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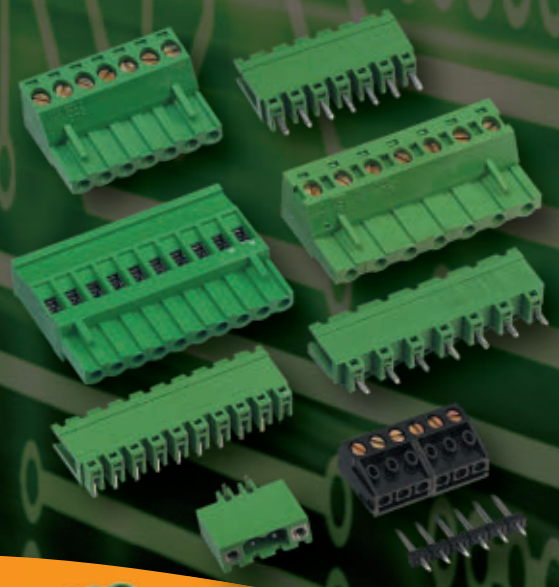

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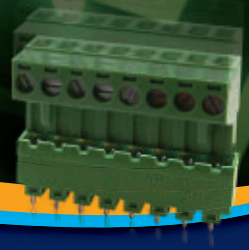

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Will 2024 Unleash Another
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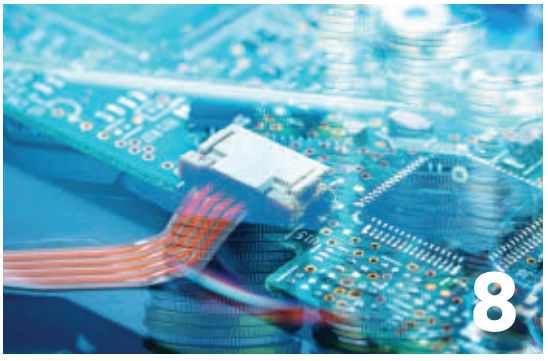

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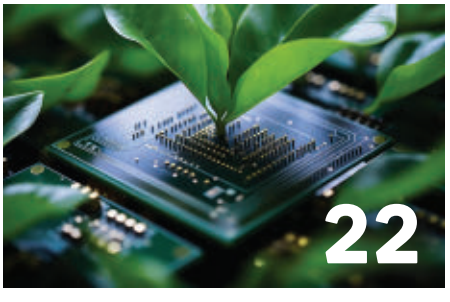

COLUMNS & DEPARTMENTS

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Editorial

BILL WONG | Senior Content Director

A Truly New Year at *Electronic Design*

Editor Bill Wong talks about the direction of the industry and magazine for this year.

THIS YEAR WILL bring about lots of changes for our industry and our publication. Topics like artificial intelligence (AI) and chip designs will continue to fill our pages and website with interesting and challenging details.

One big change on our side is an all-digital move to six issues per year, which you will be able to view online using our new interface or by downloading a PDF copy. Of course, you can still see the latest via newsletters to get notification of all our articles and videos as well as our new podcast, *Inside Electronics*, hosted by technology editor-at-large Alix Paultre.

Our 2024 *Electronic Design* Technology Forecast series is off to a great start. We highlight some of the latest in our upcoming Jan.-Feb. digital issue, with more to appear online over the coming months. Not surprisingly, AI is one of the most noted topics. I wanted to touch on it briefly to point designers to the differences in this broad topic area.

AI is as broad a topic as analog or any other electronics subject matter we cover. However, like embedded software, many aspects are almost unrelated when getting to the specifics of the technology.

In the case of AI, much of the editorial noise these days is about large language models (LLMs) and chatbots like Bard and ChatGPT. We do address these along with the hardware and software that support LLMs, but it's a small fraction of the range of AI technologies available to embedded developers. Likewise, focused generative AI/LLM use offers significant benefits and is more applicable to embedded applications.

For example, microcontrollers are quite capable of running small AI models even without hardware acceleration. Plus, these days, hardware acceleration is even incorporated in Arm- and RISC-V-based single-core microcontrollers.

Developers also need to consider the types of AI models and software being employed—including their use and quality right now. While many public LLMs are essentially global beta testing, production-quality AI solutions are being deployed in applications from automotive ADAS to improved motor control.

Electronic Design will continue to bring you the latest from RISC-V to Rust to robots (operating systems) in 2024, which will include forecasts from industry experts. I hope you will join us.

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QUICK POLL:
Your Most Difficult Debugging Chore

What debugging task do you find to be the toughest one to complete?

Debugging often takes up a considerable amount of a developer's time, especially once a design has been laid out. We all have different experiences and areas of expertise, but these days we're often tasked with working on many different aspects of a design from mechanical to power supplies. In this poll, we're interested in finding out what area you find most demanding.

We want to hear from you!

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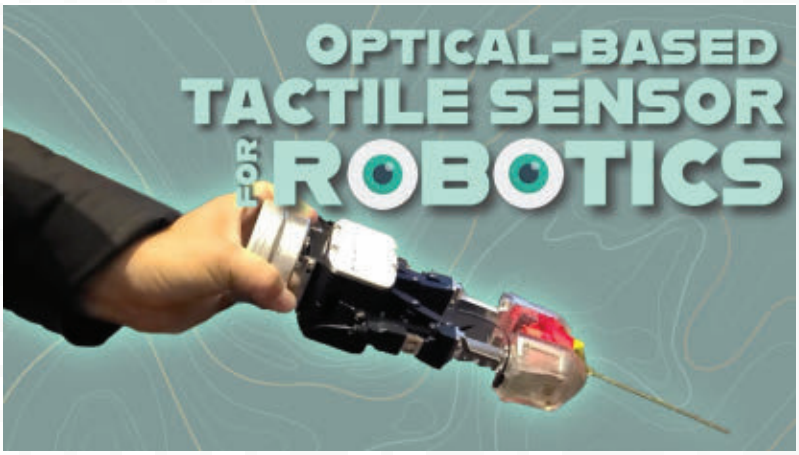

Video ▸ **Vision-Based Tactile Sensor** Helps Streamline Robotics

At CES, *Electronic Design* talked with Japan-based FingerVision CEO Yuji Nono about his company's approach to tactile sensors. Inside the gripper lives an optical-based tactile sensor with signal-processing algorithms. This sensor is composed of soft skin with an embedded marker array attached to rigid frame, and a web camera with a fisheye lens is housed inside. The processing unit can detect the array when it moves due to pressure, enabling the robot to adjust and maintain the shape of the object. The sensor tracks force distribution (the pressure on the array) as well as slip distribution (object movement detection).
www.electronicdesign.com/21280460

Video ▸ **AR/VR Platform** Built for Industrial Applications

The ThinkReality VRX headset developed by Lenovo supports mixed-reality (MR), augmented-reality (AR) and virtual-reality (VR) applications. It's intended primarily for industrial and commercial applications, though, where hardware and software support is critical after purchase of the headset. MR/AR/VR is often shortened to XR to cover all the bases. I talked with Vishal Shah, Lenovo's General Manager for XR and Metaverse, about the hardware and software platform.
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Automotive Electronics Take Center Stage at **CES 2024**

Visitors attending CES in Las Vegas found that in terms of technology, the event attracts more stars than an Oscar party in Hollywood. Regarding automotive-related exhibits, there were more than 250 exhibitors from the world of automotive tech, including self-driving, electric vehicles, and personal mobility.
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In 2023, we saw notable developments in passive components and design tools, making it even more difficult than usual to trim down our long list of deserving candidates for this year's PowerBest awards.
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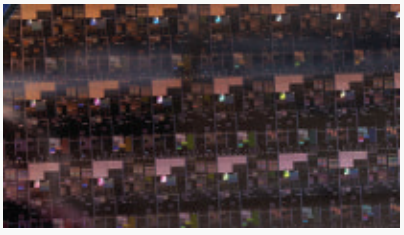

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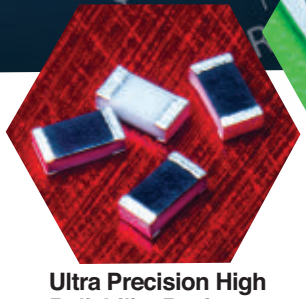

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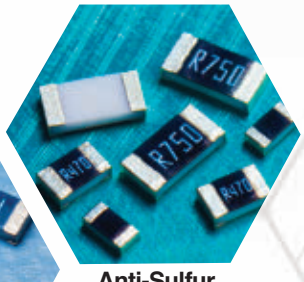

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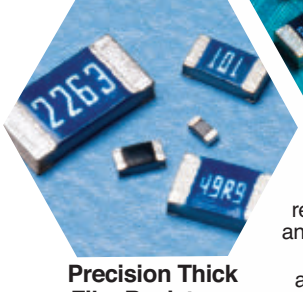

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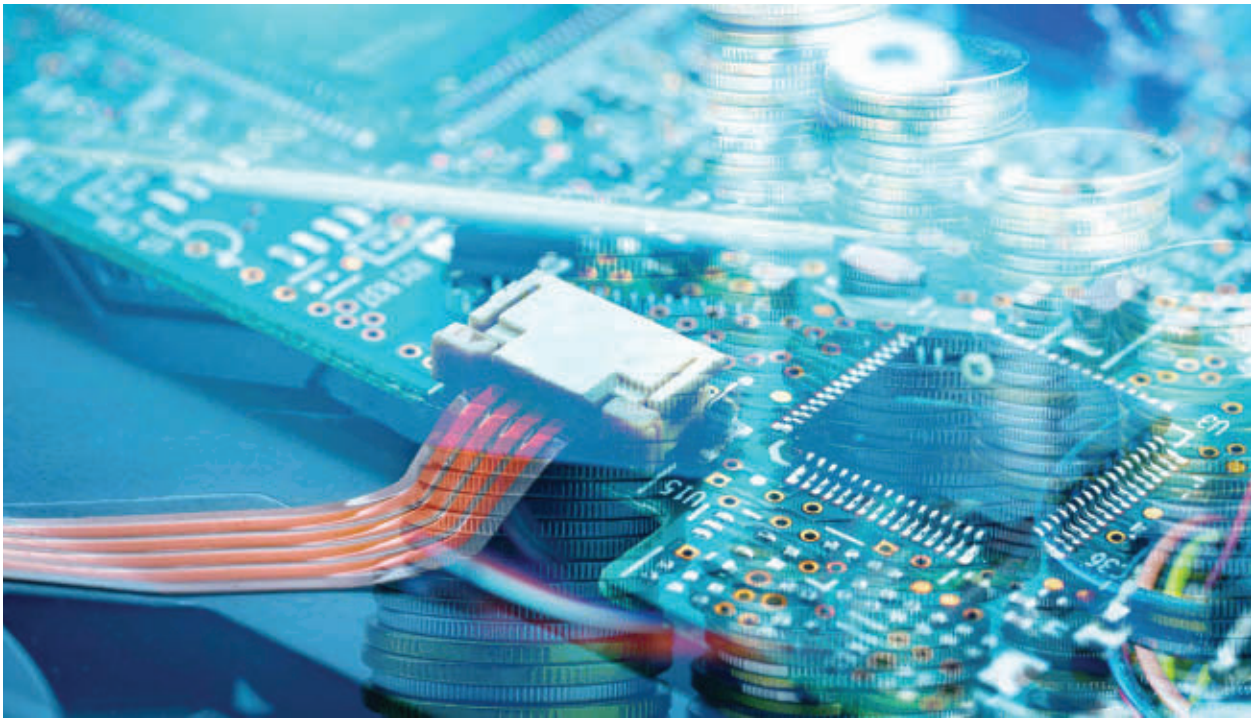
JIM HANDY | General Director, Objective Analysis



Will 2024 Unleash Another **Semiconductor Super Cycle?**

Objective Analysis' Jim Handy looks at key aspects to likely influence the AI semiconductor market for this year, from the post-pandemic return-to-work trends to both trade and regional wars.

WITH 2023 IN the rearview mirror, and along with it the big 2022-2023 down cycle, what have we to look forward to in 2024? Glad you asked. 2024 promises to be a year of change.

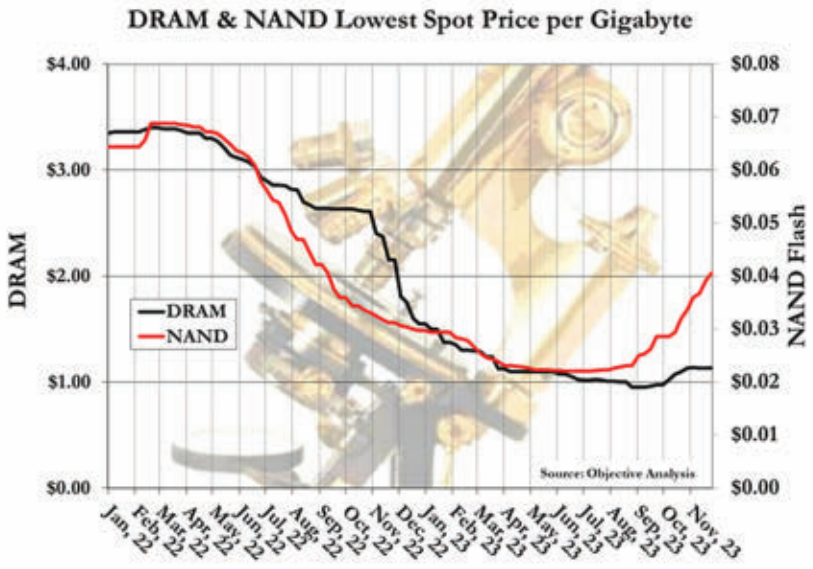
COVID's Continuing Impact

The biggest change will be the return from the return to work. In 2022, as workers in most of the world returned to their workplaces, students to their schools, and everyday people to entertainment venues, the demand for internet connectivity dropped, and data centers saw a corresponding drop in online traffic. PC sales declined as well, and this led to an oversupply of computing and communication chips.

Even though the shortage of older-technology linear and power-conditioning chips continued, this wasn't enough to prevent semiconductor sales from plummeting. It was the result of the return to work.

That scenario appears to have fully played out. One indicator of this is DRAM and NAND flash spot market pricing, which has been rising in recent weeks, NAND more so than DRAM for the time being. We can call this the return from the return to work *(Fig. 1)*.

The pre-pandemic market patterns seem to be falling back into place—PC unit shipments are returning to a slow and steady decline, and cell-phone shipments are back to their pre-COVID growth curve. 2024 should return these two markets to pre-COVID spending patterns.

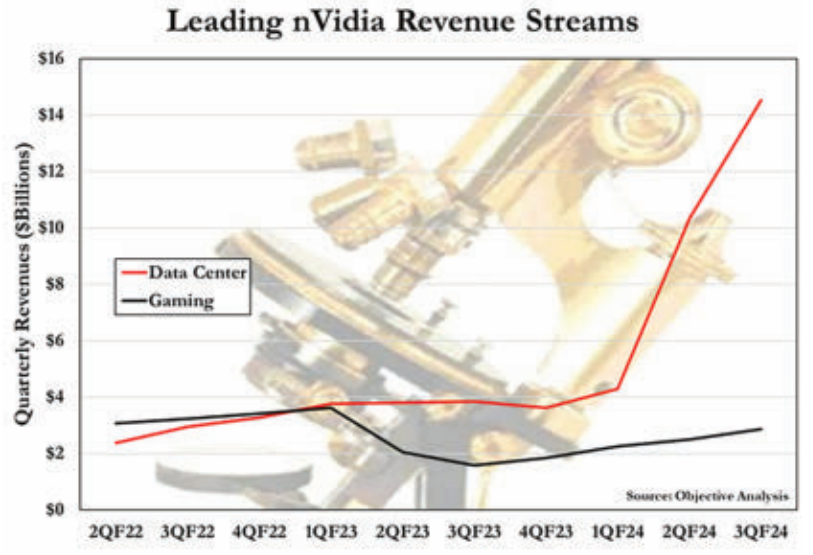


1. DRAM and NAND flash spot market prices are on the rise. *Objective Analysis*

AI in the Data Center

Data-center demand is the only market in question, since AI is being explored as a means of slowing the ballooning rate of server deployment that's been the data-center norm for the past decade or longer.

That change is made more than evident if we look at the sales growth of NVIDIA's two largest revenue centers: data center and gaming. While gaming is NVIDIA's established market, one that's showing great stability, sales of GPUs into the data center edged past it in the first quarter of the company's 2023 fiscal year (approximately the first quarter of calendar 2022), and then took off like a rocket a year later *(Fig. 2)*.



2. NVIDIA's established market showed great stability. Sales of GPUs into the data center edged past it in the first quarter of the company's 2023 fiscal year and then took off like a rocket a year later. *Objective Analysis*

Today, the company's data-center business accounts for a full 80% of total its revenues. And it looks like that share will continue to grow rapidly over the next few quarters as data centers migrate from standard servers to AI servers.

Other semiconductor manufacturers who produce companion chips to AI GPUs look hopefully at these numbers. However, the reality is that data centers can't be expected to grow their total spending at a rate to support both this kind of growth of AI spending and the continuing purchase of the same number of standard servers as they have purchased in the past. Expect standard server sales to decline to offset AI spending.

The net result of this is that total data-center spending will not grow at the same rate as NVIDIA's data-center revenues. Rather it will shift from a conventional server-centered model to an AI-plus-server model. It's too soon to estimate how this will change the complement of semiconductors shipped to the data center. Rest assured, though, that the balance of CPU/GPU to other semiconductor revenues will change, perhaps leaving more money in the pockets of the CPU/GPU makers, or perhaps shifting it in the other direction. Don't anticipate a sudden AI spending frenzy in 2024.

World Factors

Other factors have also made a significant impact on the semiconductor mar-

ket. We've already discussed the whipsaw effect of the return to work, so let's explore some of those others. They can be grouped into two categories: Old, which are elements that have been with us for over one year, and New, which have developed in recent months.

The first on the Old list is the U.S./China Trade War. As the shift in U.S. administrations brought a stylistic shift to the way the issue is being managed, little has changed except for the predictability of events.

The U.S. has moved to a position of warning of its responses to various events and then following through. This renders it somewhat unlikely that the industry will see a purchasing surge in 2024 like the one we underwent in 2017-18. That's when chip purchasers in China built contingency inventories for fear that their supply would be cut off suddenly and unexpectedly. We shouldn't expect a 2018-style super-cycle in 2024.

After the Trade War comes financial considerations—interest rate hikes and inflation. Inflation was a very natural result of COVID stimulus payments that governments used to prevent the collapse of their economies in the early stages of the pandemic. A big bolt of new money was created and pushed into the economy, which responded as it always does to a supply/demand imbalance: If there's too much money around, then prices increase.

Some economists liken that effect to a goat being swallowed by a boa constrictor—you can watch the lump travel through the snake as the goat progresses through the snake's digestive system. The new cash traveled through the economy in a similar way. This process seems to have run its course, and inflation is likely to return to pre-incentive levels. With this, consumer spending should improve in 2024, helping to improve consumer electronics sales.

As for interest rate hikes, this has been triggered in the U.S. largely by attempts from the Federal Reserve Board of Governors ("The Fed") to cool down an overheated U.S. housing market. The Fed has only one knob to turn to achieve its goals, and so they made a pretty dramatic change. Since credit is bought and sold globally, an interest rate rise in the U.S. required similar interest rises in other nations to prevent all investment from being drained out of those economies and into U.S. debt.

The Fed now seems to be easing back from that stance out of concerns of destabilizing the economy. This should benefit capital spending, which could have a minor positive impact on the 2024 chip market.

The last on the Old list is Russia's invasion of Ukraine. This conflict appears to have reached a stalemate. Neither side wants to back down, and neither can seem to win. Both sides understand that there are some pretty dire consequences to escalation, possibly resulting in nuclear war. The world seems to have found a way to live with this stalemate, and Europe continues to purchase natural gas from Russia despite its sanctions on other imports, while Russia is coping with the sanctions.

Economies that used to purchase produce from Ukraine now have other sources lined up to cover for any losses. The people of Ukraine continue to suffer. Although there were initial fears that a helium shortage would threaten chip production, those fears were misplaced. This war has had little impact on the global chip market. The world has reached a balance that can be expected to continue through 2024.

Moving to new factors, we've already discussed AI, which is today's hot topic, and the economy. That leaves us with the new war between Israel and Hamas.

This dreadful situation is also one in which escalation could lead to a rather terrible outcome, and it appears that Israel, in a somewhat heavy-handed way, is try-

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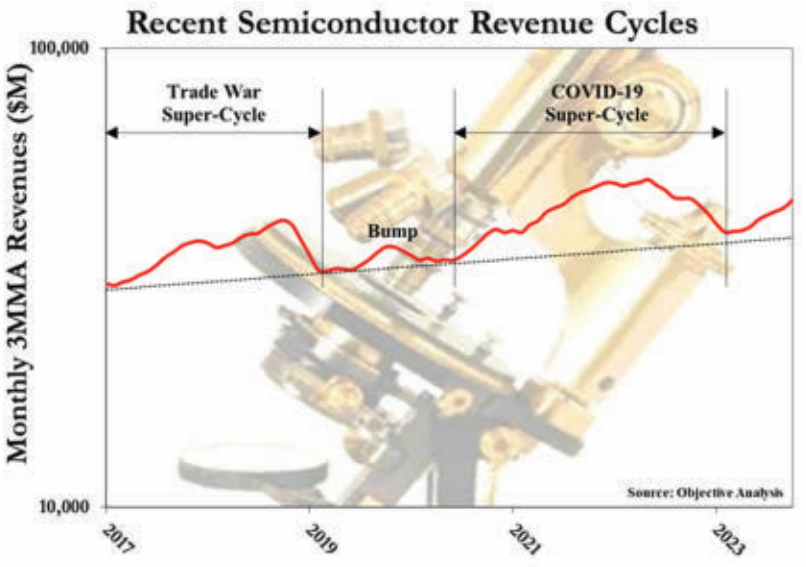
As for interest rate hikes, this has been triggered in the U.S. largely by attempts from the Federal Reserve Board of Governors ("The Fed") to cool down an overheated U.S. housing market.

ing to avoid triggering an all-out Middle East crisis. It appears that Israel will be satisfied and go no further if it can root out Hamas. It seems Hamas intended to trigger a much broader conflict to permanently damage Israel, something that Hamas can't accomplish alone.

At the situation's absolute worst, all of Israel's neighbors could attack the country, which would draw in the nations that support Israel, as well as other nations that support the surrounding nations. Russia is closely tied to Syria, and this, at its worst, could directly pit Russia against the U.S. That level of Middle East conflict would interrupt the flow of petroleum to wreak havoc on the world economy. Hopefully diplomacy will prevent anything of this magnitude from evolving.

For the time being, we're taking the stance that fighting will not escalate past its current level, and that the lasting effect will be ongoing high-level tension in the Middle East. We don't incorporate any changes to our 2024 forecast to account for this event.



3. Will the current market be like the Super Cycles, or like the intervening bump?
Objective Analysis

Outlook for 2024

So where does this lead us?

The first question is whether the semiconductor market will continue on the growth trajectory that it's been following since May. This growth, which is evident at the far right of the chart in *Figure 3*, is surprisingly similar to the beginning of the two Super Cycles that the industry experienced starting in 2017 and 2020.

This chart's red line is actual WSTS three-month moving average (3MMA) worldwide semiconductor revenues, and the black dashed line represents the 3.9% average annual growth that was closely followed by the market from 1996-2016.

The 2017 Super Cycle was triggered by the U.S./China Trade War and partly fueled by the surprise moves made by that period's U.S. administration. The current administration's approach, as mentioned before, has been following a more predictable path and is unlikely to trigger panic semiconductor purchases in China.

The second Super Cycle was triggered by the change to work/play/study-from-home, and there's no reason to expect a similarly abrupt change to occur over the next year or two.

So, if we don't have a Super Cycle, then how will the market's recent rise play out? Objective Analysis expects it to follow a path more similar to the bump that the market underwent between these two Super Cycles. This bump is similar to other bumps over the past few decades, even resembling bumps that are superimposed on top of the 2017 and 2020 Super Cycles. We expect a correction to set in relatively soon, with growth falling back into line with the market's 3.9% long-term revenue growth trend.

This implies that growth will be modest in the wildly swinging memory chip market and in the semiconductor market in general. Our forecast is for 2024 to see a 3% growth in DRAM revenues and 0%-5% growth in the overall semiconductor market. Given that recently announced semiconductor forecasts have been in the 11%-17% range, that's a very unusual outlook. On the other hand, were anyone to forecast that we would have another Super Cycle this year like that of the 2020-2022 cycle, then the forecast would be for growth of about 27%.

The Objective Analysis forecast calls for end-market growth to fall back to the trends that they were following prior to the pandemic, with PCs on a slow decline, and smartphones growing more moderately than in past years. Meanwhile, the move that hyperscale data centers make toward AI will redirect data-center spending, but not substantially increase it.

Still, the market continues to be susceptible to unpredictable influences stemming from the China/U.S. Trade War, consumer sentiments in light of inflation, and general economic conditions. Although our forecast sees no reason to anticipate another Super Cycle, or a rash of AI spending, we do see a return to pre-COVID growth that will benefit the industry in a smaller way in 2024 than in the following year. ed

JAMES MORRA | Senior Staff Editor

Employment Prospects for Engineers are Looking Up

AS TECHNOLOGY AND manufacturing companies seek out scarce talent to stay ahead of the innovation curve, engineers are seeing their stock rise. In such a tight labor market, they're getting more optimistic about their salary potential.

Nearly 70% of the survey's respondents said that not enough engineers have the necessary skills, according to *Electronic Design's* annual salary survey, which was conducted in recent months along with the other titles in Endeavor Business Media's Design and Engineering Group.

What skills are considered "necessary" can be subjective and constantly changing. But as it turns out, 64% expressed their companies are having trouble finding qualified candidates—whether in electrical, mechanical, wireless, power, or other disciplines—to fill open positions.

Have companies started to realize that they need to pay better to retain top engineering talent?

While they continue to struggle with long hours, tight deadlines, and the pressure to take their work home, most engineers have a favorable outlook on the future of the profession and their place in it. Despite the challenges of staying up to date on the latest innovations, they feel confident for the most part about their prospects for pay in the year ahead.

More than 65% of this year's survey respondents earned raises in 2023, and many anticipate further wage growth in 2024. But as inflation—particularly in the U.S.—keeps rising, these paychecks simply don't stretch as far as they did before.

The engineering profession is reaching a point where a large portion of the workforce is retiring, which not only creates

opportunities for engineers entering the field, but for those who are in the thick of their careers. It's also raising red flags about the lack of engineering and technical talent entering the industry. A recent report from Oxford Economics revealed that around 1.4 million jobs requiring such skills will remain open by 2030 in the U.S. alone.

While many engineers admit that they need to move into management or executive roles to start seeing significant gains in compensation, the shortage of engineering talent is paying dividends for those with skills in high demand. Some engineers believe their companies are starting to realize they need to pay better to lock down top talent. About two-thirds say employers are already compensating them sufficiently.

Engineering pros are a motley—and geographically diverse—group. This year's survey polled a sample of 2,660 engineers comprised of *Electronic Design, Machine Design, Microwaves & RF*, and *Power & Motion* readers. They include engineers from around the world at varying stages of their careers in disparate areas of technical competence, including full- and part-time workers with a wide range of job duties and titles.

While we're still reviewing salary figures from the survey, here's what engineers are saying about their employment outlook.

Skilled Engineers See Their Stock Continue to Rise

The consensus from the rank-and-file engineers, managers, and executives on the front lines of the profession is that opportunities abound. Many companies are moving ahead with their hiring plans, undaunted by economic uncertainty.

About 30% say that the status of hiring and budgeting for the engineering department at their company is up in 2023, giving them a degree of stability at a time when—at least in the U.S.—high interest rates threaten to pitch the economy into recession. Less than 25% of the engineers who participated in this year's survey say their companies have put hiring on pause due to business challenges or broader economic pressures.

Besides hiring more talent, companies are taking steps to hold onto their existing employers and reduce the productivity drain involved with recruiting and training new hires, including offering raises or other perks.

On the other hand, only 14% of respondents say they have seen budget cuts to their engineering teams in 2023, while a roughly equal number of engineers indicated that such budget cuts resulted in workforce reductions.

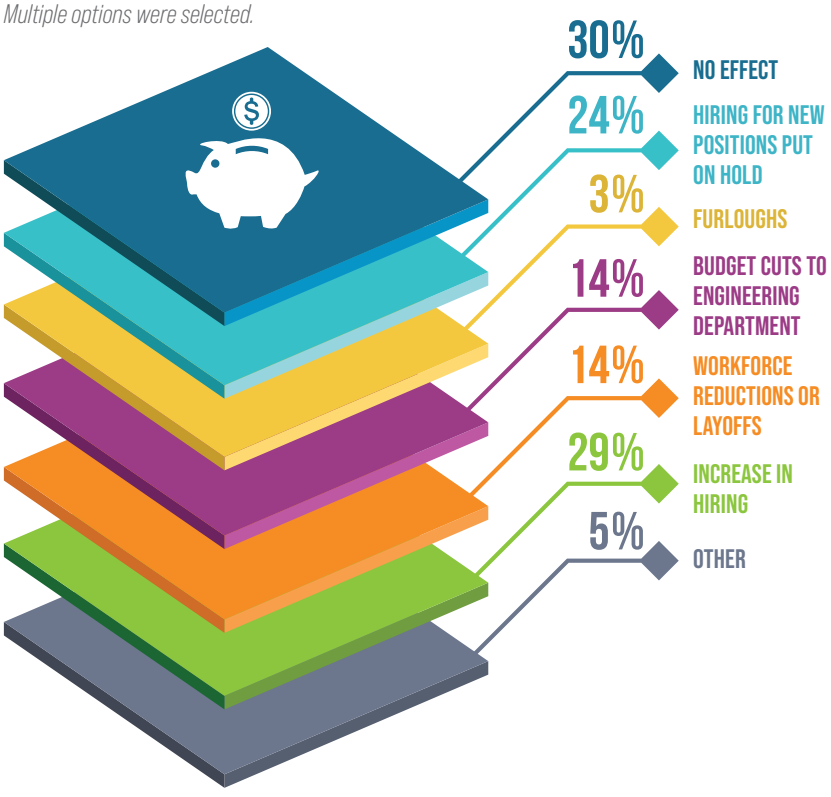
When asked about the employment outlook for engineers at their companies, about 39% of respondents said their employers intend to increase the number of engineering jobs in the coming year. More than 52% revealed that, to the best of their knowledge, their companies have no plans to expand or cut engineering staff in 2024. In contrast, only 9% are aware of plans to scale back engineering roles at some point next year.

Besides hiring more talent, companies are taking steps to hold onto their existing employers and reduce the productivity drain involved with recruiting and training new hires, including offering raises or other perks.

About 65% of engineers say their companies are just as focused on employee retention this year as they were in 2022.

What is the status of hiring and budgeting at your company?

Multiple options were selected.



For which engineering specialties are you having difficulty finding qualified candidates?

Multiple options were selected.

ANALOG	27%	MACHINE LEARNING/ARTIFICIAL INTELLIGENCE	21%
RF	29%	SAFETY AND SECURITY	15%
POWER	23%	MECHANICAL DESIGN	27%
DIGITAL	25%	SYSTEMS ENGINEERING	38%
EMBEDDED	26%	PHOTONICS	14%
SOFTWARE	33%	OTHER	12%

What is your status regarding new employment?

Multiple options were selected.

ACTIVELY SEEKING A NEW POSITION	15%
NOT ACTIVELY SEEKING, BUT WOULD FOLLOW-UP IF I READ OR HEARD ABOUT AN INTERESTING OPPORTUNITY	32%
NOT ACTIVELY SEEKING, BUT WOULD FOLLOW-UP ONLY IF PERSONALLY APPROACHED WITH AN INTERESTING OPPORTUNITY	35%
CANNOT ENVISION CHANGING JOBS IN THE FORESEEABLE FUTURE	30%
WORK FROM OFFICE REQUIREMENTS DO EFFECT MY DECISION	17%
WORK FROM OFFICE REQUIREMENTS DO NOT EFFECT MY DECISION	14%

While salary potential and the rush of researching and designing new products are critical factors, they're not all that matters to engineers considering whether to change jobs. The ability to work in team situations, a company's culture and values, and recognition from others all play into job satisfaction.

While many engineers feel as though they could be making more money in another career (or even at just another company), 90% vouch for engineering as a career path to young people who are looking for work that's personally fulfilling and comes with good employment prospects.

Though the profession has its share of challenges, most respondents are upbeat about the salary potential in engineering and manufacturing disciplines. About 70% feel it's as favorable as it was pre-pandemic.

More Stability, More Mobility in a Tight Job Market

So, what are engineers saying about the areas of technical competence where demand is highest?

The survey cited systems engineering (38%), software (33%), analog (27.5%), radio frequency (29%), mechanical design (27%), and power (23%) as areas where engineers—or their employers—experience the most trouble locating qualified candidates to fill job openings. While many engineers are folding artificial intelligence into their products or employing it in their tools or processes, 21% say they're struggling to hire experts in the field.

When it pertains to hiring new technical staff, 45.6% said their companies are requesting three years of experience or less in new hires, and another 39.4% seek those with five years of experience. Only about 14% are in the market for engineers with 10 years or more of experience. Of the engineers polled, about 33% said their company offers signing bonuses or other incentives to lure new engineering hires.

At the same time, engineers are changing companies more frequently in pursuit of higher wages or better working condi-

tions. Only 12% say they have been with their employer for more than 25 years, 53% have worked at their current employer for less than 10 years, and about 34% have been there for less than five.

Despite the challenges of maintaining an engineering career, most believe their pay is competitive with what other companies are offering workers with the same skills and level of experience. And they're generally content with their current jobs. However, many respondents do stay open to new opportunities.

While only about 15% of respondents are actively seeking new positions, another 67% say that they would follow up if they learned—or were personally approached—about a job opportunity that seemed interesting.

In general, engineers are changing jobs (and companies) more frequently than before. Still, most are staying put. Compared to last year, close to 90% replied that they have the same job this year, and most who changed jobs said they were promoted or reassigned within the same company where they worked the prior year. Additionally, about 30% said they can't imagine changing jobs in the foreseeable future.

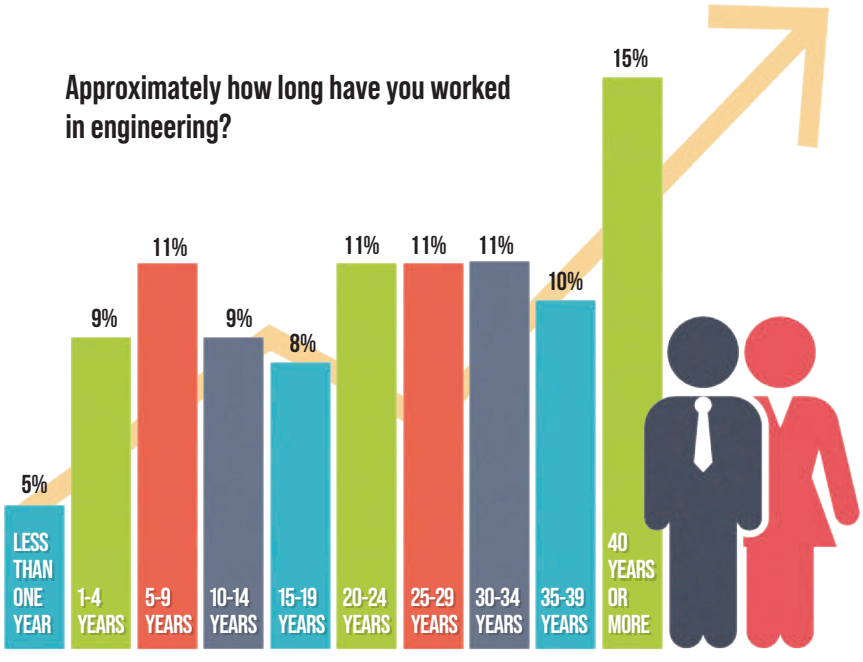
New Engineers Step Up Amid Generational Shift

Many engineers point out that the competition for talent is getting more acute given the generational shift taking place in the profession, where the typical engineer currently has 20 to 24 years of experience.

As the survey revealed, a severe imbalance exists between young and veteran engineers. About 25% of respondents have worked in engineering for less than 10 years. In contrast, another 36% have 30 years of experience under their belt, and many workers in this group are considering retirement at some point soon. It's unclear whether enough new engineers are in the pipeline to replace them when they call it quits.

While younger engineers working today will cover some of the losses, efforts to convince students to pursue a career in engineering as well as recruiting and training young people with technical skills will be critical.

A number of respondents say that it was worth it to pursue a career in engineering, but some aren't sure they want to do it long term.



A number of respondents say that it was worth it to pursue a career in engineering, but some aren't sure they want to do it long term. About a third reveal they have considered leaving the profession at some point.

For many of the engineers who have considered leaving (44%), they're interested in trying a different line of work. Others cited wanting a less stressful career and the desire for more freedom and free time after work.

Given the level of education and technical expertise required for the job and the increasingly wide range of responsibilities and technologies they must stay on top of to succeed, other engineers feel their salaries are out of step with what they bring to the table. Thus, they have considered reapplying their skills to other industries that pay better. For context, about 51% say they often handle tasks outside their primary area of expertise.

About 20% of the respondents stated that while they don't plan to start another career, they're ready to retire, further highlighting the challenges ahead for companies already struggling to recruit talent.

As the engineering shortage drags on, engineers with the right combination of skills and experience are only going to become more valuable assets. And it seems as though they're getting rewarded for their efforts. ed

CHRIS KRUELL | Head of Marketing, CDSG

The Future of Endpoint Security: Navigating Trends in 2024 and Beyond

Unfolding trends upon the arrival of 2024 suggests that organizations must be more vigilant than ever in protecting their digital assets, and it will require a multifaceted strategy.

VIRTUALLY EVERYONE HAS a laptop today, especially after COVID-19 altered our work locations and habits. But most people don't realize that laptops are perfect examples of critical "endpoints" in the world of IT. And they're especially important in cybersecurity planning.

In general, an endpoint is a device or node in a network, such as a computer or smartphone. Endpoint security protects these devices from cyber threats, ensuring data integrity, confidentiality, and availability.

At the onset of the pandemic, nearly everyone worked from home if they had that option. This sudden transformation in workplaces burdened IT staff all over the world.

Not only did IT need to furnish employees with proper equipment, but they had to consider the security concerns for the millions of laptops and computers that were suddenly put into the hands and homes of people who never thought much about cybersecurity. Even though many employees have returned to work in offices, the widened need for diligent endpoint security that surfaced during the pandemic is still vitally important.

In 2024, several trends will shape the landscape of endpoint security. These span the integration of artificial intelligence (AI) and machine learning (ML), the growing importance of Zero Trust Architecture (ZTA), and more. The following key trends will influence the future of endpoint security most dramatically in the coming year.

AI and ML Integration

It's been barely a year since ChatGPT arrived on the scene, catapulting AI into conversations and workflows everywhere. We will see a significant leap in the use of AI and ML in endpoint security in

2024. The ability to quickly analyze large amounts of data from networks and users means that sophisticated threat detection and mitigation will take place more rapidly and in real-time.

However, the cat-and-mouse game will escalate between those who need to constantly reinforce endpoint security against the latest cyberthreats and those bad actors who create the cyberthreats. It's not only cyber defenders who utilize AI and ML, but threat actors use AI and ML to create more sophisticated attacks that will slide by undetected.

Zero Trust Architecture Implementation

The adoption of ZTA will continue its expansion drumbeat in 2024, representing an ongoing paradigm shift in cybersecurity philosophy. The concept revolves around the idea that trust is never assumed, and strict access controls are maintained regardless of a user's or device's location. With the proliferation of remote and mobile work, organizations will implement continuous verification of users and devices, a fundamental principle of Zero Trust, to bolster their defense against potential breaches.

Endpoint protection is a key component of a ZTA. That's because endpoints are most often the intersection between the world (or internet) at large and sensitive, secret, and proprietary information that should be kept under strict control.

As the Internet of Things (IoT) continues to expand, we will see increased integration of IoT security into endpoint protection strategies. Endpoint security solutions will be tailored to secure a broader range of connected devices beyond traditional computers and mobile devices, recognizing the diverse threat landscape posed by an interconnected world.

Hardware-Assisted Endpoint Security with Secure SSDs

Zero Trust adoption likely means that there will be more checkpoints for access to secure, or sensitive, networks and data, especially data at rest (DAR).

Heightened emphasis on mitigating insider threats will be a key focus area in 2024. Behavioral analytics and monitoring will play a crucial role in identifying potential risks within the organization.

In the military and other government agencies, the use of certified storage devices, such as Commercial Solutions for Classified (CSfC)-listed components, to build secure, encrypted storage solutions for DAR, will continue to increase. CSfC is an NSA program to enable secure cybersecurity solutions that leverage commercial technologies and products instead of expensive custom products.

In endpoint security, we will continue to see the use of CSfC-listed, self-encrypting storage integrated into endpoint devices. Features such as pre-boot authentication (PBA), which requires users to authenticate to the boot storage device before the computer starts up, will become the new table stakes in a variety of industries for eliminating unauthorized device boot access as well as access to DAR.

Secure storage embedded in endpoints will become the basis for sophisticated software endpoint security solutions layered on top.

Enhanced User Authentication and Focus on Insider Threats

In addition to PBA, user authentication will see continued advances in 2024, with a focus on bolstering identity verification. Multi-factor authentication (MFA) will evolve to become more sophisticated, incorporating biometric authentication and behavioral analysis. These enhancements will contribute to creating a more secure access environment, mitigating the risks associated with compromised user credentials.

Heightened emphasis on mitigating insider threats will be a key focus area in 2024. Behavioral analytics and monitoring will play a crucial role in identifying potential risks within the organization. Endpoint security solutions will be designed to prevent data exfiltration and unauthorized access, addressing the challenges posed by employees or other insiders with malicious intent.

Endpoint Detection and Response Advances

Endpoint detection and response (EDR) will improve significantly in 2024, offering more comprehensive threat visibility and response capabilities. These solutions will not operate in isolation, but rather integrate seamlessly with other security tools, fostering a holistic approach to cybersecurity. By enhancing threat detection and response capabilities, organizations can better safeguard their endpoints against evolving cyber threats.

Conclusion

As endpoint security evolves, it's paramount for organizations seeking to safeguard their digital assets to keep pace. As we anticipate the trends shaping 2024, it's evident that a multifaceted approach, encompassing advanced technologies, strategic architecture, user empowerment, and secure SSD storage, will be crucial for building resilient and adaptive endpoint security strategies. By embracing these trends, organizations can fortify their defenses and navigate the evolving threat landscape with confidence.

Design Feature

BOB ZOLLO | Solution Architect, Battery Testing, Electronic Industrial Solutions Group, Keysight Technologies

Selecting the Right Voltage Measurement When Testing Batteries

Zeroing in on the right voltage measurement device is critical to achieving the accuracy and speed of measurement required for your voltage measurement task.

MEASURING VOLTAGE MAY be the most basic measurement you can make on a cell or battery. Cell or battery voltage is used to determine the state of charge, the resistance, and other key behaviors of the cell. Current is determined by measuring the voltage across a current-sense resistor or current shunt.

Depending on the sensor type, temperature is determined by measuring the voltage across a temperature sensor, and resistance is determined by measuring the voltage response of the cell or battery to a current stimulus. Finally, auxiliary voltage measurement points are measured to determine proper functional operation of the battery system.

With all of these voltage measurements, it's important to understand how to make the voltage measurement properly to gain the desired measurement insight. In some cases, very accurate voltage measurements are needed, and measurement time is a secondary consideration. In other cases, capturing dynamic voltage behavior is needed, such as looking at voltage response to a current pulse. When faced with these scenarios, a fast digitized voltage waveform is required to observe the response voltage versus time, and voltage measurement accuracy will be the secondary consideration.

DMMs for High-Accuracy Measurement

The basic dc voltage measurement device is a digital voltmeter (DVM). Most DVMs today do much more than just measure dc voltage by including measurement of ac voltage, ac and dc current, resistance, and capacitance *(Fig. 1)*. In these cases, the DVM is called a

1. A typical system DMM suitable for cell voltage measurements is the Keysight model 34470A. *Images courtesy Keysight Technologies*

digital multimeter (DMM). Regardless of whether you have a DMM or DVM, they both measure dc voltage, so I'll refer to this instrument as a DMM, as this is the more commonly available configuration.

DMMs come in many different configurations. Handheld DMMs are very convenient when you need to quickly measure a voltage at a test point, but they're not suitable for a cell or battery test system.

Benchtop or system DMMs, like the DMM shown in *Figure 1*, are commonly integrated into test systems. These instruments are rack-mountable and can be controlled remotely over digital programming interfaces like Ethernet or USB. Such DMMs have a front-panel display, so that they can offer high confidence during testing because you can see the measurements that are made.

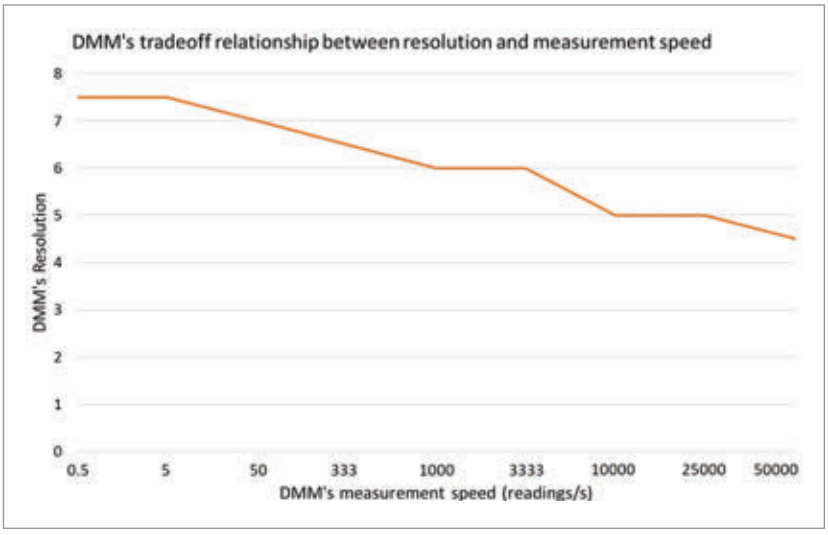
DMMs are also available in modular instrument form, such as PXI, which offer reduced space in the system, but sacrifice the front panel operation. Reputable DMMs are calibrated and traceable to national standards, so you can trust the measurement.

How Many Digits?

DMMs are classified by the number of digits, with the lowest performance being 3.5- and 4.5-digit versions. The typical DMM used in cell and battery test systems have 6.5 and 7.5 digits. The highest-performing DMMs are 8.5 digits, but these are seldom used in cell or battery test systems.

While performance of the DMM typically tracks the number of digits, it's important to understand that the number of digits refers to the resolution of the DMM, not necessarily the accuracy. Generally, 7.5-digit DMMs are more accurate than 6.5-digit DMMs, 6.5-digit DMMs are more accurate than 4.5-digit DMMs, and so on. But understanding the datasheet of the DMM is important to understand the actual accuracy you will get when using it.

Independent of the number of digits, when using a DMM, the length of the measurement time determines the performance of the measurement *(Fig. 2)*. The DMM voltage integration time is the programmable parameter that you can adjust to trade off measurement speed for measurement performance. Longer integration times enable the DMM to reject noise and give a better measurement. Shorter times will be less accurate due to increased noise, but it's possible to accelerate readings.



2. The chart illustrates DMM resolution in number of digits versus DMM measurement speed in readings per second.

Accuracy and Throughput Tradeoffs

Therefore, understanding how accurate you need to make the measurement will tell you the achievable measurement throughput. For a 50-Hz AC power system, a measurement interval of 100 ms or two power line cycles (PLCs) will often reject enough noise whereby you can get a reasonably accurate measurement without sacrificing too much measurement speed. The resulting measurement is suitable for determining cell or battery open-circuit voltage with relatively high confidence.

Likewise, for 60-Hz AC power systems, a measurement of 120 ms can be sufficient. Note that as you adjust the measurement interval or NPLC (number of power line cycles), you will be effectively changing the DMM's number of digits.

A 7.5-digit DMM running at its highest speed (shortest integration time) will perform similar to that of a 4.5-digit DMM. It's only at long integration times that you achieve the highest resolution (number of digits) and highest accuracy (through increased noise rejection) *(Table 1, page 20)*.

A final consideration of DMM accuracy depends on the measurement range setting of the DMM. While DMMs can easily measure millivolts and microvolts with high accuracy, measuring these minute voltages will require the DMM to be in a low full-scale range, such as 10 mV full scale.

If you're trying to measure a cell voltage of 3.65 V, you can't measure on the 10-mV range. You'll need to be on a range that's larger than the cell voltage. This could be a 5- or 10-V range. On the DMM's 10-V range, the accuracy will yield 100s of microvolts or even a few millivolts of error. Be mindful of this when trying to measure small voltage changes on top of the cell or battery voltage, which is commonly done when measuring resistance or aging.

For DMMs, clearly there's a tradeoff between speed and accuracy. For the highest-accuracy measurements, individual long integration time measure-

ments are needed. For example, if you're measuring the drop-off of open-circuit voltage during aging, you will want to use the longest measurement integration time, because you're trying to accurately measure millivolt or microvolt changes in open circuit voltage.

Digitizers for High-Speed Measurements

Measuring a voltage waveform to observe voltage changes versus time will require a digitizer. In fact, better DMMs can be used as digitizers as well. In this mode, the DMM will rapidly capture individual measurements and store them in an internal buffer, allowing your program to pull that data out of the instrument in the form of a digitized waveform. As you can imagine, the faster you make these measurements, the lower the accuracy and resolution of the measurement.

Pure digitizers are optimized for fast measurements, while DMMs are optimized for accurate long-measurement interval measurements. Digitizers are specified in number of bits, with 16 bits being common; however, 20- and 24-bit digitizers are available.

Just like a DMM, a digitizer provides programmability to trade off speed for accuracy. As you increase the digitizer's speed, the number of bits will be reduced, along with the digitizer's accuracy. When you read the performance specifications of a digitizer, you will see the term "effective number of bits" (ENOB). The ENOB describes how the digitizer's performance will be adjusted with increasing speed *(Table 2)*.

Even a high-resolution digitizer will have significantly lower accuracy and resolution at full speed. Therefore, you can capture rapidly changing voltage waveforms (thanks to the speed of the digitizer), but you will not be able to resolve small steps in the voltage due to the reduced accuracy and resolution of each measurement point.

For example, when making a DCIR measurement, you may want to capture the voltage and current waveforms using a digitizer to ensure you can see the fast-rising edge of the voltage waveform, which determines the ohmic resistance of the cell or battery. But if the digitizer's accuracy and resolution are insufficient, you will have too much measurement uncertainty in the voltage measurement. Thus, you will not be able to accurately assess the change in voltage caused by the pulsed current. This could result in a DCIR with a large error, like 1 mΩ ± 0.5 mΩ.

Integration Time for 60-Hz AC Power	Reading Speed in Readings per Second	Resultant Number of Digits
1.67 seconds = 100 PLCs	0.5 readings per second	7.5 digits
167 ms = 10 PLCs	5 readings per second	7.5 digits
16.7 ms = 1 PLC	50 readings per second	6.5 digits
3 ms = 0.2 PLC	333 readings per second	6.5 digits
1 ms = 0.6 PLC	1,000 readings per second	5.5 digits
300 µs = 0.2 PLC	3,333 readings per second	5.5 digits
100 µs = 0.006 PLC	10,000 readings per second	4.5 digits
20 µs = 0.001	50,000 readings per second	4.5 digits

Table 1: Relationship between integration time, reading rate, and resultant number of digits for a 7.5-digit DMM (Keysight model 34470A).

Digitizer Speed	Effective Number of Bits (ENOB)	Comment
5 µs per reading	12.7 bits	Fastest speed (200K readings per second) results in lowest ENOB
50 µs per reading	13.9 bits	
100 µs per reading	14.2 bits	
1 ms per reading	16 bits	
10 ms per reading	17.6 bits	
16.6 ms per reading	18 bits	Slowest speed (60 readings per second) results in highest ENOB

Table 2: Digitizer speed is compared with resultant effective number of bits (ENOB). The digitizer has 18-bit maximum resolution with a maximum speed of 5 µs per reading.

Summary

By understanding the performance specifications of the voltage measurement instrument and the tradeoff of speed, accuracy, and resolution, you'll better know when to use a long-integrated measurement from a DMM versus a high-dynamic measurement from a digitizer. This will lead to achieving the best possible measurements from your test system. ED

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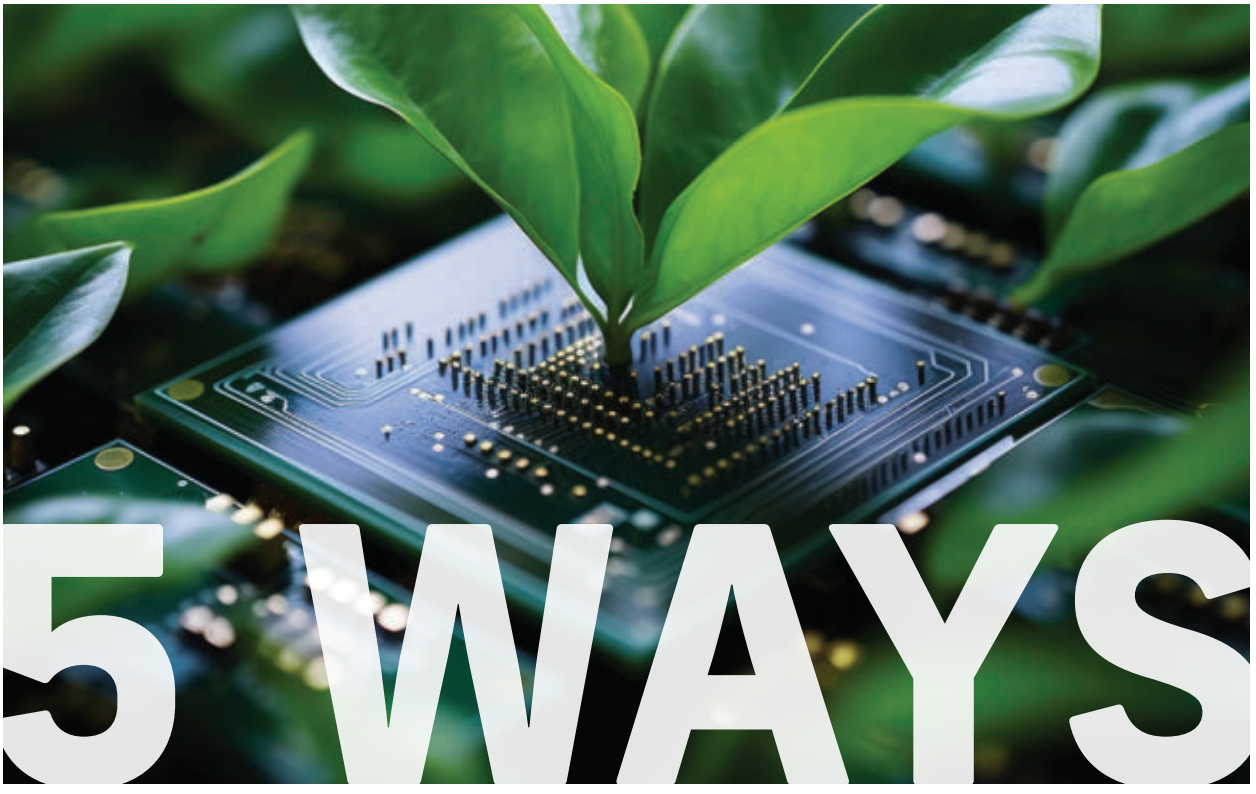

5 WAYS to Improve the Sustainability of Electronics

New initiatives focused on electronics circularity are putting the pressure on manufacturers to create more sustainable flexible products. This article outlines five plans of attack.

BY 2030, GLOBAL electronic waste will reach 74 million metric tons, with only 20% collected or recycled properly (Forti et al 2020). Today, the electronics industry faces major challenges with availability of critical materials and increasing pressure to cut its environmental footprint and move toward circularity.

In March 2022, the European Commission published its Sustainable Products Initiative, which aims to ensure that all products placed on the EU market become more sustainable.

The European Commission also adopted the new circular economy action plan (CEAP) in March 2020. It's one of the main building blocks of the European Green Deal, Europe's new agenda for sustainable growth. The EU's transition to a circular economy aims to reduce pressure on natural resources and create sustainable growth and jobs.

Because these initiatives ultimately cover and include the electronics industry, manufacturers are met with increasing pressure to meet new sustainability requirements in the years to come.

That's easier said than done—the major looming question is how to actualize these goals. Electronic waste is piling up, and numerous factors exacerbate the problem. Electronic waste is notoriously difficult to recycle because many tiny working parts and multitudes of different materials make it a challenge to separate. Product turnover and demand for new

gadgets accelerates every year, so people replace their old phones and gadgets at unprecedented rates.

In addition, mandatory device registration makes it difficult to pass used devices on to a second-hand life. As a result, many products wind up in landfills or office drawers well before their time. Due to rapid production rates and high demand, it's also increasingly difficult to access the necessary raw materials to build new products, and the list goes on.

The fact that these problems exist is widely discussed, but how can the industry realistically tackle a problem with so many nuanced angles? In January 2019, we established the ECOtronics project at VTT Technical Research Centre of Finland in collaboration with national universities and industry partners, and we set out to find concrete answers to the challenges at hand.

Over the course of the next two years, we conducted experiments and trials to determine how electronics can have a more sustainable future. The work continues in the KDT JU Sustronics project, an EU-wide three-year initiative with 46 partners that started in June 2023.

Known as the country that pioneered and popularized personal mobile phones in the 1990s, Finland is a considerable technology development hub that has made its mark on the world. Coupled with a strong nature connection, sustainability-minded thinking and innovation is widespread in Finland. It's with this backdrop that VTT has set out to tackle the e-waste issue.

We began with the goal of setting a new standard for sustainability in the electronics industry and answering one key question: How can we increase circularity and sustainability at every stage of the electronics lifecycle?

The ECOtronics project ultimately found that the industry needs to improve upon five main areas to achieve more sustainability in flexible electronics. These include designing for circularity, using more sustainable raw materials, creating more efficient manufacturing techniques, and designing for sustainability for both the use and end-of-life phases. Our focus in the project was to study these aspects in connection with flexible electronic products.

1. Design with circularity in mind

On average, the global consumption of electrical and electronics products increases by 2.5 million metric tons of total weight each year (Forti et al., 2020). Electronic products need to be designed so that the aforementioned EU environmental targets are incorporated at every phase of their lifecycle. This means designing with sustainability in mind from the ground up, and for each component. Holistic and streamlined sustainability assessment should support the design phase to achieve those goals.

One major blockage to circular design is planned obsolescence, which has become a major obstacle in the circularity and lifespan of electronics (Elia et al., 2017; Guiltinan, 2009). Products are thrown away and replaced unnecessarily quickly because they're designed to stop working early. That said, rethinking business models is increasingly important in the transition to a circular economy. Currently, many business models are product-based, but to shift into a more sustainable electronics industry, we need to see the focus change from products to service-based models (Bocken et al., 2019).

One of the major challenges to recycling current electronics is that they're often composed of various components and materials in small quantities. Components consisting of monomaterials are ideal for any recycling and recovery process.

We found that new products could be designed in a modular way so that they can effectively be separated for reuse or for remanufacturing. This potentially lengthens the lifecycle of components and materials, but it can also help to alleviate raw material shortages by enabling access to secondary raw materials. However, process development for more efficient material recycling and recovery is needed as well.

One of the major challenges to recycling current electronics is that they're often composed of various components and materials in small quantities. Components consisting of monomaterials are ideal for any recycling and recovery process.

One example is the modular and biodegradable ECG patch, which we pioneered at VTT. Today, disposable single-use ECG sensor patches consist of skin-adhesive electrodes and embedded electronics, and they're based in plastic materials. The new nanocellulose ECG patch that we developed is made of a recyclable and biodegradable nanocellulose plastic alternative while the electronics are detachable. Therefore, they can easily be peeled off for reuse.

The objectives of ecodesign and circular design need to include energy efficiency, material efficiency, longer product lifecycles, upgradeability, and the ease of recycling the materials.

2. Sustainable choices of raw materials

With global consumption of material resources expected to roughly double between 2017 and 2060 according to the OECD, the electronics industry needs to start using more and more raw materials that are based on renewable natural resources, such as replacement of fossil-based composite and plastic substrates with cellulose or bio-polymer based materials.

Many traditional technologies used in the manufacture of electronics are based on subtractive processes. However, printing and other additive and roll-to-roll compatible technologies significantly reduce material waste and energy use during the manufacturing process.

Assembling electronics inherently consumes energy, and if the raw materials are ultimately wasted, then the consumption goes up. One solution focuses on circular targets. This means using secondary raw materials instead of primary raw materials. Secondary materials have been used before and are recovered from waste and recycling.

An ultimate goal for the industry is that almost all electronic materials come from secondary sources. Keeping electronics modular also means that the parts with limited lifespans are easy to replace or dispose of.

As an example, in the ECOtronics project, VTT and collaborators investigated the replacement of commonly used plastics with bioplastics and successfully realized a smart label based on bioplastics and printed organic photovoltaic cells for energy harvesting and printed supercapacitors for energy storage. Use of new energy-harvesting solutions improves energy efficiency of electronic products, and ultimately makes them energy autonomous.

In addition to substrate materials, metals are used in electrical leads, soldering materials, and components. For example, silver is a great material for electrical leads and is commonly used for printed electronics, but it has a high environmental impact. Silver is also becoming a scarce material and is scattered throughout the earth, so it requires many resources to be located and mined.

In some cases, silver can be replaced with more abundant and less valuable alternatives, such as copper or carbon-based materials. Silver dominates the environmental impact of any printed device, and the global warming potential decreases significantly, up to approximately 80%, by replacing it with copper—and even more so with carbon, as reported by LUT University and VTT (Nassajfar, 2023). However, their conductive properties aren't as good as silver and must be compensated through design.

Other examples of potential bio replacement materials could include cellulose and even silk. Cellulose can be used to make paper, which is superior to other deformable passive materials due to its low price, flexibility, and roll-to-roll (R2R) fabrication capability at a fast process speed of about 25 $m \cdot s^{-1}$ (Fuentes, 2021).

In addition, silk-derived carbon materials have good conductivity and can be easily formed into different structures and shapes. This natural material has a long history that's been applied in the dielectric layer and as an electronic device substrate (Barras, 2017).

3. Energy-efficient and material-efficient manufacturing techniques

One of our most significant findings showed that environmental impact could be reduced by 86% when additive printing methods are used to create flexible electronic components, as reported in detail by the Finnish LUT University.

Many traditional technologies used in the manufacture of electronics are based on subtractive processes. However, printing and other additive and roll-to-roll compatible technologies significantly reduce material waste and energy use during the manufacturing process.

Changing the substrate utilized in printed electronics has a drastic effect on a product's sustainability. Traditionally, metal electronics parts are etched out of copper sheets in a process called PCB etching. The process removes unwanted copper from a printed circuit board; therefore, only the required circuit remains while the rest of the sheet isn't used. The team found that flexible metal electronics parts can instead be printed onto bio-based substrates, like paper or bio-plastic film.

The process requires less energy and avoids the use of harmful chemicals while drastically reducing material waste and increasing the use of renewable materials. We found that this change in the manufacturing process is the single largest factor in potentially reducing the climate impact of flexible electronics.

4. Sustainability for the use phase

We also found new solutions to make electronic products more sustainable during the use phase. For example, the energy consumption of products can be decreased by creating more low-cost and low-weight devices, as well as new technology enabled by thin and flexible bio-based materials combined with additive manufacturing.

Extending product life expectancy and increasing durability also contributes to sustainability. Furthermore, energy-harvesting capabilities, such as using organic photovoltaics (OPV), offer new opportunities for energy autonomous devices.

Efficiency benefits can be achieved by applying new manufacturing technologies, such as additive manufacturing and roll-to-roll printing, to produce affordable and intelligent devices. In one example, the weight of a car was reduced when using flat printed cables, thus contributing to lower emissions during the car's lifetime (Hakola, 2022).

Another example is a smart label that's printed on bio-based plastic substrate and powered by a rechargeable supercapacitor with photovoltaics capable of harvesting even indoor light. This label can be added as a part of the product packaging and be used to monitor, for example, the transport conditions of food and medicines or other temperature-sensitive products. The environmental impact of this smart label is overcompensated with the sustainability improvements in logistics that it enables.

As a third scenario, the global amount of food waste is estimated at 1.6 billion metric tons per year, of which the edible parts amount to 1.3 billion metric tons (FAO, 2022). RFID or other intelligent tags could potentially be used to monitor and prevent this loss and the associated environmental footprint.

5. End-of-life management for the circular economy

In the EU, e-waste continues to be one of the fastest-growing waste streams (Circular Economy Action plan, 2022). End-of-life management for electronics still holds challenges in separating electronic material fractions, such as metals, for recycling and reuse without losing material value in landfilling and incineration.

Every year, 1.5 billion new mobile phones enter circulation. Old handsets end up in desk drawers or in landfills, which means that their materials and components are lost. But these materials need to be returned to the industry for reuse. End-of-life solutions and strategies are something that we haven't completely cracked yet. Questions like, "What are the most compatible waste streams?" and "How do we arrange efficient material recovery?" are issues that we're still tackling.

Single-use diagnostic tests and other single-use products, such as smart labels, are new emerging electronic devices that need to be designed for sustainable end-of-life management. Since the number of intelligent electronic features integrated into packages is expected to grow, the packaging waste of electronics recycling is a mounting concern. Thus, electronic material recovery should be considered.

The concerns also relate to safety if the recycled content is circulated back into, say, food packaging or toys. Therefore, it would be important to separate the electronic materials before package recycling processes.

Designing with biodegradability in mind is also important in some cases. Effective collection of electronic devices is a challenge, and some products will inevitably end up in waste streams or the environment.

In addition, designing biodegradable components wherever possible contributes to less e-waste—this might apply to packaging, plastic waste, or substrate material. However, remember that these materials are then lost from circulation and will thus not contribute to material shortage issues.

VTT's new nanocellulose electrocardiogram (ECG or EKG) patch is a good example. Because the device is modular, electronic components can be easily removed from the disposable patch and used again. The patch itself is biodegradable, consisting of nanocellulose and printed with carbon conductors and sensing electrodes. Traditional ECG patches are made of plastic-based materials with electronic components that can't be removed.

Pushing Progress in the Right Direction

The electronics industry has several possibilities to decrease its environmental impact. It all starts at the design phase with the selection of layouts, materials, and manufacturing processes. New materials and processes are currently being scaled up for the electronics industry to start using them.

However, all three aspects of sustainability—environmental, social, and economic—are important to consider when finding an optimal balance between cost, performance, and environmental impact for future electronic products. ED

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STEVE TARANOVICH | Contributing Editor

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Control Ambient Noise

Through Isolation and Cancellation

Different methods of passive and active noise isolation and noise cancellation, or combinations of the two types, can be applied to help defeat the noise that plagues most all electronic systems.

THE MOST OBVIOUS way to get rid of ambient noise is to employ some form of passive or active noise cancellation (ANC). The type of ANC we're familiar with today was coined in 1989 by Dr. Amar Bose with the Series I Aviation Headset by Bose Aviation.

Noise Isolation and Cancellation

Passive noise isolation can be accomplished by blocking ambient sound using physical barriers. When we cover our ears with our palms, we reduce ambient noise. Headphones, with foam pads in the ear cups, are creating a secure seal around our ears that isolates your ear from any ambient sound. This easy method is only mildly effective—any sound, albeit lower in volume, will still get through to our ears, depending on the fit, materials, and design of the headphones.

Active noise isolation (ANC) uses a system of components that are placed within the ear cups of headphones. This offers a better means to block off ambient sound. Tiny microphones "listen" to the ambient sound all around us, leading to the sound wave data that will be relayed to a built-in chipset. That chipset will enable algorithms to produce an opposing soundwave (180 degrees out of phase with the noise) through the speakers and into our ears. This will cancel out incoming ambient sound waves.

Some common methods to control electronic/electrical noise in systems include:

Noise isolation

Noise isolation is also known as "passive noise cancellation." This method blocks pesky noise via the usage of physical barriers like your hands or headphones.

Environmental noise cancellation (ENC)[1]

It's all around us! That is… environmental noise! Many of us who live or have lived in a busy metropolis like I did in Brooklyn, N.Y., just got used to the con-

stant drone of motor vehicles (thank you for electric vehicles) and noisy clanking, screeching, whining, and more.

Active Noise Cancellation Explained: What is ANC in Headphones?

Headphones achieve phase cancellation for their ANC features via two primary components:[3]

- *Beamforming microphones:* These are used to record environmental noise.
- *Sound cards:* Typically, a digital signal processor (DSP) will be employed. The card receives the noise signal and intervenes in its phase character.

A headphone performs ANC in this manner:

- Headphones, with a beamforming microphone, will record the listening environment.
- The audio is then picked up by the microphone(s) and that audio is sent to the DSP in the headphone electronics.
- The DSP will then invert the phase of the received audio.
- The noise is cancelled or significantly reduced via phase cancellation. It occurs when the sound waves, from the environment, get added to their phase-flipped duplicates, which are produced via a DSP and speakers within the headphones.

Phase cancellation uses identical waves, 180 degrees out of phase, which will cancel each other. This action makes the ANC effect possible *(see figure)*.

Typically, non-ANC headphones can reduce any sounds at mid-to-high frequencies as much as 15 to 30 dB. These types of headphones aren't very effective at reducing any low-frequency sounds (20 to 800 Hz), such as the noise from car engines, aircraft engines, and air conditioners.

So, ANC headphones are able to typically block an added 30 dB of low-frequency noise below 1 kHz. ANC headphones can also reduce ambient sound by as much as 60 dB. This will depend on the use of active and passive components used in the headphone electronics.

ANC performs best when reducing noise that repeats, such as an air-conditioner vibration. However, reduction isn't as good with sudden loud noises.

There are shortfalls with ANC, though. This is because ANC functions via the recording of ambient noise and will process this noise before the speaker output. Unfortunately, latency is a nasty shortcoming in ANC systems, regardless of using a feedback or feedforward structure.

A multi-rate signal-processing method can minimize electronic delay within the control loop. This technique employs digital controllers that are necessary in the interpolation and decimation of discrete-time signals. Computation efficiency can be further enhanced by using a polyphase method. This approach necessitates the use of phases of low-pass finite-impulse-response (FIR) filters that must be carefully designed to avoid unnecessary delays.

Acoustic hear-through technology

Standard in-ear headphones have a high-level isolation. Ambient sounds that are transmitted to our eardrum will get attenuated as they flow through headphones being worn by users.

Acoustic hear-through (HT), a.k.a. the acoustic transparent transmission technique, is used to enable the natural listening of ambient sounds for users wearing headphones.[4,5] If the in-ear headphones have ANC, the design of an acoustic HT digital filter can embed the headphone system with that HT function.

When combined with the speech spectral subtraction algorithm, the speech enhancement is applied based on the HT system to achieve selective HT of noisy speech.

Through experiments and simulation, a full-band HT filter has been designed using known actual acoustic transmission path parameters that are combined with hardware conditions. The transfer function has been compared with that of a system without headphones or HT headphones. The result led to superior HT performance that was accomplished in the observed frequency band.

Best Grounding Techniques to Minimize Noise

Many methods will help to lower noise in electronic circuitry, such as the use of a star ground, differential signal path, or a robust ground plane. Electromagnetic-compatibility (EMC) grounding employs an equipotential point/plane that's a reference point for all circuit components. This serves as a low-impedance path

In active noise cancellation, the active microphone picks up ambient noise and creates an inverted sound wave. The two waves will cancel each other out.

that enables the current to return to the signal source.

Robust EMC grounding is needed to minimize emissions, coupling interference, and susceptibility. Designers must observe the signal's frequency, amplitude of the current, an effective impedance path, and the maximum voltage noise that the circuitry must be able to tolerate. Designers must be aware of improperly grounded circuitry that can create common-mode noise in the circuitry.

Higher levels of EMI will appear with a large area of ground loops and a high impedance in the grounding path.

Digital Isolators vs. Optocouplers

Digital isolators have many advantages over optocouplers, such as size, speed, power consumption, ease of use, and reliability.[9]

Optocouplers (i.e., optical isolators) are an effective, alternative isolation technology as compared to digital isolators. Optocouplers use LEDs to transmit light data across an isolation barrier: When the LED turns on, the optocoupler burns power; thus, it's a poor choice when power consumption is a concern.

Digital isolators, in many cases, may prove to be a better solution for myriad types of applications. Digital isolators have the advantage of better power-consumption efficiency, faster data rates, and lower propagation delays than optocouplers. Digital isolators also offer higher reliability than optocouplers because they don't suffer from such issues as LED failures or interface contamination.

Designers should use short trace lengths between a digital or optical isolator and the surrounding circuitry. This will help prevent any noise pickup.

Also, digital and optical isolators may be used with isolated DC-DC converters, which enables supply power across the isolation barrier.

Single-ended transmission signaling is sensitive to noise pickup. The 500-kHz to 3-MHz switching frequencies, from DC-DC converters nearby, can be picked up via long signal traces.

More Noise Isolation and Cancellation Techniques

Signal averaging (SA)

Signal averaging is a technique to increase signal-to-noise ratio (SNR). It may be applied in such fields as nanotechnology and biomedical engineering. If we assume that the noise is random and of zero mean, its average across multiple signals will tend towards zero. (Zero-mean noise is a random signal that will not exhibit any net disturbance or bias. The signal will oscillate randomly around a true value; the positive and negative values will eventually cancel each other out. Zero-mean noise is serially uncorrelated, so that each sample is independent of the previous ones.)

A good example of zero-mean noise is white noise, which has a constant power spectrum. Every additional measurement in the average should lead to raising the SNR. For the SA to function, averaged signals should be in-phase. If these signals aren't in-phase, the obtained average will not be accurately characterizing the sampled signals. That's because their unique fragments will be repeated or distorted.

Filters

There are four main filter types for circuits:

- *Low-pass filter:* Prevents high-frequency signals from passing through.
- *High-pass filter:* Prevents low-frequency signals from passing through.
- *Bandpass filter:* Only a certain range of frequencies can pass through.
- *Notch/band-reject filter:* Blocks a specific range of frequencies.

Amplifiers with differential inputs

Differential circuits will always offer better performance over single-ended circuits.[10] Differential circuits provide higher linearity and immunity to common-mode interference signals.

Summary

This article provides noise isolation and cancellation techniques. Sometimes, combinations of these methods will further enhance the noise-cancellation capability. Headphones, earplugs, or earphones typically appear at the top of the list of methods to employ.

A passive method in noise isolation is the physical blocking of any external sounds from reaching the human ear. It relies on the design and construction of headphones or earbuds to create a seal around the ears or within the ear canal, preventing outside noise from seeping in.

Noise cancellation is defined as an active technique which employs electronic circuitry and external microphones that will counteract any incoming sounds. It proves more effective for low, constant sounds, while noise isolation is better for mid-to-high frequencies. ed

Read more articles in the TechXchange: Delving into EMI, EMC and Noise.

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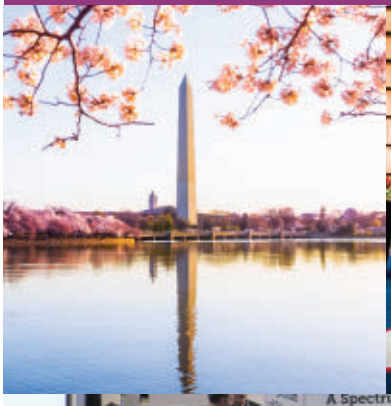

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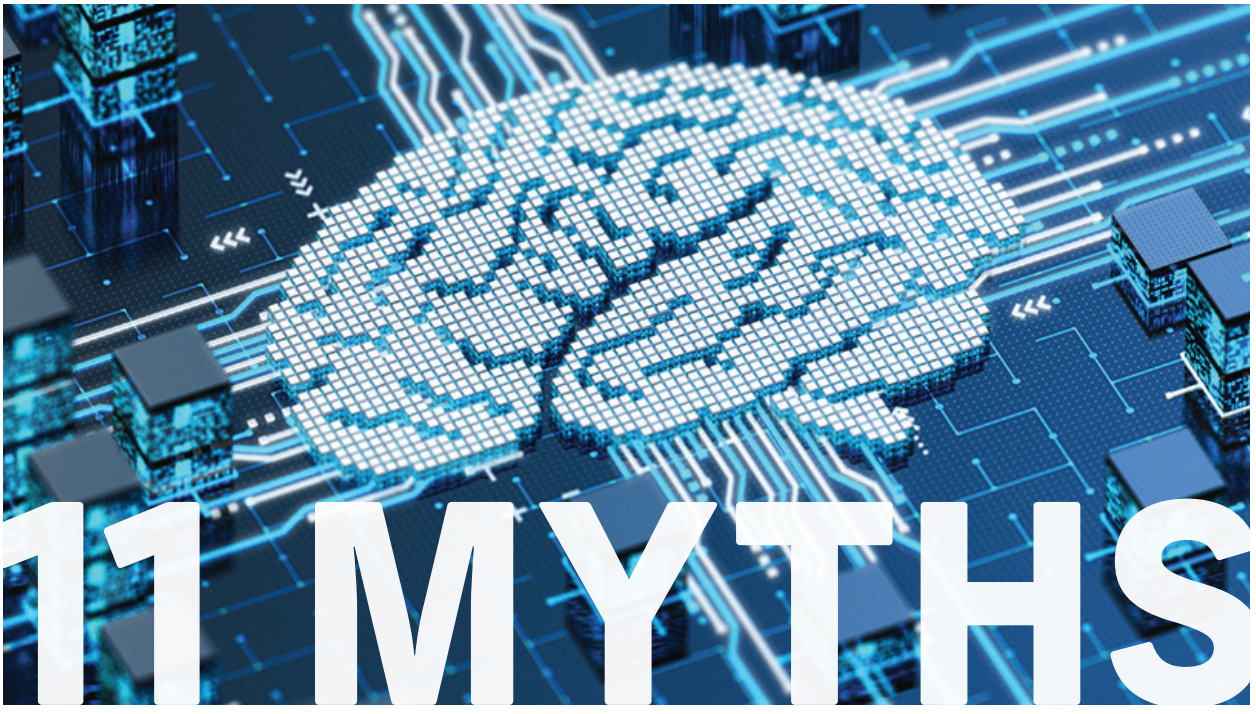

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About **Generative AI**

Lauro Rizzatti breaks down the potential, deployment, and value of generative AI, along with misunderstandings and exaggerations to help debunk myths surrounding the technology.

LAURO RIZZATTI HAS turned his vast understanding of the semiconductor and verification markets to generative AI to better understand its benefits and limitations, something long overdue as myths and misconceptions multiply across the internet. Below he debunks 11 of those myths surrounding the technology.

1. Any computing engine, whether CPUs, GPUs, FPGAs, or custom ASICs, can accelerate GenAI.

Not true. CPUs don't have the performance to accomplish the task. GPUs possess the nominal performance but suffer low efficiency that crashes the deliverable speed to a fraction of the nominal specification. FPGAs are less than ideal for the job.

Custom ASICs, when tailored to a specific task, are the only viable solution.

2. GenAI accelerators can handle both training and inferencing.

In principle, it's possible to train and infer a model with the same GenAI processor. The reality is that training and inferencing are two different tasks with unique attributes. While model training and inference share performance requirements, they differ on four other characteristics: memory, latency, power consumption, and cost *(Table 1)*.

The unique set of attributes lead to GenAI processors with rather different characteristics. Typically, the model training is carried out on extensive computing farms built on vast arrays of state-of-the-art GPUs. They run for days, consume large amounts of electric power, and cost up to hundreds of billions of dollars.

The real problem resides with inference at the edge. Edge GenAI processors today can only execute models tailored to specific tasks. No GenAI hardware is able to run interference on the full GPT-4.

3. Custom GenAI accelerators trade off programmability for performance.

While this may be correct for some custom implementations, it's not true for a practical solution. An ideal solution must be programmable to allow for in-field upgrading. AI in general and GenAI in particular are endeavors in constant

Attributes	Training	Inference
Memory	FP32 or FP64	FP8
High Throughput	Critical	Critical
Low Latency	Important	Critical
Constrained Power Consumption	Important	Critical
Affordable Cost	Important	Critical

Table 1: Algorithm training and inference share some but not all critical attributes. *VSORA*

Integer	Energy
Add	
8 bit	0.03 pJ
32 bit	0.1 pJ
Mult	
8 bit	0.2 pJ
32 bit	3 pJ

FP	Energy
FAdd	
16 bit	0.4 pJ
32 bit	0.9 pJ
FMult	
16 bit	1 pJ
32 bit	4 pJ

Memory	Energy
Cache	64 bit
8 kB	10 pJ
32 kB	20 pJ
1 MB	100 pJ
DRAM	1.3-2.6 nJ

Table 2: The tables compare energy consumption of simple arithmetic operators versus memory access.

evolution. Today's cutting-edge AI algorithms will be obsolete tomorrow. New larger, more powerful algorithms will replace them. Expensive hardware solutions must be upgradeable in the field for at least three years.

4. GenAI accelerators consume less energy than traditional computing resources.

The reality is the opposite. Data processing consumes less energy than moving data. As numerically shown in a study from Stanford University led by Professor Mark Horowitz, power consumption in CMOS ICs is dominated by data movement, not data processing *(Table 2)*.

The power consumption of memory access consumes orders of magnitude more energy than basic digital logic. Adders and multipliers dissipate from less than one picojoule when using integer arithmetic to a few picojoules when processing floating-point arithmetic.

By contrast, the energy spent accessing data in cache jumps one order of magnitude to 20-100 picojoules and up to three orders of magnitude to over 1,000 picojoules when data is accessed in DRAM. AI and GenAI processors are examples of design dominated by data movement.

5. Large language models (LLMs) are evolving with newer versions that are smaller than previous generations, since algorithm engineers learned how to reduce their dimensions without compromising functionality.

Not really. Since LLMs were created several years ago by a Google research team, they have constantly improved and, in the process, grown larger and larger. The trend continues and poses a challenge to the computing hardware. Attempting to alleviate the pressure on the hardware design community, software modeling teams design smaller models to address specific tasks in narrow applications.

6. Creating LLMs is just a software modeling endeavor; it requires no specific skills.

According to a panelist at the recent "2023 Efficient Generative AI Summit," there are possibly 100 software designers in the world with the talent to design effective and efficient LLMs. Giving the panelist the benefit of the doubt, LLM development is an engineering endeavor as much as an artistic conception that requires a unique skill set not in abundance today.

7. A single LLM will define all use cases.

This may be every LLM development teams' dream, but the truth is that such a goal may never be achievable. An LLM usable for text generation and image/video/music creation across the entire universe of applications, including financial, legal, medical, scientific, industrial, commercial, educational fields, and more, would lead to a model of astronomical dimensions. It's not practical to design and virtually impossible to train and deploy.

8. GenAI is effective in all languages.

As a general statement, a GenAI model is trained on a specific language and then deployed in inference in the same language environment. To date, the development language has been English, but versions in other languages, such as main European and Asian languages, do exist.

In principle, it's always possible to train and then deploy a model in any language, but the source data necessary to thoroughly train a model may be insufficient.

9. GenAI is unbiased and objective.

AI is built on a statistical, not deterministic, foundation. GenAI responses embed a degree of uncertainty. They

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ought to be accepted on the basis of being "probably" correct. They're often correct; it's infrequent when they're wrong. The human overlooking the GenAI application should always evaluate the response with a critical mind.

10. GenAI can replace human creativity and innovation.

A resounding no. As stated in response to Myth #8, GenAI responses must be evaluated by a human with a deep knowledge of the specific field in which GenAI has been applied. Ignoring the assessment may lead to trouble, ultimately jeopardizing the institutions of an entire country, ruining education, and enabling plagiarism.

Still, GenAI has the potential to lift human productivity. A June 2023 report from McKinsey titled "The economic potential of generative ai" stated that Generative AI could add up to $4.4 trillion annually to the global economy across 63 analyzed use cases. The estimate might double when adding the impact of embedding generative AI into software currently used for other tasks beyond those use cases.

As stated in response to Myth #8, GenAI responses must be evaluated by a human with a deep knowledge of the specific field in which GenAI has been applied.

11. GenAI is too new and too risky.

GenAI is indeed new, but not risky. It's a misconception to believe that humanity will disappear because GenAI has gone off track. The concern stems from some "chatbots' threats to destroy humans" reported by bloggers, researchers, and the like.

It's important not to take emotional responses to AI too seriously. After all, as discussed in WIRED magazine, we're capable of downplaying reactions to inanimate objects. Pinocchio, for example, tells us he wants to be a "real boy," but why do we react with an emotional breakdown when a chatbot says she wants to marry us. ed

MIKE HACK | Vice President, Business Development, Universal Display Corporation (UDC)

The Green Dot that Changed How We See the World

Organic LEDs (OLEDs) evolved from a single green dot to the high-definition displays we use every day. As advances continue to transform the technology, applications such as foldable smartphones and next-gen EV displays will grab the spotlight.

GREAT MINDS ASPIRE to discover ideas that will change the world. We can all envision the "light bulb" moment when the connections between knowledge, creativity, inspiration, and innovation rapidly form and result in a novel concept. For Sherwin Seligsohn, the founding father of Universal Display Corporation, a literal light—a small green dot—set his mind in motion and inspired a path to a display revolution that has changed the way many of us see the world.

This pioneering journey began in the 1990s, when Seligsohn read about the novel research work on organic self-emissive organic materials by Drs. Forrest and Thompson. He decided to explore this groundbreaking technology with a visit to the electrical engineering school at Princeton University.

While there, he observed a green dot, with a 9-V battery hanging from it, light up for only a couple of seconds. From this tiny organic green dot, Seligsohn envisioned the future of display technology—energy-efficient OLEDs (organic light-emitting diodes).

Today, energy-efficient phosphorescent OLEDs emit light and color in about half of all smartphones worldwide and are used in devices including smartwatches, laptops and tablets, TVs, as well as AR/VR devices and automobiles. From the green dot discovery to modern OLED displays, numerous technological advances and a transformation within the display industry were required before OLEDs could be seen in popular electronics globally.

While a "light bulb" moment could happen instantly, the pace of innovation is often complex and steady, requiring a methodical effort of research and development to achieve breakthroughs, meet customer requirements, and unveil new paths forward.

OLEDs: From Idea to First Prototype

Before OLEDs entered the market, cathode-ray tube TVs were the dominant technology available to consumers. Though LCD TVs were still improving and gaining traction, the display industry was rife with opportunities to be disrupted.

However, the barriers to entry were high. Although backplane technology was maturing, the world didn't have an OLED ecosystem that could support the proliferation of OLED displays throughout the consumer electronics landscape.

There were also complex scientific and engineering challenges, such as developing a commercial phosphorescent OLED (PHOLED) material with the necessary color and lifetime for high-performance consumer products. Consumers own and use devices for years, a far cry from the several seconds offered by the original green dot.

In addition to inventing and commercializing PHOLED materials that met consumer specifications, the innovative material had to be mass-produced in high volumes and with purity levels higher than some pharmaceutical drugs.

Meeting Customer Demands and Eliminating Barriers

Even after overcoming the initial scientific and engineering challenges, UDC also faced new challenges due to having PHOLED materials incorporated into devices. When display manufacturers were first introduced to OLEDs prior to the emergence of UDC's technology, they weren't immediately impressed because most associated the technology with inefficient fluorescent technology.

Furthermore, this kind of technology wasn't competitive with LCDs because of the high-power consumption of fluorescent materials. When UDC introduced PHOLEDs with the possibility of reducing power consumption by a factor of three to four, OLEDs became compelling.

Existing OLED display panel manufacturers began to warm to the idea of using phosphorescent OLED technology due to its ease of adoption. However, engineers needed to update the design of the TFT backplane used to drive the display. Because backplane changes are routine in a design-in cycle, panel makers could introduce energy-efficient OLED technology into production quickly and realize the benefits of phosphorescence.

Another convincing feature was the groundbreaking form factors and stunning visual performance that OLEDs make possible. While LCDs are typically limited by the rigidity of glass, OLEDs are thin film layers that can be deposited on glass, plastic, or even metal foil. OLEDs are inherently conformable, bendable, and rollable. While this trait could not be immediately utilized in the early days of OLED, it was part of the ubiquitous OLED future envisioned by Seligsohn and UDC.

Finally, OLEDs have excellent visual performance due to the wide color spectrum, fast response times, near-infinite contrast ratio under dark conditions, thin form factor mentioned above, and 180-degree viewing angle. With PHOLEDs adding energy efficiency to the list of attributes, manufacturers were keen to take advantage of OLEDs' benefits in a range of consumer applications.

OLED Technology: Ready for Prime Time

In the early days of the OLED market, the primary consumer electronics applications were cell phones and MP3 players. With battery life being a critical factor in mobile products (as it continues to be today), improvements in OLED technology and materials enabled OEMs to deliver more efficient displays than the mainstream display technology of LCDs.

The first commercial display utilizing phosphorescent OLED technology was released in 2003 with a Fujitsu flip phone. The phone used red PHOLED material as part of a small sub-display on the front of the closed clamshell phone, which allowed the viewer to see the time and date. Only three years later, phosphorescent OLED material was designed into the first commercial active-matrix OLED display of a cellphone, the BenQ-Siemens S88.

The actual rise of OLEDs came when smartphones were introduced into the market. With the advent of the smartphone, quality displays and performance prompted consumers to shift from using their phones primarily for telephone and text to using them as multipurpose devices.

In 2010, Samsung Electronics ignited the industry by unveiling its flagship Galaxy S model smartphone, which featured an OLED display. Samsung's commitment to high-quality, energy-efficient OLED displays bolstered the OLED industry, prompted huge capacity investments, and sparked the proliferation of OLEDs.

What's Next for the OLED?

Since the advent of energy-efficient phosphorescent OLEDs, Seligsohn's company has continued to make breakthroughs in high-performing, highly efficient display materials and technology that enable low-power, eco-friendly displays and lighting. OLEDs are quite literally everywhere we look, from our modern-day smartphones to TVs, smartwatches, laptops, AR/VR headsets, screens in cars, and more.

While a tiny green dot started a cascade of research and innovation that pioneered a path forward and supported the OLED industry, those of us who understand this technology's power still feel there's much more ahead.

The growing importance of energy efficiency is driving the best scientists and engineers working in OLED technology to push boundaries. The commercial phosphorescent OLED portfolio currently includes red and green (mostly used for mobile phones, tablets, and laptops), as well as yellowish green (for certain OLED TV recipes).

OLED devices using PHOLEDs are significantly more energy-efficient than LCDs, and Universal Display is the sole source supplier of these materials to the world's largest display panel makers. The forthcoming addition of the company's phosphorescent blue into the market in 2024 is expected to further increase OLED display energy efficiency by approximately 25% as well as enhance performance capabilities in products across consumer electronic markets.

Plasmonic PHOLEDs and Flexible Substrates

UDC's team is also working on the research and development of Plasmonic PHOLEDs, which centers on a proprietary and novel device architecture that extends the OLED panel's lifetime and enhances its efficiency. This work is part of the company's long-term energy-efficiency roadmap to broaden OLED solutions. Continual improvements in energy efficiency results in higher performance, longer battery life, and brighter displays in a variety of devices, from small smartwatches to big-screen TVs.

Another significant development comes from the fact that OLEDs are more widely deposited on flexible substrates. This means that displays are no longer made on flat, breakable glass but rather highly flexible, bendable, and rollable plastic and other substrates. This opens a vast array of new opportunities for displays that can be seamlessly integrated into everyday devices and be folded, rolled, and curved without compromising visual quality or performance.

In fact, some market analysts estimate that the foldable smartphone market will quadruple to 55 million units by 2025, with companies like Google, Oppo, Samsung, Vivo, and Xiaomi already offering foldables.

Finally, the automotive industry is becoming an increasingly important market for OLEDs as more automakers envision the dashboard of the future and release new electric-vehicle models. OLEDs' interior displays in our cars, taillights, and even mirrors can be enhanced to allow for wider viewing angles, better performance in extreme temperatures, improved energy efficiency, and more.

From the invention of phosphorescent OLED technology to the discovery, development, and delivery of next-generation OLED materials and technologies, the legacy of the green dot and Seligsohn's work are supporting UDC and the OLED industry as we collectively continue envisioning, shaping, and strengthening the future of OLED technology. ED

CABE ATWELL | Technology Editor

The Best Python Compilers and Interpreters for Developers

The Python programming language and its applications can be supercharged by these leading compilers and interpreters.

CREATED BY GUIDO van Rossum in 1991, Python has become a popular coding language used by many developers and engineers due to its ease of use and reliability. The language is characterized by its readability, straightforward syntax, and versatility, allowing it to be used with multiple operating systems without modification. That versatility also extends to the number of compilers and interpreters used to execute programs.

A compiler is a software tool that translates Python code written in a high-level, human-readable form into low-level machine code or "bytecode" that can be executed directly by a computer. The compiled code is typically more efficient and faster to execute than the source code. Compilers can also optimize code, perform static-type checking, and generate standalone executable files.

Interpreters are software programs that read and execute programs. They're an essential component of the Python programming language, enabling developers to run scripts or interact with the programming language. They read, parse, execute, runtime, output, and handle errors. Like compilers, interpreters are available for a myriad of platforms and wide range of applications, including web development and scientific computing.

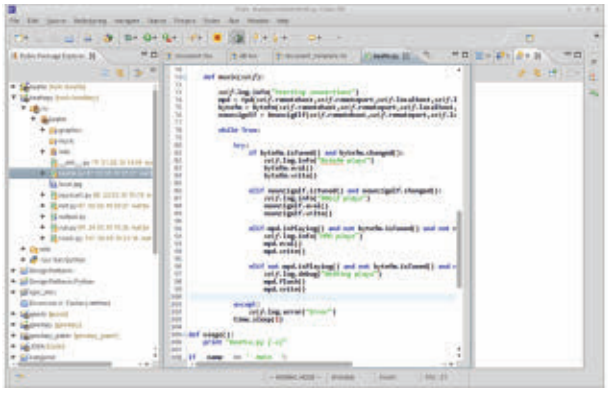
Compilers and interpreters are designed to facilitate speed, efficiency, and compatibility for any number of applications. They're fundamental tools that enable the development of Python code, providing versatility, accessibility, and innovation within the software development ecosystem, from web development and scientific computing to artificial intelligence and more.

In this roundup, we look at some of the popular compilers and interpreters for the Python coding language:

PyDev

PyDev is a third-party plug-in for the Eclipse IDE used in Python, Jython, and IronPython development. It's designed to enhance the Python development experience by offering a range of features and tools to aid coding, debugging, and even project management. The platform features an editor with syntax highlighting, code completion, and code analysis.

PyDev.org



It also packs an interactive console, allowing developers to run Python code and experiment with snippets without leaving the development environment.

PyDev also features a debugger with step-by-step options, variable inspection and code breakpoints. It offers Django support, code refactoring, code templates, version control integration, and unit testing. Moreover, it provides third-party library integration, including those from NumPy and Matplotlib.

However, PyDev does have some disadvantages, including unstable plug-ins and library components, and its performance decreases when using multiple plug-ins.

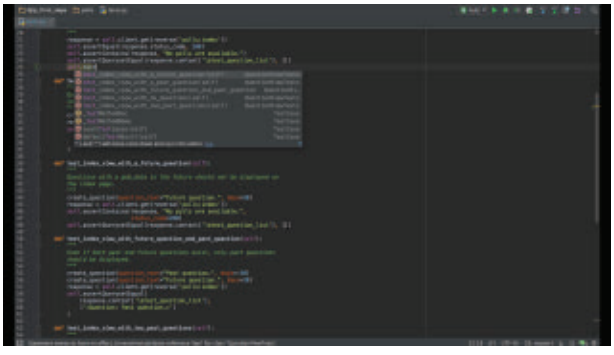
PyCharm

Another great compiler for Python is PyCharm. It's compatible with multiple operating systems, including Linux, macOS, and Windows. The compiler has many modules, packages, and tools to help streamline Python development and increase efficiency. It can also be customized depending on requirements and user preferences.

PyCharm offers several helpful features, including an intelligent code editor that facilitates writing Python code, which offers enhanced code comprehension and readability via color schemes for keywords, functions, syntax and more. It also supports integrating tools, such as Anaconda, IPython, Kite, Pylint,

WakaTime, and others. Moreover, PyCharm works with scientific libraries, including Matplotlib and SciPy, to help users with data science and machine-learning projects.

Additional PyCharm features include an integrated debugger and testing programs, multi-technology development for creating web applications, project and code navigation, refactoring, VCS integration, remote development, and more. It has a few drawbacks, though, including a steep learning curve unsuitable for beginners, and it takes a significant performance hit when dealing with large data.



JetBrains

Programiz

Programiz is more of a learning platform for beginners learning to code with Python, but it provides a great online and mobile app compiler. Beyond Python, it can be used with programming languages such as C, C++, Java, and others. An interactive code editor allows users to write, run, and test code snippets directly on the platform. The platform is free, although there's a Pro version geared toward certificate earning for those pursuing an education in coding.

Programiz also offers an extensive library and community to make it more useful for programmers. While the platform is more for beginners, there are some drawbacks for experienced compiler users—it takes lengthy periods to execute code and large programs tend to bog the online version down or simply won't work.

Programiz

Spyder

Spyder

A free and open-source IDE compiler for the Python programming language, Spyder is designed for scientific and data science programming. It provides a powerful and interactive environment for data analysis, scientific research, and development. The compiler is feature-rich and includes an interactive console where users can execute Python code line-by-line—a helpful tool for data analysts. It also packs a code editor with syntax highlighting, code completion, and more.

Another key feature is a variable explorer that enables users to manipulate variables, arrays, and data structures. In addition, there's a plot viewer to create and visualize plots and graphs, a debugger, a project explorer to store and manage projects, iPython integration, and a plug-in system.

Like the other compilers, Spyder has some issues. For instance, it can be difficult to navigate, it doesn't offer a standard layout, and finding the terminal can be problematic.

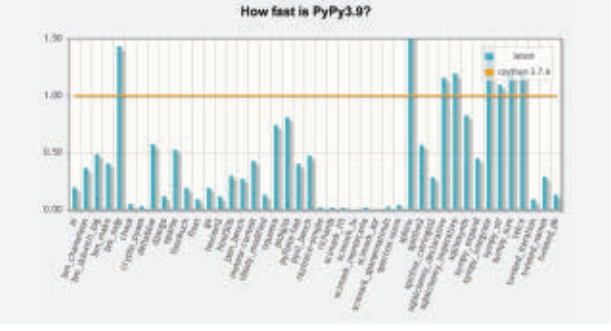
CPython

CPython is the default implementation of the Python programming language that can be defined as both an interpreter and compiler as it compiles Python code into bytecode before interpreting it. It provides a foreign function interface with several languages, too, including C and other programming languages. The open-source interpreter/compiler features dynamic typing, meaning that variable types are determined at runtime, and users can change the variable type on the fly during execution.

Maciek905_50188994 | Dreamstime

With CPython, users can manage memory using reference and garbage collecting to clean up objects with circular reference. The platform has an extensive library that provides a host of modules and packages for various tasks, making it useful for a wide range of applications. It also allows for integrating C and C++ code through some of those modules, making it possible to optimize critical sections of code using existing C libraries and interface with low-level system functions.

CPython does have some issues, including the use of GIL (Global Interpreter Lock), which can pose a limitation as it turns off the concurrent Python threads for a process. It's also slow compared to other languages, such as Java, and has issues with runtime errors as the language is dynamically typed.



PyPy.org

PyPy

PyPy is a runtime interpreter that's faster than a fully interpreted language but slower than a fully compiled one. The interpreter provides many valuable features, including a just-in-time compiler to translate Python code into machine code at runtime. It also has better memory management and provides improvement over CPython when it comes to reducing needed resources for long-running processes and applications.

Pluggable garbage collectors let developers choose the best approach for their memory-management requirements. And an interactive debugger enables users to look through and inspect Python code as it's executed. On top of that, PyPy supports extensive libraries, can be integrated into existing C extension modules, and has cross-platform compatibility.

That said, it does have compatibility issues with some C extension modules, and the performance can vary depending on the workload and nature of the Python code being executed.

IronPython

An alternative Python programming language implementation, IronPython is designed to run on the .NET Framework and .NET Core platforms. It's an open-source project that allows Python developers to work with .NET technologies, including libraries, components, and services. It also provides full access to the Common Language Runtime (CLR) platform, the heart of the .NET framework. This means developers can create and manipulate .NET object methods and inherit from .NET classes.

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IronPython supports dynamic and static typing, making it flexible for both Python-style dynamic coding and more structured .NET. Like some other interpreters, IronPython supports cross-platform utilization, making it essential for running Windows-based systems. Moreover, the platform integrates with Microsoft Visual Studio for increased .NET development. An Interactive Mode lets users enter Python commands and visualize the results immediately.

As with some other interpreters, IronPython does have some drawbacks. For one, it's slower than CPython in execution speeds.

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Jython

Jython is another implementation of Python designed for the Java Virtual Machine (JVL), meaning Python code can be executed within the Java ecosystem. The platform provides interoperability between Python and Java libraries and components. Thus, they can coexist within the same project. It also allows for embedded scripting, which lets developers add Jython libraries to their system so that end users can write simple or complicated scripts for increased functionality of applications.

An interactive interpreter can be used to interact with Java packages or run Java-based applications. This lets developers experiment with and debug their applications. According to Jython, the platform also opens the door to rapid application development, as Python programs are typically 2X to 10X shorter than the equivalent Java program.

However, Jython does suffer from some issues. This includes performance loss due to the JVM overhead and compatibility, as Jython isn't always up-to-date with the latest Python features. ed

ALIX PAULTRE | Editor-at-Large

What is the ***Inside Electronics*** Podcast?

With its mix of interviews and commentary, the new podcast, hosted by Alix Paultre, puts a different spin on the latest developments impacting the electronics industry.

***ELECTRONIC DESIGN* HAS** been serving the engineering community with pride for decades, providing you with news, commentary, and interviews about what is going on in the industry. Through text articles and videos, we've shown you the latest and greatest solutions and people in an engaging, informative, and interesting way, and we're expanding that footprint with our new podcast, *Inside Electronics*.

Hosted by industry veteran Alix Paultre, the podcast will also bring you commentary, news, and interviews about the things going on in the electronic design engineering community and its surrounding business ecosystem—but from a different perspective. Tune in to our biweekly *Inside Electronics* podcast to check out the discussion and analysis on the latest developments making an impact across the electronics landscape.

This **High-Speed Eight-Channel Oscilloscope** Claimed as the Fastest

Alix talks with Rohde & Schwarz's Dr. Ernst Flemming and CS Wong about the new MXO 5 oscilloscope featuring four-channel bandwidth up to 2 GHz.

IN TODAY'S EPISODE of *Inside Electronics,* we talk about Rohde & Schwarz's latest R&S MXO 5 oscilloscope with Dr. Ernst Flemming, the company's Director of Product Management, and Chun Soong (CS) Wong, Product Manager.

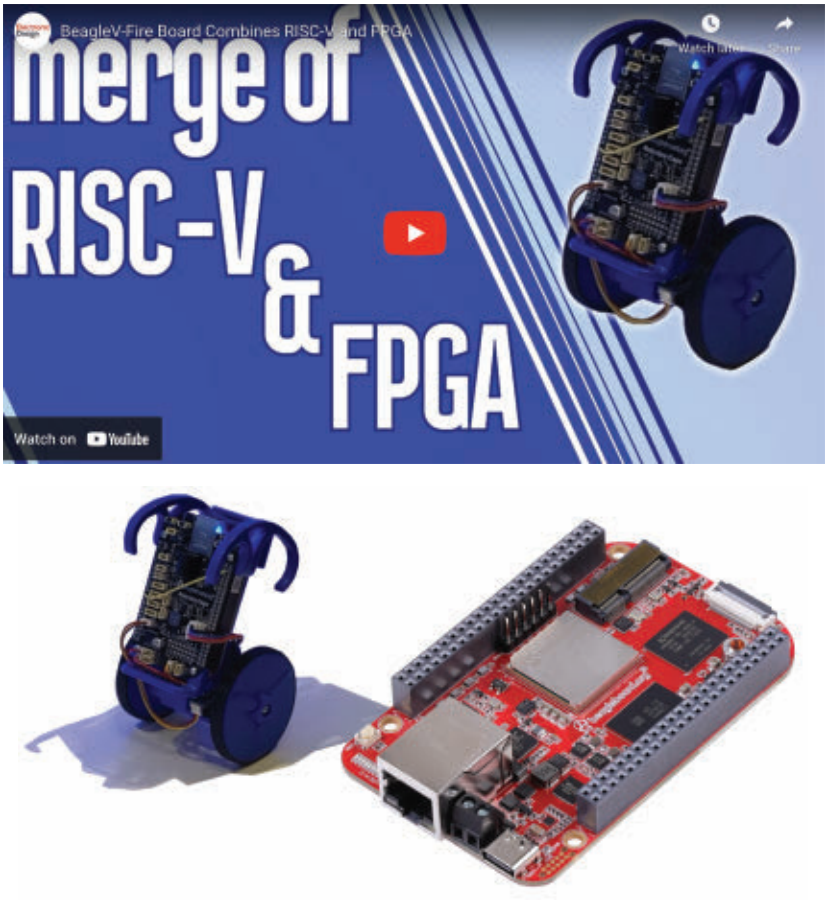
A next-generation solution created to address the latest design challenges, the R&S MXO 5 is presented as the fastest oscilloscope available.

Features include a four-channel bandwidth of 350 MHz to 2 GHz, and an eight-channel bandwidth from 100 MHz to 2 GHz, with an 18-bit vertical resolution and 12-bit ADC. Offering the deepest in-class standard memory at 500 Mpoints, according to R&S, it maintains a simultaneous spectrum acquisition rate of 45,000 FFT/s and up to 4 spectra. The oscilloscope's 15.6-in. HD capacitive touchscreen and very low audible operating noise maximize performance while minimizing power consumption.

BILL WONG | Senior Content Director

BeagleV-Fire Board Blends RISC-V and FPGA

The BeagleV-Fire targets robotics and control applications with a Microchip SoC FPGA.



1. The balancing robot (left) is powered by the BeagleV-Fire (right) as shown in the video (above). *BeagleBoard*

I WAS ABLE to talk with Jason Kridner, founder of BeagleBoard.org, about the organization's latest BeagleV-Fire platform *(Fig. 1)*. The video *(right)* shows the board controlling a balancing robot.

The BeagleBoard family of modules is built around a dual 46-pin BeagleBone cape header. The BeagleV-Fire is the latest platform. In the demo, a BeagleBone cape with interfaces is used for motor control to handle the wheel motors. The balancing act is trivial with minimal load on the FPGA or RISC-V cores, but it's visual. The possibilities with an FPGA SoC are very interesting, though.

BeagleV-Fire is built around a Microchip PolarFire MPFS025T FPGA SoC. This includes a five-core RISC-V system—a 64-bit, SiFive E51 RV64IMAC control processor and four 64-bit, RV64GC SiFive U54-MC cores. The latter includes virtual memory support capable of running operating systems like Linux.

The FPGA incorporates 23K logic elements, 68 math blocks (18 × 18 MACC), and four 12.7-Gb/s SERDES. A SYZYGY connector on the board is targeted at high-speed FPGA connections. The SoC also has 128 kB of eNVM and 65 kB of sNVM.

The module includes 2 GB of LPDDR4 memory, too. Non-volatile storage comes in a 16-GB eMMC chip and 128-Mb SPI flash. Furthermore, there's a microSD socket and an M.2 E-Key socket, although that tends to be used for a wireless adapter such as Wi-Fi/Bluetooth. It supports PCIe and SDIO interfaces. Also in the mix is a single, 22-pin CSI camera connector. Gigabit Ethernet is built-in and the USB Type-C operates at 480 Mb/s. And there's a 6-pin, 3.3-V UART connection plus JTAG support.

In case you want to work with RISC-V but don't care to have an FPGA on-chip, then the BeagleV-Ahead might be a better bet. This board is built around an Alibab T-Head TH1520 SoC with a 2-GHz, quad-core, 64GX Xuantie C910 processor with a 4 TOPS@INT8 network processing unit (NPU). It also offers a 50-GFLOPS, 3-Mpixel/s Imagination GXM-4-64 GPU.

This board includes 4 GB of LPDDR4 as well as a 16-GB eMMC flash memory. Memory expansion is via a microSD socket. The system supports Ethernet, dual-band Wi-Fi, and Bluetooth. Other features are a micro-HDMI output, a mikroBUS connection, two CSI camera interfaces, and a DSI connector.

The BeagleBoard family is a popular alternative to Arduino and Raspberry Pi. Microchip's Libero SoC Design Suite provides FPGA programming support. The RISC-V processors can run BeagleBoard Linux, which comes preinstalled.

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