncing after 1ms. These sources include respected authorities like *The Art of Electronics* (Second edition, Page 506) by Horowitz and Hill, which states: "When the switch is closed, the two contacts actually separate and reconnect, typically 10 to 100 times over a period of about 1ms." Countering this, embedded systems guru Jack Ganssle performed his own tests on a collection of switches, reporting an average bounce time of 1.6ms and a maximum bounce time of 6.2ms. This means that any developers who assume that everything will be stable 1ms after detecting the initial transition may be in for an unpleasant surprise.

Even if developers do understand switch bounce and employ sophisticated counter-based or shift register-based debounce solutions, for example, this adds to the size and complexity of the code. This may become burdensome in systems featuring multiple switches, especially when employing resource-limited microcontrollers.

## A 21st century solution

LogiSwitch offers a variety of solutions to address switch bounce for SPST (single pole, single throw) and SPDT (single pole, double throw) switches. For the purposes of these discussions, we will focus on the 3-channel LS18 integrated circuit (IC), which can debounce up to three SPST switches. Accommodating a supply voltage of 2.5V to 5.5V, the LS18 is available in both lead through-hole (LTH) and surface-mount technology (SMT) packages (6-channel LS19 and 9-channel LS20 versions are also available).

Observe that no additional pull-up resistors are required on the output from the switch or the input to the microcontroller because these functions are provided internal to the LS18.

Using LogiSwitch's adaptive NoBounce™ technology, the LS18 rejects any noise spikes presented to its inputs. Each output from the LS18 tracks the state of its associated input 20 milliseconds after the final bounce on that input.

Addressing switch bounce using a LogiSwitch IC dramatically simplifies the software running in the microcontroller and removes the burden from software developers who may not understand the switch bounce problem. At the same time, having all of the electronics—including any pull-up-resistors—in a single device that automatically adapts to the characteristics of different switch bounce profiles makes this a solution a "no-brainer" for the hardware design team.

*www.logiswitch.com*

> ***"Unless something is done to mitigate the switch bounce, a microcontroller may perceive a single actuation of the switch as comprising multiple events"***

# Miniature feedthru capacitors for compact broadband EMI filtering

*In addition to digital signal processing (DSP), feedthru capacitors provide a great solution for power line conditioning, high dI/dt environments, and voltage regulators to name just a few applications*

As wearables, remote monitoring, and discrete IoT nodes become prevalent, the issue of EMI (electromagnetic interference) also becomes more common in these small circuits. These electronics typically have sensors on an analog circuit and—if digital processing is needed—feedthru capacitors offer an ideal, small and easy-to-implement single component EMI filtering solution.

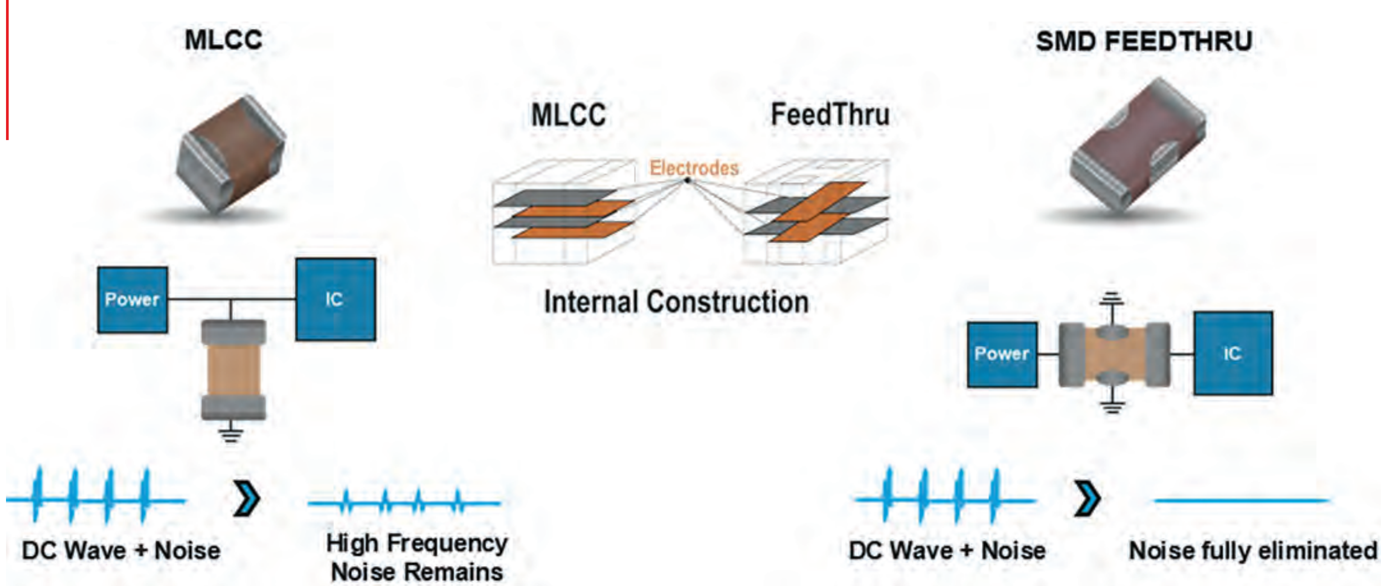
In addition, digital-to-RF interfaces provides another example where filtering is needed. EMI filters can be achieved in many shapes and sizes, but it is not intuitive to know how performance is achieved with these small form-factor devices and this topic is worth talking about.

Feedthru capacitors are made from the same materials—and employ the same processing and manufacturing technologies—as do multi-layer ceramic capacitors (MLCCs), but they differ in their electrode design and terminations.

Feedthru capacitors are also called SMDs (surface mount devices), EMI filters, or three-terminal capacitors because they have Input/Output and Ground terminations. If we compare the internal construction and typical layout of MLCCs and feedthru capacitors, we see that they both have filtering capability, but the feedthrus do this

***"MLCCs and feedthru capacitors both have filtering capability, but the feedthrus do this much more efficiently and across a broader spectrum of frequency"***

Comparison of MLCC and feedthru capacitor construction and layout



*"When designs are size-limited, it becomes apparent how well these passive components fit in and facilitate high performance of active ICs in wearables"*

much more efficiently and across a broader spectrum of frequency.

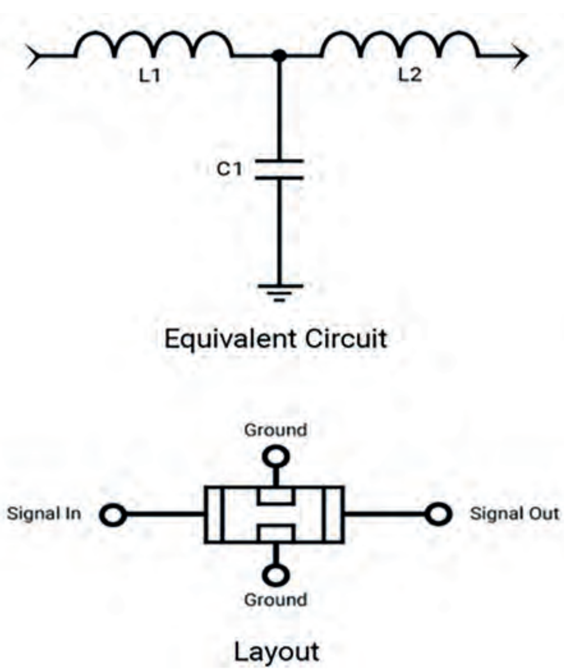
A series inductance is purposely introduced on feedthru designs, and the parallel capacitance makes for an efficient LC-T filter. The benefit of using an MLCC form factor is that MLCC manufacturing is well established and advanced, constantly undergoing innovation, and this technology is well-suited for very small designs.

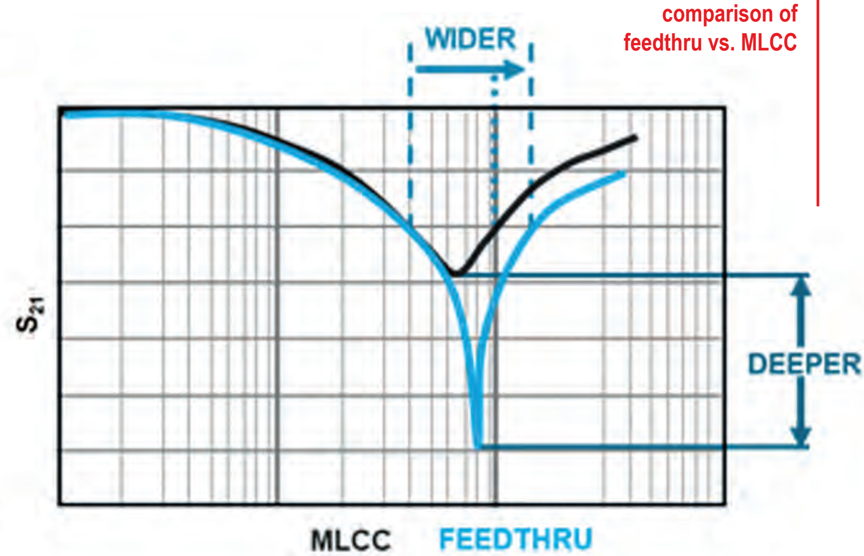
EIA 0402 size feedthru capacitors are easily realizable with up to 15uF of capacitance and 2A current handling, as exhibited by devices from the KNH series of feedthru capacitors from Kyocera-AVX.

This enables effective analog and digital isolation for size-constrained and compact circuits. This replaces larger filter capacitor banks or discrete LC filters; it also provides more consistent performance than filters using ferrite beads. Attenuation characteristics are also consistent from part-to-part and lot-to-lot thanks to MLCC innovations. These devices typically have low voltage ratings, but they trend well along with ICs that commonly have lower voltage ratings and higher dI/dt requirements.

In addition to digital signal processing (DSP), feedthru capacitors provide a great solution for power line conditioning, high dI/dt environments, and voltage regulators to name just a few applications. When designs are size-limited, it becomes apparent how well these passive components fit in and facilitate high performance of active ICs in wearables.

*www.kyocera-avx.com*




Equivalent circuit, typical layout, and characteristic S21 comparison of feedthru vs. MLCC

# What's non-cellular 5G and why you should know about it

*The 5G-driven IoT will ultimately be defined by the new non-cellular 5G rather than improvements on the cellular 5G side. By Teppo Hemiä, CEO of Wirepas*

The IoT world has cried wolf for quite a long time. There have been good tries for industrial use, but nothing that would have revolutionized anything. Perhaps the biggest problem has been not being able to scale up affordably for the technologies to create any difference. Now, with a recent 5G standard update, we've got a chance to change the IoT the non-cellular way.

## What is non-cellular 5G?

In October 2021, the world received the first ever non-cellular 5G standard. This new standard was designed specifically for IoT use. ETSI DECT-2020 New Radio (NR) was recognized by the WP5D of ITU's Radiocommunication Sector (ITU-R) and included as part of the 5G standards in its IMT-2020 technology recommendation.

Even though it has its history in the 1990s, this new standard has been implemented using modern radio technologies, such as orthogonal frequency-division multiplexing (OFDM) modulation, efficient channel coding, and hybrid automatic repeat request (HARQ). Supporting operating channel bandwidths from 1.7 MHz to 221.2 MHz, DECT-2020 NR as a technology foundation is targeted for local wireless applications that can be deployed anywhere in no time, thanks to decentralized and device-based decisions.

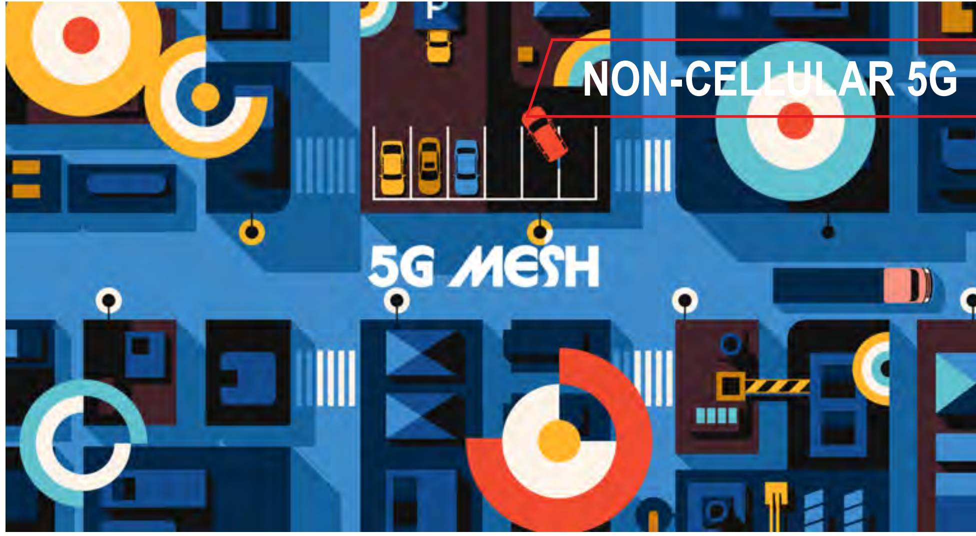
DECT-2020 NR includes specifications for the PHY, MAC DLC, and convergence layers, and it addresses industrial applications requiring massive machine-type communications (mMTC) and/or ultra-reliable low latency communications (URLLC).

The technology supports star and mesh topology communications and enables autonomous and automatic operation with minimal maintenance effort. Moreover, any node in the network can function as an access point with a backhaul connection to the internet, which allows for self-healing capabilities and increased reliability. A vital aspect of the DECT technology has its dedicated global spectrum at around 1900 MHz, which ensures low interference levels. Moreover, its dynamic selection feature means that it does not require frequency planning.

## So what? We've seen standards before

In most cases, standards are created from theories, after which they may be applied to actual use. Standards are a good thing—we are all

*“Think big. This is bigger than what you think is big—we’re talking about millions of devices in one network!”*




for them—but it takes time and money to develop a viable product out of a new standard. That’s why we, Wirepas, have opened up a lot of our technology for the greater good, making us one of the key contributors to the development of this new standard. This has allowed us to get our standard-based product to the market faster. At the same time, it means good parts have already been used and tested.

We’ve developed our new Wirepas 5G Mesh based on this new standard. In fact, the product and the standard are basically the same. As the standard enables multiple profiles and numerologies, we’ve simply chosen one configuration we think the IoT should look like. In fact, the Wirepas technology itself is more comprehensive than the standard, with some purpose-built features on top of the standard, such as OTAP, network monitoring, and location tracking—just some of the things we see as being critical for the IoT.

## What difference does it make?

No technology impacts anything if we don’t adopt it. Fortunately for the IoT world, the Wirepas 5G Mesh technology has received huge interest, especially in smart metering and smart city applications. Not to forget building management systems, either. What’s common with these applications is the volume needed. Think big. This is bigger than what you think is big—we’re talking about millions of devices in one network! With this technology, you get to connect millions and millions of devices, even in very dense deployments, and the network is the devices. Wireless means these trackers can be battery-operated with years of battery life. Think about containers or pallets. Location monitoring without any other infrastructure than the battery-powered devices? Done!

Even better, the technology is affordable enough to connect even the tiniest aspects of your business. Think about condition monitoring, for example. It’s easier and less expensive to conduct predictive maintenance than shut down operations in case of unexpected malfunctions or repairs. That’s what we call being genuinely frugal. The application can be almost anything imaginable.

Too good to be true, you think? If something is affordable, there’s always a catch. Not for us. We are open about our business model because we want win-win deals. In the case of our Wirepas 5G Mesh, you only pay a license fee and a one-time royalty per device. Everything after that is free, and the network user owns their own data, which affects security. You own what’s yours when there’s no need to put any data on “public” clouds.

## Nothing can grow big alone

That’s why we love our ecosystem of partners. We provide the connectivity software, but our partners are the actual users. Our typical partners are the semiconductor sector, OEM, gateway, and cloud providers. Then, of course, we’ve got solution providers who will bake all this in.

The beauty of this technology is that you can make a complete solution all on your own, or you can get it straight from our partners. If you think neither of these options are the way to go, you can always make some parts of the solution yourself and get others from our ecosystem. This results in a lower level of R&D investments and the fastest time to market, and it’s precisely what one of our loudest partners does: Just ask Schaeffler about their OPTIME product.

## Our prediction for the future of the IoT

The 5G-driven IoT will ultimately be defined by the new non-cellular 5G rather than improvements on the cellular 5G side. Non-cellular 5G is a powerful wireless solution that will enable totally new uses case to allow more devices to be connected than we could have ever imagined. The 5G label means it’s part of the global 5G family to meet the agreed set of requirements for the massive density of IoT devices. In addition, the non-cellular 5G IoT provides new opportunities to manage your data affordably. The Wirepas 5G Mesh will be available for all lead customers in 2022, with general availability starting at the beginning of 2023. Meanwhile, the technology can already be tested on 2.4 GHz and sub-GHz frequencies.

Welcome to the real IoT revolution!

*www.wirepas.com*
*www.abiresearch.com*

# The latest weapon for designers against supply chain disruptions

***The Spectra Electronic Design to Delivery Index (EDDI) helps designers overcome the component selection dilemma they're facing due to supply chain interruptions***

Printed circuit board (PCB) designers have a tough job. Supply chain issues have made the job tougher, especially when it comes to building a resilient bill of materials (BOM). Problems such as lack of available electronic components, long lead times, pandemic uncertainty, and transportation delays have made a designer's job especially difficult.

The lack of available solutions to these supply chain-related problems can result in board respins, loss in revenue, and more. These added responsibilities—include choosing the right components, figuring out what will be available at production, pricing, and selecting alternate parts—are now falling on the designers' shoulders because all this research needs to begin at the design stage.

The Spectra Electronic Design to Delivery Index (EDDI) is a great resource from Nexar, a business unit of Altium, to help designers overcome the component selection dilemma they're facing due to supply chain interruptions. It gives a category-level view with two years of supply and demand history across the spectrum of the electronics components landscape.

The Industry Supply Index (ISI) provides a high-level view of availability trends. The Industry Demand Index (IDI) shows how difficult it is to source parts, such as how much competition individual companies are going up against when trying to source components. EDDI gives in-depth analysis and actionable intelligence into what is happening in the electronics component industry by comparing current insights with information sourced from more than two years of history across tens of millions of parts.

## Why should you trust this information?

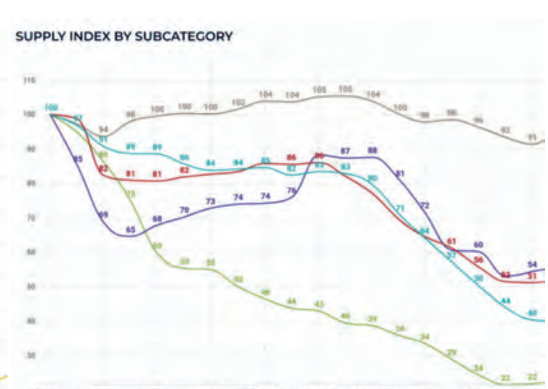
Nexar sits at an interesting intersection in the electronics industry, with millions of users every month that interact with our EDA tools, as well as the Octopart component search engine and the Nexar API. Our users span from PCB designers to procurement and supply chain professionals with all of their activities being signals of intent. We look back into the history of millions of components—two years' worth of data—to illustrate the current supply and demand of part categories and how that compares to a pre-pandemic baseline of January 2020. Based on user intent and historical data, we aggregate this information to create unique insights that designers can use to understand various trends in component availability, history, and demand.

## Why is historical and demand data important to a designer?

As the responsibility of cultivating a sustainable BOM has fallen on designers' shoulders, they need as much information as possible to make informed decisions. Historical data on component availability and demand signals to gauge competition for parts can be used to identify supply chain risk across the entire component list. This kind of information empowers designers to make choices that will remain intact throughout design, supply, and manufacturing process.

For designers today, mitigating risk is more important than ever. Understanding supply and demand trends can help you navigate throughout your parts planning process. Utilizing EDDI insights helps you to take advantage of market conditions and to source the components you need to get your product to manufacturing and to market.

*www.nexar.com/spectra*

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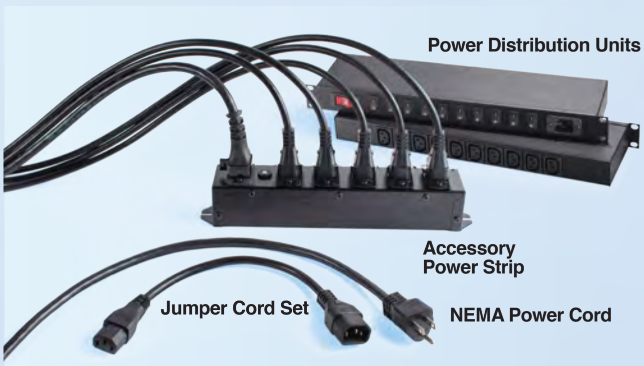


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