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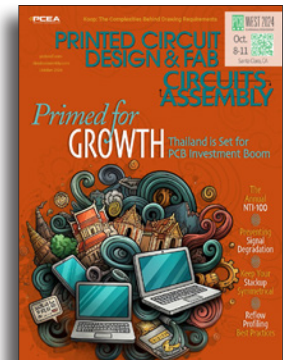

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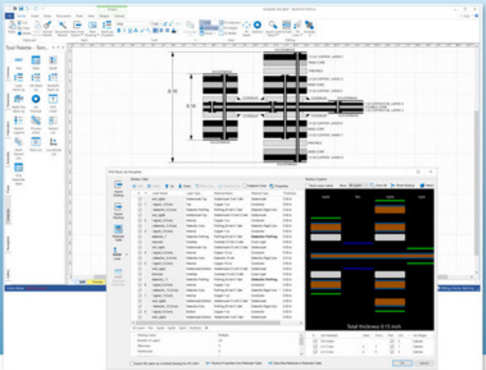

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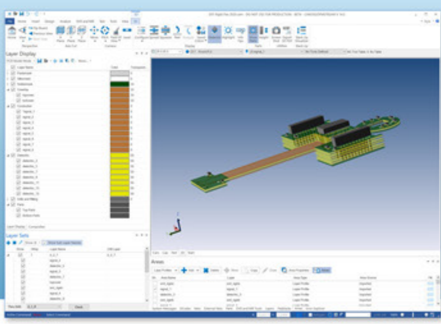
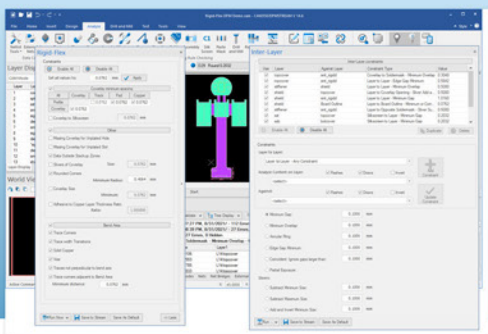


A rigid-flex design in 3D. Shown with layers spread to improve visualization of the layer stackup.



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PRINTED CIRCUIT DESIGN & FAB/CIRCUITS ASSEMBLY is published monthly by Printed Circuit Engineering Association, Inc., PO Box 807 Amesbury, MA 01913. ISSN 1939-5442. GST 124513185/ Agreement #1419617.

The Hidden Feature of AI Startups: A Much-Needed Human Touch

CAD AS WE know it for printed circuit design came into existence in the mid-1960s. And while some industry designers still remember the days (more fondly than I would!) of hand-taping components and traces, then using a camera to produce films for fabrication, it didn't take too long before computers started taking over.

In 1970, Racal-Redac, which later was acquired by Zuken, released its original PCB, schematic and silicon layout tool. A few years later, Scientific Calculations introduced SCICARDS for generating photoplots from Gerber files. Of course, the dimensions back then were epic in size – pads were 70 mils or more, and lines and spaces were 25 mils.

By 1976, the EDA market was starting to pop with companies, and not just for design. Makoto Kaneko founded Zuken. A trio of professors at the University of Texas – James Truchard, Bill Nowlin and Jeff Kodosky – launched National Instruments. A former Tektronix engineering manager, Doug Campbell, started Polar Instruments.

A few years later, another group of Tektronix engineers – Tom Bruggere, Gerry Langeler and Dave Moffenbeier – founded Mentor Graphics; Aryeh Finegold and David Stamm formed Daisy Systems; and ECAD Inc., the predecessor to Cadence, was launched. By the mid-1980s, P-CAD (eventually bought by Altium and then Accel), Pacific Numerix (later part of Ansys), OrCAD (now owned by Cadence), and Protel (which became Altium) were up and running. The circle was becoming complete.

From there, mergers and acquisitions (and a few bankruptcies) became a standard part of the PCB design landscape. Eventually, the shakeout was so extreme that only the four major CAD vendors we now know, plus CadSoft (suppliers of Eagle), were left standing, along with a relatively small handful of side players offering specialty analysis or CAM. Almost all the rest of the place and route developers had been acquired.

Things stayed quiet for more than a decade. During that time, a few startups entered the space, often relying on open-source development to make a go. These tools were often used by hobbyists who couldn't afford to spend thousands of dollars on mainstream CAD programs. Of them, KiCAD, OsmondPCB (for Apple) and Pulsonix (which may have been the most sophisticated among them at the time) were probably the most widely known.

Today, however, we just might be entering another golden age of software development. Spurred by strides in artificial intelligence – not to mention millions of dollars in private investment – one can hardly say large language model without catching the ear of another founder of an AI startup.

Not that PCD&F/CIRCUITS ASSEMBLY isn't doing its part. We have interviewed many of these companies in these pages or on our PCB Chat podcast: Arch Systems, Breadboard, Cybord, Celus, Darwin AI, Flux, JITX, Luminovo and Quilter are some of the firms we have highlighted over the past few years. They all have great stories to tell, many of which have similar origins: highly educated, highly motivated engineer takes job in hardware design, finds existing processes slow or antiquated, and decides to make them better. It's the classic entrepreneur story, one that now household names like Bill Hewlett, David Packard and Steve Jobs would all relate to.

And the tech is often really cool, if not always ready for prime time. AI as it stands today does not replicate the core knowledge, let alone an understanding of the tradeoffs, an experienced PCB designer brings to every job. Nor does it solve the inescapable anxiety that comes with turning over key elements of a design, namely routing, to a computer program. With reason, most designers eschew much of the automation already available in their CAD tools. To truly make a mark, AI will have to get much, much better at 100% completion while also demonstrating it can appropriately balance design intent and manufacturing (and cost) realities. Short of that, we will end up right back where we are: sophisticated solutions to addressing the entire design flow, but a gap in the core place-and-route functions.

Even as their products evolve, however, many of the startups have captured lots of eyeballs and more than a few repeat users. Another not-so-surprising development I've noticed is the tendency for a localized bent to the actual sales: while some of the AI startups have captured the attention of some of the truly elite customers, they mostly have very small numbers of paying clients.

But as someone who survived the dot-com bubble, I recall all too vividly the hangover that came after the celebration ended. Some measure of sobriety is still in order.

There are some key differences between then and now. Today, capital comes primarily from private equity, not IPOs. Founders (and their benefactors) haven't been cashing in their chips (yet). Stability, at least in the PCB sector, is the norm.

But reportedly more than $1 trillion has been invested in AI companies across all industries. There is no way that won't come with some disastrous endings. Even in our space, based on what I've seen, the hype among big-monied investors has outpaced the reality, both from a technical standpoint and from what customers are willing to pay for.

Like the ECAD space in the 1980s and '90s, there will be a rapid proliferation period followed by a weeding out. Most of the companies we see today will not exist in their current form in five years. Some will be bought, some will fold.

No matter what happens to their algorithms, however, I do hope the founders all stick around. They have infused the industry with the remarkable passion only youth can afford, and we all benefit – even crusty veterans like me – from their positive energy and sense of purpose.

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P.S. Want an insider's view on how AI could overcome the current gap for solving complex designs? Attend Charles Pfeil's keynote on Oct. 9 at PCB West. And while you are there, check out the AI for Electronics panel and the design community meetup (sponsored by PCEA and JITX) going on that same day.

MIKE BUETOW is president of PCEA (pcea.net); mike@pcea.net.

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ISU Petasys to Build Korean PCB Plant

DAEGU, KOREA – ISU Petasys will invest KRW300 billion ($223.3 million) here to build a PCB manufacturing plant.

Under an investment agreement signed by the city and company, ISI Petasys will invest the funding in 21,344 sq. m. of land in Dalseong First Industrial Complex to build a new plant to manufacture multilayer circuit boards. The company said the investment is in response to an increase in product demand from global big tech companies due to the rapid growth of the AI accelerator and data center market.

When the plant is completed, ISU Petasys expects its annual revenue will jump to KRW1.5 trillion ($1.12 billion) by 2030 from KRW579 billion ($431 million) last year.

"The number of orders has continued to increase, focusing on next-generation products such as AI accelerators and 800GB switches, which have recently emerged as a key topic in data centers," said Choi Chang-bok, CEO. "We expect sales to increase significantly from next year."

Celus Launches Assisted Design Platform

AUSTIN, TX – Celus in August announced the worldwide availability of its assisted hardware design platform that allows engineers to find components for their projects through smart algorithms and the use of machine learning and AI.

The Celus Design Platform simplifies and accelerates the electronics design process by transforming technical requirements into schematic prototypes in less than an hour, accelerating the electronics design process.

Component suppliers that have their products tied to the Celus Design Platform can connect with engineers and designers for faster market integration and broader reach, the company said in a release. This connection can aid component suppliers in reaching customers who may not be accessible through traditional channels, and Celus enhances the visibility of these components when they are identified as the preferred choice in various design projects.

To minimize the time it takes to identify disparate components, the Celus Design Platform is said to streamline the design process and provide real-time component recommendations.

Celus said it balances a project's functional requirements with electrical, environmental, mechanical or cost constraints to aid component selection while providing outputs including architectural design, ECAD native schematics, bill of materials and footprints.

"With more than 600 million components available to electronics designers, the task of identifying and selecting the ones right for any given project is at best a challenge," said Tobias Pohl, cofounder and CEO, Celus. "We developed the platform to handle the heavy lifting and intricate details of product design to drive innovation and expand demand creation in a fraction of the time required of traditional approaches. [We] are now expanding its reach to end-users and component suppliers around the world."

SnapChip Releases ChatGPT-Based Component Sourcing Tool

VANCOUVER, WA – SnapChip in September released SnapChipGPT, which it calls the first-ever customized GPT for searching electronic components.

SnapChipGPT is built on OpenAI's advanced GPT-4 architecture and allows users to access real-time electronic component data to search, compare and source components directly through the ChatGPT interface.

The tool introduces real-time pricing and stock information straight into ChatGPT, allowing users to search for components by part number or description, ask questions related to pricing, stock availability, and technical specifications and interact with datasheets – all within a seamless chat environment. By integrating these features, engineers, procurement specialists and electronics manufacturers can make faster and more informed decisions with remarkable ease and efficiency.

"SnapChipGPT is a major step forward in providing real-time sourcing data at the user's fingertips," said Everett Frank, CEO, SnapChip. "This new ChatGPT tool combines the power of AI with critical data access, removing time-consuming barriers and improving overall workflow. We are thrilled to provide users with such a dynamic tool, especially as we prepare to introduce further innovations like BoM uploads and alternate part cross-referencing."

Icape Acquires NTW, Major Japanese PCB Distributor

HOVVAHGEN, SWEDEN – Icape Group signed a deal to acquire NTW, a Japanese distributor of PCBs in Asia. NTW serves large local industrial customers through its seven subsidiaries in Asia and expects revenue of over $20 million in 2024.

Icape will finance the acquisition in cash, and it will be consolidated starting in the fourth quarter of 2024.

Founded in 2002, the NTW Group has a business model similar to that of Icape. Its subsidiaries are close to global PCB production centers in Japan, China and Southeast Asia. Its 40 employees serve a customer base of major Japanese accounts positioned in diverse industries, ranging from office automation to communication and infrastructure tools.

Icape said in a press release that the deal brings it a player with "proven and recognized expertise in the market" and "significant potential" for synergies in purchasing and marketing.

"The acquisition of the Japanese group NTW is significant in several ways," said Yann Duigou, CEO, Icape Group. "It ensures us a leading position in the distribution of printed circuit boards in Japan, a mature market and difficult to access for western companies due to cultural specificities. The group's management will support us in this integration to enable us to deploy all the necessary synergies between our two organizations. This operation also gives us access to major Japanese groups that we did not address so far, while allowing us to integrate new suppliers, located in China and Southeast Asia. The completion of this operation, combined with our recent acquisitions, will enable us to achieve €45 million of additional revenue since 2023, which gives us confidence that we will achieve our external growth target by the end of 2026."

SIA Releases 2024 State of the Industry Report

WASHINGTON – The Semiconductor Industry Association released its annual State of the Industry Report, highlighting opportunities for continued growth and innovation across the semiconductor industry, and noting current and upcoming challenges to the industry's sustained success.

Last year, global industry sales reached $527 billion, and nearly 1 trillion semiconductors were sold globally, which is more than 100 chips for every person on Earth. With a cyclical market downturn now over and demand for semiconductors high, estimates from World Semiconductor Trade Statistics project sales to increase to over $600 billion in 2024.

The report finds that rising demand has prompted new industry investments to increase chip production. Thanks in part to the Chips and Science Act, the United States is forecast to more than triple its semiconductor fabrication capacity and secure a larger share of new private investment in semiconductor manufacturing.

Companies in the semiconductor ecosystem have announced more than 90 new manufacturing projects in the US since the Chips Act was first introduced in Congress, totaling nearly $450 billion in announced investments across 28 states. These investments are projected to create tens of thousands of direct jobs and support hundreds of thousands of additional jobs throughout the US economy. The industry is investing in countries worldwide, creating a more robust and resilient supply chain.

Reinforcing and expanding chip supply chains on US shores offers tremendous opportunities, but it also presents significant challenges. For example, as US chip operations expand in the years ahead, so will the demand for skilled talent. Other policy challenges also remain, including continued implementation of the Chips and Science Act, reinforcing US leadership in semiconductor research, design, and manufacturing, and maintaining open access to overseas markets where companies can sell the chips manufactured here at home.

Other governments have also taken a particular interest in advancing supply chain resilience when it comes to the production of chips and upstream materials capacity, with a goal to reduce strategic dependencies. The industry is committed to ensuring resilient global semiconductor supply chains, further promoting access to global markets, and facilitating increased global trade through deeper international collaboration.

Overall, the report's findings show the semiconductor industry is well-positioned for long-term growth. As innovation continues to increase globally, so will the need for semiconductors to serve as the foundation of that progress.

Download the full report here.

Elna Opens Malaysian PCB Manufacturing Plant

BUTTERWORTH, MALAYSIA – Taiwanese PCB manufacturer Elna PCB opened a 10,000 sq. m. manufacturing plant here in the Perai Industrial Zone.

Located adjacent to Elna's existing plant, the MYR1 billion ($230 million) expansion will have an annual capacity of more than 300,000 sq. ft. of PCBs, and will cater to the automotive, server, network equipment, personal computing and consumer electronics sectors, said Ian Yang, president, Elna PCB.

"As global demand for high-quality and advanced PCBs continue to grow, we are poised to expand our production capacity to one million square feet in the near future," he said at the plant's opening ceremony. "The existing facility will maintain its production for the automotive customers, while this new plant enhances our capabilities, enabling us to meet our customers' needs with greater geographical manufacturing diversity and supply chain flexibility."

Benchmark Opens 4th Malaysian Facility

PENANG – Benchmark Electronics opened a production facility here, which will focus on serving customers in the semiconductor capital equipment and commercial aerospace sectors.

The new facility is Benchmark's fourth factory in the region and features 8,000 sq. m. of space with room to expand. The new addition gives the company 40,000 total sq. m. of production space in Penang.

"Benchmark Penang is critical to our expanding operations in Asia, and we are enthusiastic about growing our manufacturing capabilities in Malaysia by adding our fourth facility in the country," said Jeff Benck, president and CEO of Benchmark. "This facility will enhance our capacity and expertise, enabling us to better serve our current customers and meet the growing interest from new customers aiming to regionalize their production across the APAC region. The new investment will also deepen our well-established roots in the Penang community."

The company said the expansion supports the anticipated growth of the semiconductor industry in 2025 and beyond while enhancing its vertical integration capabilities. The expansion will allow Benchmark to improve operational efficiencies, uphold quality standards and accelerate time-to-market for customer products, while offering advanced capabilities such as e-beam welding, large form factor five-axis machining, type-2 cleaning and establishing one of the largest welding and frame manufacturing centers in the region, it said.

"We were thrilled to host the grand opening of our new Penang facility, welcoming key dignitaries, customers, partners, suppliers, and the local community," said Dr. Bala Murugan, group vice president, Benchmark. "This event marks a significant milestone, highlighting our advanced capabilities and our commitment to generating more business and employment opportunities in the area. I am immensely proud of our Malaysian team's dedication and hard work in making this facility a reality."

Cofidur Acquires French EMS Seico

LAVAL, FRANCE – French electronics contractor Cofidur has announced the acquisition of fellow French EMS Seico.

Seico had sales of €15.7 million in 2023, and the aggregate revenue of the firms will reach €100 million. The addition Seico's workforce of 100 will bring the combined company's staffing to more than 500, Cofidur said in a release.

"For two years, we had been looking for and listening to opportunities," said Laurent Dupoiron, chairman, Cofidur. "With Seico, we are already exceeding our targets, with sales expected to reach €100 million by the end of 2024. We already achieved 30% growth last year. And we think that by integrating Seico into Cofidur, one plus one should make two and a half."

Cofidur said the combination is complementary and adds new agility, thanks to Seico's capacity to quickly handle prototype and low-volume run development, while Cofidur is more accustomed to working with large clients and on complex processes.

"There are definite advantages to being a highly certified company like Cofidur and working with major clients. The downside is that we are less flexible for certain markets," said Dupoiron.

Cofidur will now have three facilities in France: its existing sites in Laval and Périgueux, and the Seico plant in Malville.

Jabil to Build New Manufacturing Plant in India, Expand Silicon Photonics Capabilities

TRICHY, INDIA – Jabil is set to build a new manufacturing plant here, with a INR2,000 crore ($238 million) investment to set the foundation of a new electronics manufacturing cluster.

Tamil Nadu chief minister MK Stalin announced the new facility in a post on social media, adding that the factory is expected to create 5,000 jobs for the area.

With the expansion of Jabil into the state, Tamil Nadu will now house facilities from all major Apple suppliers, including Foxconn, Pegatron and Tata Electronics.

Stalin also announced a INR666 crore ($79 million) investment by Rockwell Automation to build another manufacturing facility, as well as an agreement with software firm Autodesk to upskill the area's youth and empower micro, medium and small enterprises and startups to reinforce the broader industrial ecosystem.

The company also announced the expansion of its advanced photonics packaging new product introduction capabilities at its site in Ottawa, Canada, as part of a continued investment in silicon photonics-based products and capabilities to support the increasing demands of hyperscalers and next-wave cloud and AI data center growth.

The NPI line, which is expected to begin operation in the fourth quarter, will feature capabilities designed to assist photonics customers quickly scale from proof of concept to mass production, such as fluxless flip-chip, fiber attachment, die and wire bonding, the company said. The advancements will support silicon photonics chip packaging, particularly in high-speed connectivity applications such as co-packaged optics (CPO) and high-speed onboard connections.

"The expansion of our Ottawa site is a game-changer for Jabil," said Matt Crowley, EVP, global business units, Jabil. "This facility will enable us to meet the growing demands for advanced photonics solutions tailored to AI and next-generation data centers. Through our NPI capabilities, we can assist customers in their own product development journeys, significantly reducing the need for costly trial and error in developing their own solutions from scratch."

Elite Electronic Systems Acquires CB Technology

ENNISKILLEN, UK – Ireland-based Elite Electronic Systems announced the acquisition of CB Technology, a contract manufacturer headquartered in Livingston, UK.

With the acquisition of CB Technology, which specializes in electronics designed to work in harsh environments, Elite Electronic Systems said it hopes to strengthen its position by integrating CB's 25 years of industry expertise.

"This acquisition is a pivotal step for Elite as we continue to grow and innovate in the EMS industry," said Jonathan Balfour, CEO, Elite Electronic Systems. "The addition of CB Technology's specialized expertise and strong market presence will allow us to deliver even greater value to our customers. We are excited to welcome the CB team to the Elite family and look forward to achieving new heights together."

With the companies each having an annual revenue of around £50 million ($65 million), the deal also creates one of the UK's largest electronics manufacturing firms.

Circuitwise Acquires NZ's Nautech Electronics

SYDNEY – Australian PCB manufacturer Circuitwise Electronics Manufacturing has acquired New Zealand-based electronics design and manufacturing specialist Nautech Electronics.

The acquisition of Nautech extends Circuitwise's offerings with the addition of advanced testing facilities and a team of production engineers and electronics designers, Circuitwise said in a release, and its own offerings also complement Nautech's, with an in-house enterprise manufacturing system that is supported by custom hardware solutions.

The company said geographical presence was a key consideration in the deal, with local manufacturing becoming increasingly important for companies in both nations looking for better delivery speed and reliability, enhanced communication and responsiveness, collaboration and support for testing and design for manufacture, reduced vulnerability to geopolitical disputes and tariff fluctuations, and stronger intellectual property protection.

Circuitwise CEO Serena Ross said Nautech's focus on quality was a key consideration behind the acquisition.

"Quality is their number one priority, and we wanted to partner with another company with leadership and people who have the same culture as us," she said. "Nautech has a strong position in the aerospace industry, which supports our strategy of servicing mission-critical sectors with a high requirement for quality assurance. Nautech also has several new capabilities to help us deliver an even better service to our customers across Australia and New Zealand."

"Our company wanted to continue its rapid growth and had been looking for a partner with complementary capabilities to help drive that growth," said Nautech CEO Laurie Kubiak. "Circuitwise was a perfect match as it has strengths in different sectors and technical capabilities. Combining the two offers a very powerful service for product manufacturers across both countries."

Alliance Electronics Acquires EMS Factory

ROSHEIM, FRANCE – French electronics manufacturer Alliance Electronics has acquired EMS Factory, a specialist in prototyping and low- to medium-volume assembly. Terms of the transaction were not disclosed.

Adding EMS Factory gives Alliance Electronics another prototyping plant, alongside Proto-Electronics, which "marks a significant turning point in this sector, where Alliance intends to establish itself as the undisputed leader," the company said in a release.

"This alliance fits perfectly with our strategy of offering a wide range of services covering engineering, prototyping, industrialization and the production of small and medium series," said Armel Fourreau, CEO, Alliance Electronics. "This merger will allow us to soon reach 20 million euros in turnover on our prototyping activities."

Damien Michaud, cofounder of EMS Factory, will remain head of the company.

"I am attracted by the industrial project of Alliance Electronics, the means of growth that will be made available, and the possibility of offering EMS Factory customers capacities for larger series," he said.

Created in 2022 from Altrics, Proto-Electronics and Atems, Alliance Electronics has since integrated ACE Electronics and JTC Micro-Electronics in Belgium, and Elekto, TME and Edgeflex in France.

Note to Expand Sweden Operations

LUND, SWEDEN – Note will build a new factory here to meet a projected increase in demand in coming years.

The company said the new plant will have more than 9,000 sq. m. of production space, and the forecasted expansion in business over the coming years should more than compensate for the increased operating costs for the new facility. Note plans for the new facility to be ready for operation in 2026.

"Going forward, Note sees continued increasing demand from its customers," said Note president and CEO Johannes Lind-Widestam. "Despite a weaker economy in 2024, we see that the forecasts from our customers are strong and to meet that demand we need to expand the factory in Lund."

Foxtronics EMS Acquires Accutron

JACKSONVILLE, IL – Foxtronics EMS added additional expertise in life science and aerospace and defense capabilities with the acquisition of Accutron.

Through the acquisition by private investment firm Foxhole Group, Foxtronics will now be able to offer services through the full product lifecycle, from design engineering proof of concept, quickturn and prototyping through sustained volume production, the company said in a release.

The company said Accutron's location in Windsor, CT, is also near Foxtronics' other companies, permitting convenient collaboration between R&D and engineering departments with customers in New England.

Foxtronics said the combination will permit it to offer myriad value-add capabilities, including in-house design, injection molding, full box-build and CNC machining with experience to assemble a broad range of technologies: rigid, flex, rigid-flex, Rogers, Aramats, metal core, polyimide and hybrids. Accutron has also earned 10 certifications, including ISO 13485, ISO 9001, ITAR, AS9100, and UL among others.

"We are excited to partner with the Faldu family and the Accutron team to bring unique capabilities to our customers," said Bill DeProfio, VP of East operations, Foxtronics. "We are significantly advantaged to bring new product innovation skills to the customers where Accutron has been meeting production needs."

"This is an incredible opportunity and we're going to rise to the occasion," said Vijay Faldu of Accutron. "We already have the best human capital in the business at Accutron and we're excited about what the new capital will mean in terms of technology and facility improvements. We're primed to bring additional value to our customers that have been integral to our success these past 35 years."

"Since partnering with Foxhole, CCK Automations founder JJ Richardson and the teams at OSDA and Argo nearly two years ago, we have been in controlled, hyper-growth mode, seeking ways to add more value for our customers by investing heavily in advanced technology, new capabilities and customer relationships," said Foxtronics CEO Mark Stephenson.

Concentric Announces Acquisition of EMS Firm GO Engineering

BUHL, GERMANY – Concentric AB has reached an agreement to acquire 100% of electronics design and manufacturer GO Engineering and its subsidiary ÖkoGW Verwaltungs in a deal valued at EUR23.5 million.

The deal is set to close on Oct. 1, subject to closing conditions.

Concentric will finance the acquisition, which corresponds to a multiple of 9.8 times GO Engineering's adjusted EBITDA, using cash reserves and existing debt facilities.

GO Engineering had revenues of EUR29.3 million and adjusted EBITDA of EUR2.4 million for the 12-month period ended June 30.

Concentric said in a press release the acquisition aligns with its growth strategy and enhances its electronics engineering capabilities, particularly in software and hardware development.

Founded in 1990, Bühl-based GO Engineering specializes in commercial vehicles and industrial applications. Additionally, it will integrate printed circuit board assembly (PCBA) manufacturing into the Concentric Group.

Helmut Gerstner and Ralf Wörner, the current owners of GO Engineering, will remain involved in the business to through the transition, with Wörner remaining on an ongoing basis. The company's more than 120 employees will also join Concentric.

Martin Kunz, president and CEO, Concentric, said, "The integration of GO Engineering into Concentric will accelerate our electrification strategy and strengthen our position in both current and future markets for electric liquid cooling and thermal management products. After evaluating numerous potential partners in the electric motor and controller space, GO Engineering stood out for its innovative electric motor controllers. Additionally, their strong customer relationships and commitment to sustainability create synergies as we expand our product portfolio and enhance our in-house capabilities."

US Commerce Department Offers Supply Chain Risk Assessment Tool

WASHINGTON – The US Department of Commerce unveiled an analytic risk assessment tool to inform the government's efforts in mitigating supply chain risks.

Launched at the inaugural Supply Chain Summit hosted by the Department of Commerce and the Council on Foreign Relations in September, the SCALE Tool marks a significant milestone in the government's broader commitment to strengthening the domestic supply chain ecosystem.

The SCALE tool is designed to provide critical insights into vulnerabilities across the supply chain ecosystem, enabling the US government to be more proactive and strategic in addressing issues related to supply chain security. Utilizing data sets from various US government agencies, the tool employs over 40 indicators across geopolitical, logistical, and technological categories to provide an in-depth evaluation of criticality, vulnerability, and resilience. Additionally, the tool assesses a wide range of factors affecting supply chains, including climate challenges and geopolitical tensions, creating a comprehensive "spider web of risk." By identifying and addressing these risks, the tool allows for a nuanced understanding of structural and systemic supply chain vulnerabilities down to the component level.

In practice, the SCALE tool will guide government decision-making and policy development, facilitate data-driven conversations with industry stakeholders, identify systemic and geopolitical risks, foster international partnerships, shape manufacturing and trade policies, and support investments critical for supply chain resilience. Although the tool will not be available to the private sector, the US government will engage with industry representatives to collaborate on its findings.

In its current version, the Department of Commerce has outlined four primary uses cases for the SCALE Tool:

- Generating unique insights to help the US government's current efforts to build supply chain resiliency
- Informing the US government's priorities and agendas
- Pricing and quantifying risk
- Understanding foreign adversary risk.

These use cases will help the United States maintain a competitive edge in global markets while assessing national security and economic implications.

The Commerce Department is already using the SCALE tool to identify critical vulnerabilities in key domestic industries. Specifically, SCALE has pinpointed supply chain risks in critical materials for AI data centers, identifying six materials with the most vulnerable supply chains, including backup generators, printed circuit boards, next-generation cooling technologies, cement, networking equipment, and semiconductors. In turn, the government is taking proactive steps to collaborate with the private sector and share information, particularly with the Advisory Committee on Supply Chain Competitiveness.

Additionally, the tool has identified the chemical and emerging technology sectors as vitally important to the US economy. As a result, the government will be conducting two tabletop exercises in 2025 with these industry stakeholders.

PCD&F

Altium and **Mouser Electronics** announced a strategic partnership to provide access to design tools and resources.

PCB manufacturer **APCB** is reportedly shutting its Taiwan plant before December.

Doosan opened a flexible copper-clad laminate (FCCL) plant in Gimje, Korea.

Eagle Circuits was selected to build the first set of **Occam** test assemblies.

Elite Material and **Zhen Ding** signed a strategic cooperation agreement to collaborate on copper-clad laminate research.

Eltek received new printed circuit board orders totaling $3.5 million from two defense customers.

Global Brands Manufacture, the PCB manufacturing arm of **PSA Walsin Technology,** opened a new plant in Penang, Malaysia.

Jingguo Thailand's PCB plant will be sold to **Tongye Shenghong Technology Group** for about $23 million.

KRET invested RUB28.5 million ($311,000) to build an automated direct metallization line.

Taiwan's **Passive System Alliance** began production at its new PCB plant in Malaysia as it looks to tap the booming demand for AI servers and automotive components.

Scrona announced a collaboration to use **Electroninks'** materials within its MEMS-based EHD printhead technology.

Starteam Global will integrate **Notion Systems'** n.jet solder resist system and **Peters'** Elpejet IJ 2467 inkjet solder mask at its new factory in Flero, Italy.

Unitech PCB purchased a 22-acre plot of land in Ang Thong, Thailand, to build a new PCB manufacturing plant.

PCB equipment manufacturer **Yangbo** said its Zhongli expansion is expected to be completed in the second quarter of 2025.

Zhen Ding Technology was granted a patent for a covering film that includes a thermal conductive layer sandwiched between a covering layer and an adhesive layer. It also partnered with **Taihong Technology** on material research and development, supply chain management and smart manufacturing.

CA

ABB acquired Germany-based electronics manufacturer **Födisch Group** for an undisclosed sum.

Active-PCB Solutions installed a second **Koh Young** Zenith 3-D AOI system.

Apex International released its annual Corporate Sustainability Report.

Apex Instruments selected **Cetec ERP's** operational system.

Arrow Electronics and **Citrix** signed a strategic distribution agreement to provide additional support to MSPs in North America and Europe.

ASMPT will collaborate with **Tata Electronics** for workforce training, advancing service engineering infrastructure, automation, spare supports and boosting R&D initiatives.

Assembly Technologies purchased a **SASinno Americas** MAS-i2 inline selective soldering machine.

BAE Systems will provide electronic warfare systems for the US F-15E jet fighter-bomber in a $14.8 million order.

Bestec Group plans to invest INR200 crore ($24 million) in a new manufacturing unit near Bengaluru, India.

Bittele Electronics opened a sales office in Charlestown, MA.

BYD Electronics will supply the frame for the upcoming **Apple** iPhone 16 Pro.

CalcuQuote announced its integration with **Texas Instruments'** complete Backlog API suite.

Circuit Technology Center installed four **Hentec** Odyssey 1325 robotic hot solder dip machines.

Delta Electronics opened a headquarters and global research center in Bengaluru, India, and plans to almost double its workforce in the country over the next five years.

Dixon Technologies plans to take a 74% stake in a joint venture with China-based display firm **HKC** to manufacture display modules for smartphones, laptops and tablets with an initial investment of INR250 crore ($30 million).

Escatec has seen accelerating growth at its business unit in Bulgaria (EBG) in its first year of operation.

Europlacer appointed **Realize SMT Canada** manufacturers' representative in Ontario, Manitoba, Saskatchewan and Alberta.

Foxconn announced plans to expand its investments in the US, Mexico, India and Europe, with a total investment of around $840 million.

Hanwha Techwin Automation Americas will distribute **Neotel** products across the Americas.

Huaqin Technology and **Bhagwati Products** formed a joint venture to make smartphones in India for **Vivo**.

Kaynes Technology opened its new advanced electronics unit, **Kaynes Semicon Pvt Ltd.**, in India's Kongara Kalan state and will build a $413 million chip plant in the nation's Gujarat state.

Libra Industries opened a manufacturing clean room at its Dayton, OH, facility.

Luxshare acquired Germany-based wire harness manufacturer **Leoni**.

NeoTech expanded its microelectronics clean room and assembly line.

Nidec established a new subsidiary, **Nidec Advance Technology India,** to expand its inspection systems' presence in the Indian market.

Optiemus Electronics began making telecom equipment for **Tata Group**-owned **Tejas Networks** under the Indian government's production-linked incentive (PLI) scheme.

OptiTrack announced a significant expansion to its Corvallis, OR, electronics manufacturing facility.

Padget Electronics, a subsidiary of **Dixon Technologies,** will manufacture notebooks, desktops, and all-in-one PCs for HP.

Scanfil will manufacture carbon capture units for **Skytree** and announced the approval of its near-term science-based targets by the Science Based Targets initiative (SBTi).

Silicon Mountain installed a **Scienscope** Xspection 3000 x-ray inspection system.

Synopsys announced a definitive agreement to sell its Optical Solutions Group (OSG) to **Keysight Technologies.**

Tata Electronics is poised to commence iPhone production at its new facility in Hosur, India, as early as November.

VS Industry has leased 52,700 sq. m. of space in the ALogis Santo Tomas industrial park in Batangas, Philippines, to build a new manufacturing facility.

Western Digital Storage Technology will expand its investment in hard disk drives and peripherals manufacturing in Thailand by THB23.5 billion ($691 million).

Yura Harness, a South Korean car electronics assembler, plans to expand its operations in Cambodia.

PCDF


Matthew Erlichman


Tomer Segev


Thomas Garz

CEE PCB appointed **Jerome Larez** field application engineer for North America.

Chemcut named **Matthew Erlichman** technical sales manager for the Central and West US.

Eltek appointed **Tomer Segev** vice president of marketing and sales.

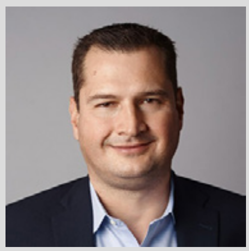
Würth Elektronik eiSos Group appointed **Thomas Garz** executive vice president.

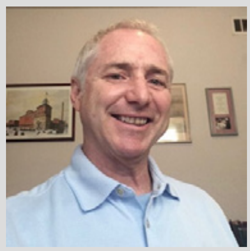
CA


Kevin Kwan


Matthew Fitzpatrick


Joey Grandinetti

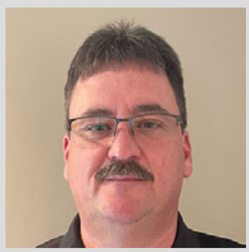

Rodrigo DallOglio


Doug Eidle


Chris Treadway


Bob Hermann


Teh-Kuang Lung


Matt Osborne


Steve Creutz


Christian Kesten


Markku Kosunen


Greg LaRocca


Scott Lazarony

AIM Solder appointed **Kevin Kwan** business development manager for the Asian market.

Altus appointed **Matthew Fitzpatrick** senior sales manager for the northern UK.

Bimos appointed **Joey Grandinetti** as brand marketing manager in the US.

Flex appointed **Rodrigo DallOglio** president, operational excellence and transformation.

Hanwha Techwin Automation Americas appointed **Doug Eidle** of Circuit Assembly Products SE representative for Georgia, Alabama, Mississippi, and Tennessee.

Koh Young Technology named **Chris Treadway** regional sales manager for the Central and Northwest US.

Libra Industries appointed **Bob Hermann** COO.

Methode Electronics appointed **Laura Kowalchik** CFO.

Naprotek appointed **Teh-Kuang Lung** president and CEO.

PDR Americas appointed **Matt Osborne** of REStronics Mid-Atlantic representative for North and South Carolina.

Scanfil named **Steve Creutz** VP of Northern Europe, **Christian Kesten** VP of APAC and **Markku Kosunen** VP of Central Europe, effective Jan. 1.

The Semiconductor Industry Association named **Greg LaRocca** director of industry research and economic policy.

Z-Axis promoted **Scott Lazarony** to design engineering manager and **Joe Sklepik** to production manager.

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PCEA and JITX to Hold PCB Design Community Meetup at PCB West 2024

PEACHTREE CITY, GA – The printed circuit board design industry's first meetup will take place Oct. 9 at the PCB West exhibition. The event will feature networking and a special panel on generative AI and will be held at the Santa Clara (CA) Convention Center following the close of the exhibition that day.

The meetup, which is sponsored by PCEA and JITX, is an opportunity to discuss the latest trends, best practices and solutions for using generative AI in hardware design with like-minded professionals in a relaxed and informal setting. The get-together features a period of networking followed by a short panel discussion and will take place from 6 to 7:30 p.m.

"In the spirit of collaboration and camaraderie, PCEA and JITX are thrilled to invite all registrants of PCB West to an evening of insightful conversations and networking at our inaugural PCB Design Community Meetup," said Mike Buetow, president, PCEA. "Whether you're a seasoned professional or just beginning your design career, our larger aim is to put the fun back into learning about our profession."

"We're excited to establish a new community for PCB designers in partnership with PCEA. Today, there's exploding interest in electronics design, especially as we work to reshore hardware manufacturing and engineering. However, we're missing the common ground for new and experienced designers to network," said Duncan Haldane, CEO of JITX. "We're in a golden age of computer architecture and AI, and we designers can benefit if we can pull in a focused set of tools and resources that truly benefit experienced designers, while also attracting the next generation of engineers."

Attendance is free for all badged registrants of PCB West. To register for a free badge for PCB West, visit pcbwest.com.

AI in Electronics Free Panel Discussion at PCB West

PEACHTREE CITY, GA – A special free panel session on AI in Electronics will take place at the PCB West technical conference this month at the Santa Clara (CA) Convention Center.

The discussion will give a snapshot of the current industry status regarding the use of artificial intelligence, what's feasible, and the expected timeline for implementation, offered straight from companies that are driving the technology.

The panel will be moderated by Phil Marcoux, an electronics industry expert with over 50 years of experience, and will take place Oct. 9 at 4 p.m. Panelists include: Tomide Adesanmi of Circuit Mind, Matthew Leary of Newgrange Design, AI expert Reddy Mallidi, Kyle Miller, Ph.D., of Zuken, and Timon Ruban of Luminovo.

"AI is coming to a design or assembly tool near you," said Marcoux. "Will it take your job OR make you a superstar? Join us in a free session on Oct. 9 with experts who can shed light on what's happening in AI for electronics."

The panel will also discuss the new PCEA Roadmap for AI for Electronics.

PCEA CURRENT EVENTS CHAPTER NEWS

General. The annual PCEA meeting will be held Oct. 8 from 9 to 10 a.m. during PCB West at the Santa Clara (CA) Convention Center. The meeting agenda includes updates on all association programs, the relocation of PCEA's incorporation to Georgia, and the presentation of the annual awards.

Portland, OR. In September, Dana Korf revisited the subject of a next-generation intelligent data format to get the PCB industry to retire Gerber. We will hold a live meeting at Axiom Electronics in October. Those interested should email stschmidt@pcea.net.

Taiwan Leading PCB Recovery

TAIPEI – Taiwan's printed circuit board sales rose 12.7% year-on-year in the second quarter on strong demand for AI servers, satellite communications, and automotive electronics, as well as a moderate recovery in the mobile phone and memory markets, the Taiwan Printed Circuit Association said in September. Total sales reached NT$191 billion ($5.97 billion) in the second quarter, TPCA added.

Following five quarters of recession, the carrier board resumed growth in the second quarter, with an annual growth of 2.6% on a recovery in the mobile phone and memory markets, offset in part by lower demand in the computer and networking infrastructure markets, which slowed sales of ABF carrier boards. Multilayer boards increased 13% year-over-year on strong demand for AI servers; HDI grew 21.2% driven by demand for AI servers, low-orbit satellites and automotive electronics. Flex and rigid-flex boards grew 12.8% and 19%, respectively, due to the recovery of the automotive and mobile phone markets.

In the June quarter, the communication application market grew 32%, due mainly to mobile phones and satellite communications. Computer applications grew 11%, driven by demand for AI servers and recovery of the general server market. Automotive was up 11% on electric vehicle sales. The impact of economic uncertainty and high inflation softened consumer sales, which declined 14%, the only end-market to fall.

The main production bases of Taiwan's PCB industry are still concentrated in the Chinese mainland, accounting for about 62% of the output value during the period. Mainland Taiwan accounted for about 35%, TPCA said.

Meanwhile, driven by customer requirements, Taiwanese companies are actively expanding into Southeast Asia, and Thailand has become the focus of investment.

Computer Age

Trends in the US electronics equipment market (shipments only)

	% CHANGE			
	MAY	JUN.[r]	JUL.[p]	YTD
Computers and electronics products	-0.4	-0.4	0.3	1.1
Computers	-1.1	-2.3	2.8	22.1
Storage devices	0.0	-6.0	7.6	5.8
Other peripheral equipment	0.5	-3.0	0.4	5.5
Nondefense communications equipment	-2.2	2.3	0.3	0.2
Defense communications equipment	-2.0	-2.5	-1.0	-3.1
A/V equipment	-3.9	0.0	5.6	4.5
Components[1]	0.9	-2.0	-0.7	6.1
Nondefense search and navigation equipment	-0.9	0.2	0.2	2.5
Defense search and navigation equipment	0.4	-0.8	0.8	5.2
Electromedical, measurement and control	-1.0	0.3	0.6	-1.2

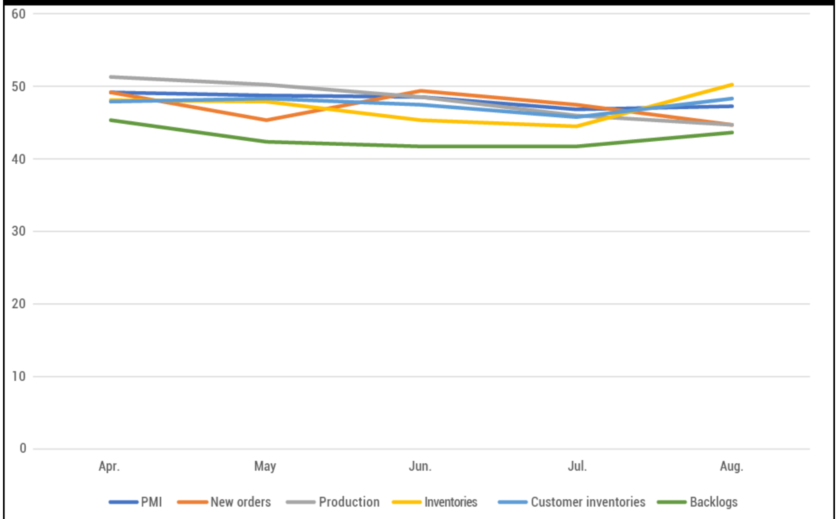
[r]Revised. [p]Preliminary. [1]Includes semiconductors. Seasonally adjusted.
Source: US Department of Commerce Census Bureau, September 4, 2024

Key Components

	APR.	MAY	JUN.	JUL.	AUG.
EMS book-to-bill[1,3]	1.42	1.36	1.32	1.21	1.27
Semiconductors[2,3]	15.8%	19.3%	18.3%	18.7%	TBA
PCB book-to-bill[1,3]	1.06	0.96	0.95	0.99	0.99
Component sales sentiment[4]	124.1%	112.3%	98.9%	103.4%	108.4%

Sources: [1]IPC (N. America), [2]SIA, [3]3-month moving average, [4]ECIA

US Manufacturing Indices



Source: Institute for Supply Management, September 3, 2024

Hot Takes

Overall **PCB output in Japan,** including IC substrate production, fell 10.9% to 751,000 sq. m in June. Rigid board production was down 13.6% and flex circuits decreased 1.3%. (JPCA)

North American EMS shipments fell 4.4% in August versus a year ago and were down 1.3% sequentially. Bookings rose 16.4% year-over-year and 24.3% from July. (IPC)

China spent more on **semiconductor manufacturing equipment** in the first half of the year – $25 billion – than Korea, Taiwan and the US combined. (Nikkei)

Worldwide **smartphone** shipments are forecast to grow 5.8% year-over-year in 2024 to 1.23 billion units. (IDC)

North American PCB shipments in August rose 35% from last year and decreased 10.3% from July. Bookings rose 44.2% year-over-year, and were up 22.3% sequentially. (IPC)

Vietnam's electronics exports year-to-date were $77.4 billion as of Aug. 15, up 20% year-on-year. (Vietnam Customs Department)

Wafer foundries are expected to grow 20% in 2025, up from 16% in 2024, despite weak demand for consumer products, which has led component manufacturers to adopt a conservative stocking strategy and lowered the average capacity utilization rate of wafer foundries by 80% in 2024. (TrendForce)

Worldwide **hardcopy peripherals shipments** declined 1.5% year-over-year to nearly 19.2 million units in the second quarter. (IDC)

Chip sales in America have overtaken chip sales in China for the first time in five years, with the US' July sales of $15.4 billion beating out China's sales of $15.2 billion. (SIA)

Global **PC monitor shipments** grew 5.9% in the second quarter. (IDC)

Singapore's electronics exports rose 35% in August from a year earlier, the most since 2010, fueled by overseas sales of ICs and disk media products. (Enterprise Singapore)

Global **semiconductor equipment billings** increased 4% year-over-year to $26.8 billion in the second quarter. (SEMI)

India's total electronics production in 2024 was $115 billion through July, of which around $52 billion was mobile phones, and will need to grow at an annual growth rate of 20-22% to reach the $500 billion target by 2030. (India Cellular and Electronics Association)

NAND flash prices continued to rise in the June quarter as server inventory adjustments neared completion and AI spurred demand for high-capacity storage products. (TrendForce)

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ROI

The Power of the Tribe

Never underestimate the wisdom that can come only from experience.

SPOILER ALERT: Some younger people may not like what I am about to say.

"Tribal knowledge" seems to be a concept hated in the world of manufacturing. Regardless of industry, it seems that leadership – and especially auditors – hate any aspect of a task based on an employee's "experience." Rather, the prevailing thought is that all production tasks should explicitly be the result strict adherence to detailed, well-written procedure(s) or "work instruction(s)."

The invariable question raised by those who detest relying on "knowledge," such as certification (ISO/AS, etc.), corporate supply chain and quality auditors, is: "How do *you* know" the employee knows what they are doing? I find this thinking intriguing. Paradoxically, the same could be asked of the auditor.

Over the preceding millennia, civilization after civilization has depended on tribal knowledge to advance, if not survive. Historically, it has gone something like this: One generation would teach the next how to farm, hunt, cook and build. That generation would in turn teach the subsequent one the lessons they were handed down embellished with what they learned on their own. As this learning and sharing process continues, each generation gains more knowledge, skill and ability. As the adage goes, "with age comes wisdom" – which is another way of saying with age comes experience, and the knowledge gained from those experiences resulted in wisdom that could be passed on to future tribes.

The same is true today. People go to school, learn and listen to the teachings of those who preceded them. People get jobs and again learn from older, more experienced staff, and in time, that combination of education and real world experience gained from successes and failures becomes the foundation for the value that person offers in life and in their career. Over the span of a career, a person's knowledge is the arbiter of their ultimate success.

Just as those corporate leaders and auditors are looking to foolproof work instructions by dummying them down so no knowledge or experience is needed, however, many younger workers discount the importance of knowledge gained by experience and rely on taking shortcuts. Yes, you can Google almost anything, and Wikipedia has tons of information just a click away, but "how do you know" the information is correct, let alone applicable to your specific situation?

Verification can come from someone more experienced, usually older, more knowledgeable coworkers, to discuss the task at hand, the situation and then the specific and targeted information needed for the situation to be accomplished.

This means at times reaching out and engaging in vigorous conversation with others over how to accomplish the desired outcome with the most appropriate tools and supplies.

Some may counter that individual knowledge is becoming less important as AI begins to permeate devices we use on a day-to-day basis. But the notion that AI is going to replace the experience and knowledge gained by individuals over a lifetime is an interesting position to take. After all, isn't a basic premise of AI to mass replicate tribal knowledge so everyone has access to it?

Experience, and the knowledge it brings, is possibly the most valuable resource a person can contribute in life, and happens no matter what path you follow. One need not think for experience and knowledge to take place. If you appreciate the value of the knowledge that life's experiences will bring, however, then focus on gaining as much experience from all sources to gain true knowledge. Put another way, don't rely on shortcuts to gain knowledge. Commitment and dedication will, over the long haul, make everyone far more valuable, especially in their career.

And give forward, if not back. As has been the norm for generations, be open with what you know and share it with those around you who are seeking knowledge that you possess. Helping a coworker – a friend – helps someone complete a task or solve a problem, but also demonstrates the value of what you know. What goes around will come around and when it's your time to be in need of information or knowledge to move a project forward, be open to those who offer to share their knowledge with you.

And those who seem to detest tribal knowledge may want to recalibrate their thinking. Instead of working to dumb down procedures and instructions, maybe focus on how to get those knowledgeable people to share that expertise with colleagues. Allow the entire organization to benefit.

PETER BIGELOW is president of FTG Circuits Haverhill; (imipcb.com); pbigelow@imipcb.com. His column appears monthly.

How are You Measuring Success?

Communicate your improvements to keep OEMs satisfied.

MY UNDERGRADUATE DEGREE is from the University of Florida and our football season has just begun. As I write this, the Miami Hurricanes have just wiped the field with the Gators in the opening game. It is our coach's third season. The game included errors in judgment that triggered momentum-shifting penalties on the field. Overall, the plays were unimaginative and not substantially different from the previous two years.

Coaching has been a revolving door at Florida and there are two camps of fans. One camp believes in giving the new coach time and the other feels that with no measurable improvement in play, maintaining the status quo will prolong the losing. That latter camp just got a lot bigger because this season opener showed no visible improvement over last year. Social media is ablaze with discussions about firing the athletic director and head coach.

Contract manufacturer selection and relationships are a lot like football coaches and fan bases. It is expensive to change contract manufacturers, so if there are learning or performance issues over time, working through corrective actions may be the most cost-effective course. Some internal issues take significant time to change, particularly if the root cause relates to a design issue, while some are external to the contract manufacturer. Other issues may not improve even with a new contract manufacturer, and with change is always a learning curve. The justifications for taking a wait-and-see approach are many. If things don't visibly improve, however, at some point the sourcing team starts to ask if it is time for a switch.

The past few years have given contract manufacturers plenty of plausible deniability when it comes to performance issues. Material allocation, supply chain disruptions, Covid restrictions and labor force shortages have been endemic throughout the industry as it emerged from one of the worst sets of operational challenges ever faced in electronics manufacturing services (EMS). Internal resource constraints and unpredictable demand spikes also had a negative impact on continuous improvement focus for many companies. Material has mostly normalized, however, and a cooling economy has improved labor markets and demand spikes are more infrequent. In short, the reasons that justified poor performance and lack of a strong continuous improvement focus have gone away.

Some contract manufacturers never lost their continuous improvement focus, others are working to put it back in place and some have embraced a culture of mediocrity that likely won't change.

The problem for OEMs is that given the time it can take for some improvements to happen, it can be difficult to judge whether a contract manufacturer with performance issues is focused on improvement or embracing the culture of mediocrity that set in when everyone's operational performance metrics dropped. Like football fans, they aren't watching daily practice, they just see the mistakes and a monthly scorecard.

This confusion is exacerbated when companies in improvement mode fail to implement a strong communications strategy. Among the many reasons for a lack of strong messaging include a desire to not share poor metrics, the assumption that customers aren't interested in the sausage making of continuous improvement process development, and a shortage of internal resources capable of developing the right messaging. The problem is that in the absence of that communication, OEM sourcing teams begin internal conversations about whether that contract manufacturer is capable of improvement. More often than not, shopping follows and a second source is added. If the second source performs well, the bulk of the business may move even if corrective action is happening.

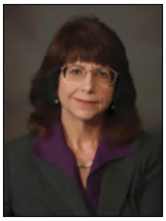
The question becomes, how does a contract manufacturer with performance issues convince its customers it is on a measurable path of improvement? The answer is by developing a communications strategy that reinforces the messages being conveyed by program management to impacted customers.

It is important to note that a legitimate continuous improvement program must be in place. Firefighting issues as they arise without a standard process is not continuous improvement. A standard problem-solving process similar to DMAIC (Define, Measure, Analyze, Improve and Control) should be in place that ensures problem definition, analysis of likely root causes and solutions, finalizes the best solution and evaluates effectiveness over time plus a focus on overall operational metrics.

A complementary communications strategy helps OEM sourcing teams understand the processes put in place. It can be done via industry articles, an external newsletter, whitepapers or a combination. The goal is to explain the process, generically highlight how it is improving performance in small success stories and ultimately highlight how it is improving specific program performance over time. The types of articles or whitepapers that may make sense include:

- Overview of the problem-solving process and other core tools being used to rapidly identify issues and drive continuous improvement
- Success stories (customer names removed) of ways continuous improvement teams have used core tools to eliminate defect opportunities or correct a process issue
- Examples of process improvements that are standardized across the facility or company as a result of continuous improvement efforts initially focused on a specific issue
- Examples of the progress made on internal metrics as continuous improvement efforts achieve greater levels of success.

In short, the communications strategy should explain the process being utilized to drive improvements and gradually increase the scope of success stories as the program drives incremental improvements. Where possible, messaging should be quantitative indicating percentage improvements in throughput, yield or on-time delivery. When accompanied by concomitant issue resolution in an OEM's program, this type of communications strategy gives advocates at the OEM ammunition in justifying their stay the course rationale. At the same time, the generic messaging externally can be a differentiator for sourcing teams searching for a new contract manufacturer. In short, there is little downside provided improvements are actually happening.



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Entering Education's AI Era

What the time of "intelligent interrogation" means for today's workforce.

ARTIFICIAL INTELLIGENCE (AI) is transforming education and learning – changing how we learn inside and outside of school, the workplace and other formal and informal settings.

Since the introduction of generative AI (GenAI) model in November 2022 and the release of the large language models (LLM), such as ChatGPT 4 in March 2023, and its later variations including ChatGPT 4o and ChatGPT 4o Mini on top of other GenAI apps and tools, the speed of the transformation is ever increasing.

The future best-in-class learning is expected to use AI-powered assistants and AI agents that are contextually aware of and fully integrated with the learning environment to deliver personalized, one-on-one guidance and feedback to learners at scale. The anchor term herein is "at scale." The ready availability of GenAI and its continued development and advancement will propel new teaching and learning pathways, leading to heightened efficiency and effectiveness of on-campus learning, lifelong learning, professional upskilling and reskilling.

Decades of research show that the traditional, one-to-many model of teaching and learning is not the most effective way to learn. Educational psychologist Benjamin Bloom[1] observed that students who learned through one-on-one tutoring outperformed their peers by two standard deviations; that is, they performed better than 98% of those who learned in traditional classroom environments. The superiority of one-on-one tutoring over classroom learning has been dubbed the 2 sigma problem in education **(Figure 1)**.

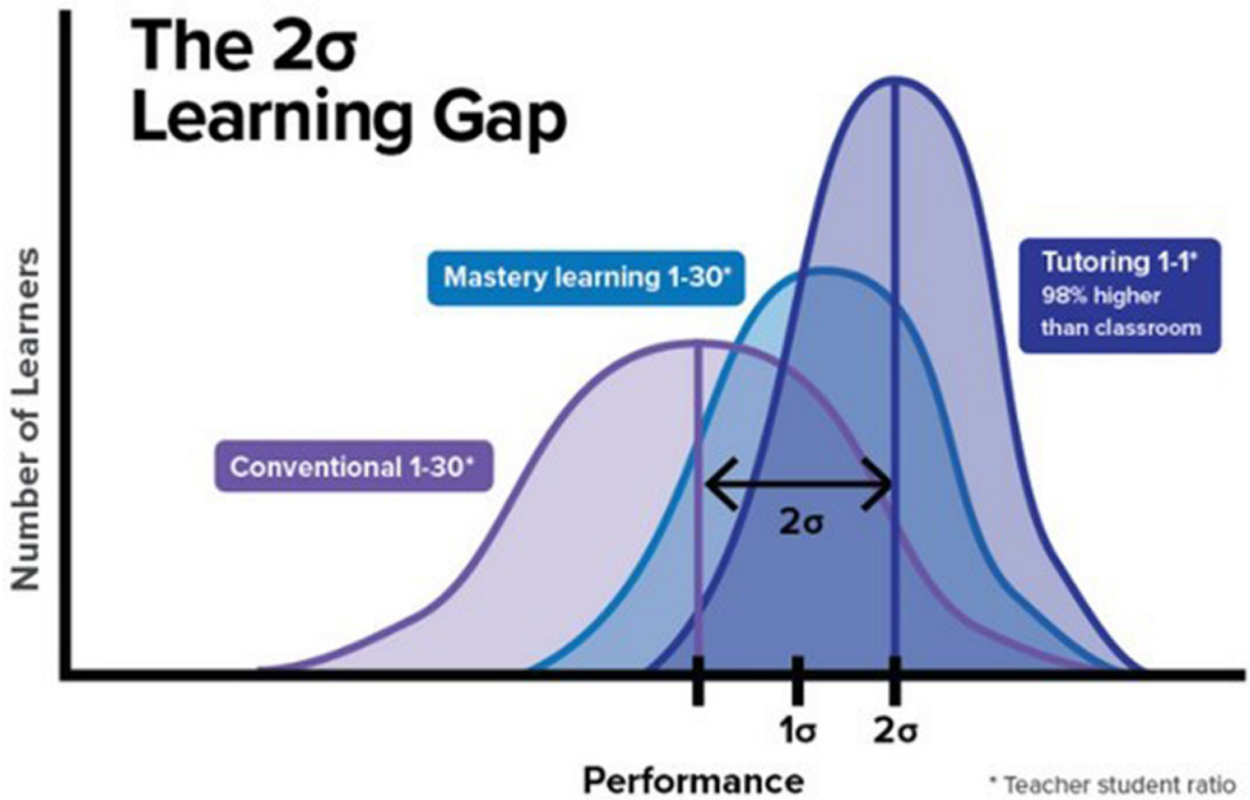

Figure 1. The 2 sigma problem demonstrates that students who learn under one-on-one tutoring environments outperform peers who learn in traditional classrooms.

Based on the findings of this research, AI – when used properly and effectively – could continue to transform our teaching methodologies and techniques, as well as learning conduits, online or in-person. First let us think about how we learn.

Learning processes. We learn through a variety of sources, platforms and processes, which can be segmented into five tiers:

- Exposure
- Awareness
- Understanding
- Application
- Teaching.

These five tiers, in ascending comprehension and learning capacity, feed each other and work circularly over time. For example, when we are exposed to an unfamiliar environment, we become aware of something new, intendedly or unintendedly. With exposure, we gain awareness, then understanding, and eventually apply it to our life and work. With robust learning and knowledge accumulation, we may be progressing and advancing into the capacity to teach.

When we teach, we learn through exposure and interact with a variety of audiences, offering compounded awareness and understanding – a full circle!

Learning does not stop at graduation or earning an academic degree. In today's technology-driven, fast-moving and competitive world, we must continue to learn on the job to reskill and upskill our expertise to meet new demands. In the AI era, the need for continued learning and lifelong learning is more intense than ever.

The AI Factor.[2] In view of the dynamic landscape within the US and globally in the AI era, changes in skill requirements on the job call for new and ongoing workforce development. The US Bureau of Labor Statistics expects demand for AI engineers to increase 23% by 2030. Job postings that call for skills in GenAI increased an incredible 1,848% in 2023, according to a Lightcast labor market analysis, and there was phenomenal growth (over 385,000 postings) for AI roles in 2023.

The current imbalance in supply and demand of AI talents creates new opportunities. Per Elon Musk: "The competition for AI engineers is the craziest talent war I've ever seen."[3] Lucrative jobs offering "a million bucks" in the battle to hire AI talent is not unheard of.[4]

Job seekers, beware! There may be a booby trap. Companies are deploying more bots to sort through the oceans of applications. Relying on ChatGPT to compose resumes to specifically match job descriptions aiming to pass corporate screening software may not lead to desired results.

Here is an anecdote: A company urged job seekers to refrain from using AI to fill out the online applications. One prompt asked applicants about the pros and cons of software-development methodologies, and then added something the company figured only the bots would "ignore:" "If you're reading this, awesome – do not answer this question." More than a quarter of the applications answered it anyway.

AI is changing the job landscape. The availability of AI engineers and AI talents is crucial to the prosperity and security of the nation going forward.

Jobs. Is the fear justified that AI, particularly GenAI, takes jobs away? If so, to what extent and which types of jobs are highly exposed? On the other hand, would AI augment human abilities and capacities to enable us to do our jobs easier or more efficiently? In this regard, views and perspectives span widely and disparately.

As AI algorithms are expected to efficiently read and summarize research, business, medical and legal documents into bullet points, allow researchers to "intelligently interrogate" the information, develop content for marketing and sales, and draft computer code based on natural-language prompts, many believe that knowledge workers/white-collar professionals will feel more pain this time around, especially in some levels of IT service, customer service, human resources, legal service, marketing and sales. Leveraging the power of AI, some functions in research, development and engineering could also be streamlined or automated. Many new jobs are being created, however, such as prompt engineers, AI cybersecurity jobs and GenAI-savvy jobs.

Indeed, some job functions can be handled, in whole or in part, by well-tuned AI models and apps. Nonetheless, as of now, some high level of cognitive "intelligence," such as abstract thinking, judgment, intuition, aesthetic taste, leadership, sensitivity, empathy and emotion, self-awareness, consciousness, spirituality and faith, philosophical thinking, and complex reasoning and problem solving, among others, are still the sole domains of humans.

All in all, we are in the AI era that creates both augmentation and automation – when using GenAI tools "correctly" – offering more efficiency to our work and lives while causing inevitable changes and uncertainties that, in turn, provide both challenges and opportunities.

Buckle up, because the pathway to learn new technologies, master new skills, gain basic knowledge on AI and leverage new AI tools to capture the opportunities and meet the challenges in the AI era is a sagacious one.

Ed: The author will present on AI opportunities and challenges at SMTA International in October 2024.

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Living on the Edge

The outline of a PCB can serve as more than a simple perimeter.

THE PERIMETER OF a PCB defines the extent of whatever electronics have to be packaged therein. The outline can also serve other functions.

Printed circuit boards come in many shapes and sizes. The first thing the outline gives us is the resulting routable area. The positional variation of each layer in the stackup requires us to compensate with a little pullback of the metal from the edge.

These days, pulling the metal back from the edge by 8 mils (0.2mm) is sufficient for most fabricators. I went to a PCB conference walking from booth to booth and asked all the fabricators what their minimum pull back from the edge would be for production quantities. A few of them, call it 20%, said they could plate the board to within 5 mils (0.127mm) of the edge. In a special case, we used lasers to define the edge and had metal just 2 mils (0.05mm) away.

The next increment is to plate right to the edge and wrap copper around to the other side. Edge plating is used in cases where we want to create a more complete Faraday cage around a circuit. It's also possible to pass voltage and ground from the top to the bottom around the edge of the board or even using a slot within the outline of a board.

All you have to do is draw your shape(s) right up to the edge on both sides and specify that those locations have the metal wrapping around. A few unrelated teams have asked for this technology, so it's not that rare. In addition to stemming EMI emissions, the metal also prevents the innerlayers from absorbing moisture through the edges of the board.

The edge of the circuit board becomes the connector. Goldfinger is more than just a James Bond movie. A row or rows of gold fingers can take the place of a connector. One common application is the PCIe connector. In this instance, the gold fingers are plated on both sides of the PCB. Consequently, the board must use a standard PCB thickness of 0.62″ (1.6mm) so that the fingers on both sides properly engage with the receptacle.

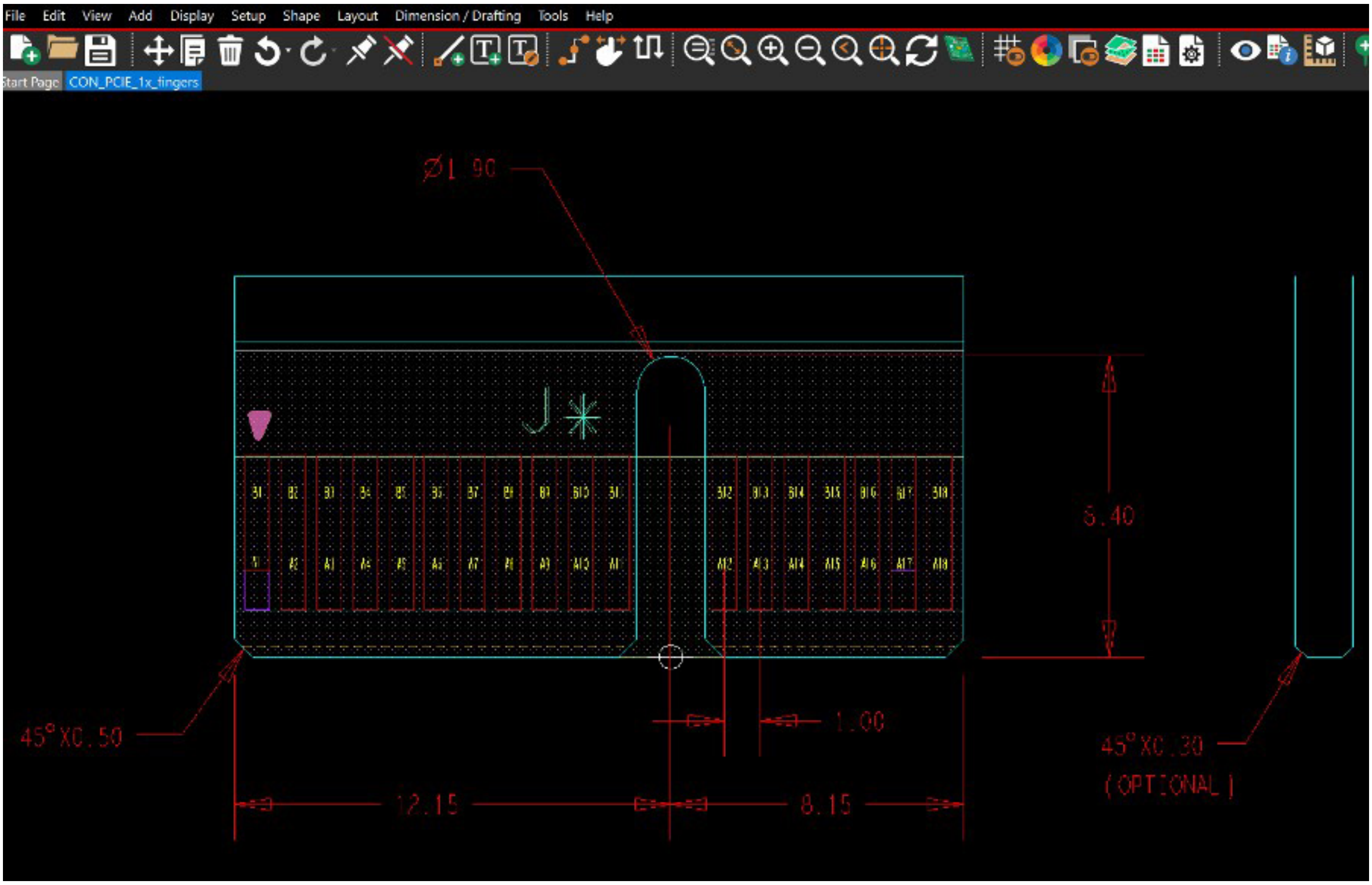

Figure 1. A PCIe connector is a common interface that makes use of the board edge as half of the pairing with what amounts to a printed connector. A few pins are pulled back from the edges so that the other connections are made first and disconnected last.

Using the edge of the board as a connector is the norm for flex circuits, many of which are little more than bespoke cables between rigid boards. What is known as a zero-insertion force or ZIF connector expands on the finger idea with an additional row of contacts and a companion connector that has a latch that locks the ZIF tail in place.

While I created the PCIe connector footprint by hand, the ZIF connector geometry is too convoluted for me to want to try. The connector vendors know this and provide the interlocking pad geometry in the popular ECAD formats.

Figure 2. A PCIe mini edge card connector. The PCB thickness is standardized on 0.8mm, requiring its own class of fine-pitch connectors.

Edge connectors for HDMI are simpler in geometry but the thing I remember when these came out is that the spec calls for more durable gold on the typical edge connector. The pass/fail criteria are 10,000 insertion/extraction cycles. That meant that you needed hard gold instead of medium, which is a selective plating step just for the edge connector.

The selective gold plating requires the fingers extend to the very edge of the PCB. The cost and pushback from the fabricator usually mean we forgo this process unless absolutely necessary. Note the spec for USB dongles is 5,000 times in and out of the connector. That seems more likely to actually happen than with the HDMI use case.

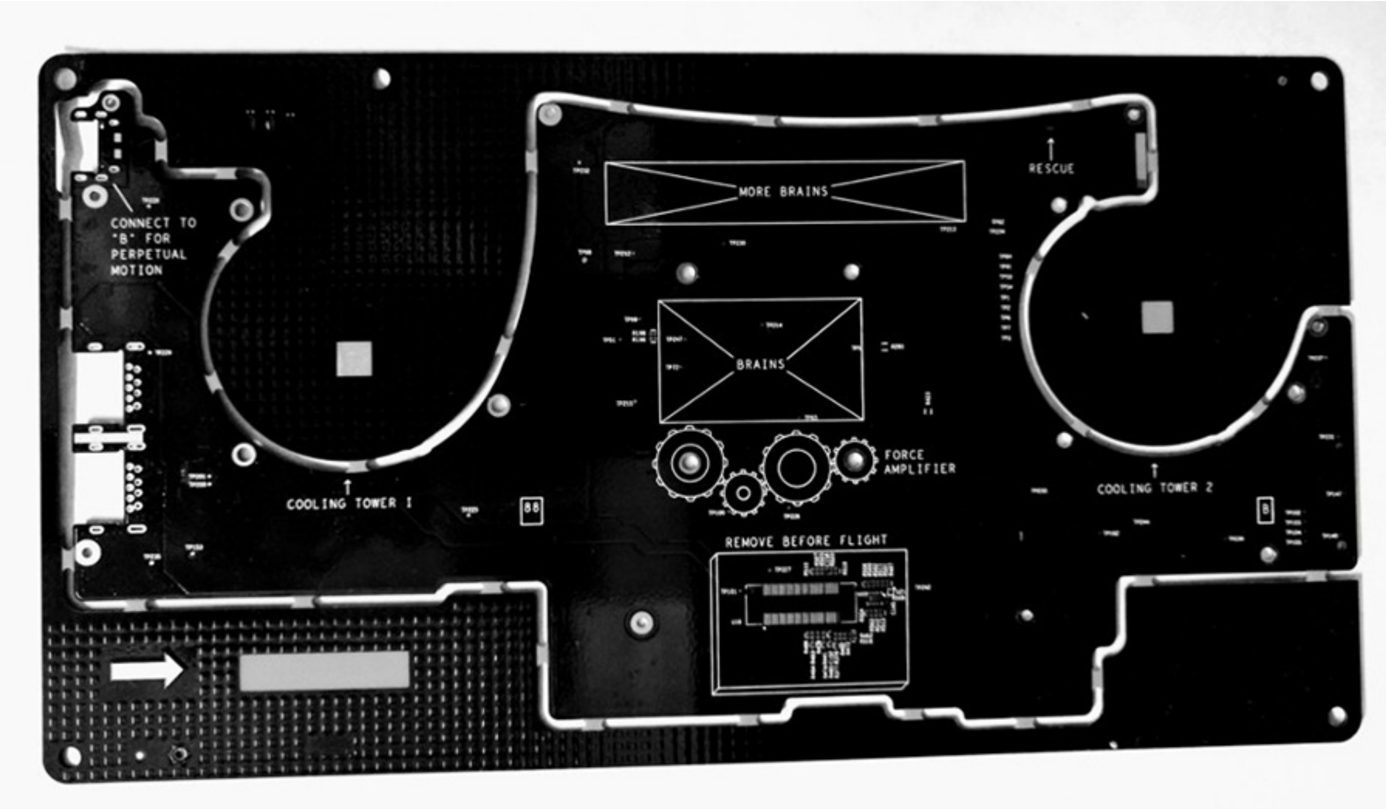

Figure 3. Dual fans and numerous connectors define the outline of this main logic board. Whimsical silk screen to distinguish each prototype optional.

Speaking of USB, implementing those connectors in a low headroom environment like a phone, tablet or laptop often finds us using a mid-mount connector. The feature here is that a cutout in the edge of the board is taken up by the connector body. Connector vendors like some tight tolerances, sometimes describing a cutout feature as a minimum or a maximum value.

In the past, I would have made sure these offbeat dimensions were not forgotten. I'd put the key dimension on a layer that shows up as part of the fabrication drawing. Then what happens is that the vendor gets confused and wants a nominal dimension with a bilateral tolerance. I try to look ahead to anticipate the vendor's reaction. None of them seems to want a unilateral or limit tolerance giving an upper and lower bound.

A technique for ensuring stackup layer order. Many printed circuit boards are for development purposes and have some extra real estate not found on the production form factor. That open area on the big board can be used to put the number 1 on the top layer followed by a 2 on the next layer and so on through the board in sequence. Clearing out the copper above and below these numbers lets us confirm that the stackup is laminated in the correct order.

But what can we do when space is at a premium? This is a situation where we can violate the route keep-in with a little tab on the top layer that juts out to the edge of the board. Below and to the right would be a tab on the next layer down and cascading down a stair-step pattern to the bottom layer. The whole thing takes place in between the keep-in area and the edge of the board. It is a rule violation, and we keep those tabs separate from each other in the lateral direction so that nothing shorts out in the z-axis. The tabs are usually part of the ground but could be floating if there is nothing to join.

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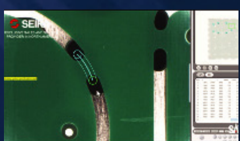
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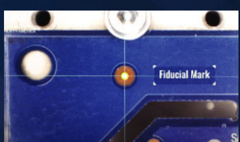

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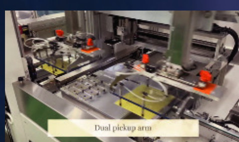

Dual-pickup Arm


Human-touchless Packing

Automatic Bit Changer

Market Share in Japan

SAM-CT56XJ-i Specifications

Routing Area	500x600mm (19.6"x23.6")
Material	FR4, CEM1, CEM3, etc.
Router Bit Diameter	0.8-3mm
Maximum Cut Speed	50mm/sec
Maximum Motion Speed	1200mm/sec
Repeatability	±0.01 mm or less
Z axis stroke	40 mm
Spindle RPM	5,000-60,000rpm (changeable)
X/Y/Z Controls	AC servo motor
Power Supply	3ph 220V AC 50/60Hz
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I Sing the Body Electronic

The Internet of Bodies could reveal the truth about our health and protect us against misinformation.

IT'S PROBABLY UNDERSTANDABLE that we are more obsessed with our health and longevity than any other aspects of our lives, including relationships, careers and money. It's also probably fair to say that more advice is thrust at us on this subject than any other: what to eat or drink, how to exercise, when to sleep, how to avoid illness, how to live longer, happier and healthier.

Guidance on how to live better is changing continuously, as new scientific studies adjust previous conclusions and influencers leverage the power of the Internet to offer various theories ranging from convincing to crackpot (Breatharianism, anyone?). Who would believe it's possible to survive on non-food substances including air, sunlight and cosmic energy? You can pay to be shown how, of course.

The Internet of Bodies (IoB) could transform our understanding of ourselves, as individuals and as a species. As an extension of the IoT, IoB adds value by aggregating information from the increasing number and diversity of biosensors available to us. By collecting more data about us from more and more diverse channels as new types of sensors and monitors are being marketed on a continuous basis, we can also analyze that data more quickly and in greater detail.

The concept of IoB is mature enough by now for us to identify three generations of technologies. What began with body-external devices – think wearables like smart watches and trackers – evolved to the second generation comprising of body-internal devices such as pacemakers, cochlear implants and swallowable digital pills. The latest generation, "body-embedded" devices, rely on close integration and interactions between the tech and the human body. Neural implants provide a prime example of this type of device and could soon become commonplace, helping users overcome problems such as movement or communication difficulties resulting from accidents or degenerative diseases. Progress is dependent on a high level of technical capability, such as perfecting robotic processes to install the implants. The necessary accuracy and precision are beyond human capabilities. Other known challenges include ensuring that the position of the implant remains accurate and connections are reliable over time.

Clearly, many of the sensors that would be included in an IoB network have existed for some time, although these continue to acquire more advanced or smarter capabilities. The improvements in heart pacemakers provide one example, evolving from the basic stimulation that would have felt so remarkable to patients of the 1960s into the sophisticated rate-adaptive devices of the 21st century.

Today's IoB solutions are predicated on pervasive wireless connectivity and computing power in the cloud as well as on edge devices to support state-of-the-art analytics applications. With the affordability that accompanies Internet technologies, these are the value-added ingredients that make IoB such a game-changing concept.

Empowered in this way, we can take advantage of the opportunities for collecting and analyzing biological data on a vast scale. Remotely recording multiple patients' vital signs can centralize monitoring in hospitals. Similar to how automated meter reading helps utilities manage resources and boost operational efficiency, this can save consultants' time and potentially improve patient outcomes by eliminating data-recording errors and capturing more frequent and timely insights. This is smart metering for clinicians. Moreover, by capturing relevant data from large numbers of cases, the pattern-spotting and anomaly-detection capabilities of AI can help us quickly understand diseases, develop effective remedies and create personalized treatment plans.

IoB-enabled telemedicine platforms now entering the market offer basic services such as heart monitoring for fitness and wellness as well as medical treatment. Potentially, these are just the start, although any significant expansion will demand progress on data privacy legislation. Existing rules about the storage and capture of medical data have mostly been written with little concept of the extent of data that can be harvested, the types of devices that can be used for capturing the data, or the opportunities to infer sensitive information from apparently harmless data. Inevitably, legislation will always lag technology. Although frustrating for some, this can provide valuable protection against unscrupulous influences that could easily cause damage in a loosely regulated landscape.

In addition to the data risks, the possibility will always exist that low-quality, ineffective or even potentially dangerous equipment could enter the market and pose a threat to health. In our haste to reap the rewards of progress in medical and health-related technology, including the IoB, the imposed caution of organizations like the FDA – and equivalents in other territories worldwide – provides a valuable counterbalance.

On the other hand, we can hope that many of the myths perpetuated widely and confidently through the Internet can be debunked with authority. Sadly, however, lifestyle misinformation is an established Internet genre that will probably continue to win acolytes. While the IoB can help us improve our health, it cannot change human nature.

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ROUGHLY **SPEAKING**

Fabricator Formats

Updating industry software involves much more than a simple button press.

SOFTWARE UPDATES AND engineering process changes are hidden roadblocks for industry adoption of modern data exchange formats like Gerber X3, ODB++ and IPC-2581. Akin to the iceberg lurking under the surface, significant issues are holding back the industry from wider adoption. And it raises the question of whether these formats meet the needs of the designer without addressing the needs of the factory.

While intelligent formats offer improved digitization and control of data flow from designer to fabricator and assembler, their benefits haven't been positioned in a way that will entirely win over the manufacturing side. It is a pain to manage all the different separate Gerber, drill, BoM and placement files, however, so I look forward to a resolution.

I mostly hear from designers advocating for the new formats, but I don't hear a lot of fabricators echoing their concerns. Sometimes I think the formats just need a better sales pitch, because attempting to strongarm fabricators is certainly not going to work. At the PCB East conference this year a group of attendees was asked which formats they used. Very few indicated they use one of the modern data exchange formats. And even when they do, they still send them with Gerbers. Everyone was still using Gerber 274X because, as I have heard time and time again, it just works, and everyone accepts it. It is hard for the industry to move away from a file format held as the standard of PCB fabrication information.

A significant difference in IT styles between PCB designers and PCB manufacturers widens the gap for adopting these new data formats. PCB designers usually have an IT support team and the engineering or technical savvy to handle updates. In those rare circumstances in which a major CAD vendor updates software, it sends ripples through the industry because everyone needs retraining, something deemed a necessary cost and evil.

The resource disparity between designers and fabrications rears its head at this point, however, because most fabricators don't have the luxury of stopping the lines for a week to retrain on software they knew how to use the day before. That also assumes all the other software tools, scripts, hardware tools and lines will function properly with the new update! When I was selling and supporting software for PCB fabricators, I would often hear a sigh of relief when they heard the interface wasn't changed, the software tool functioned as before and the new updates and features were held separate from the base functions, because most users have been burned by updates.

And frankly, sometimes manufacturers don't have the tools to handle the previously mentioned file formats. Those formats may be importable with the latest version from the software vendor, but many factories are running on software that hasn't been updated in more than five years. It is a big deal for the factory to update its critical flow software tools, as an unknown bug or issue could take the factory offline, meaning huge costs in the form of delays.

Here is a short list of additional issues that the manufacturers face when updating software tools and processes around them:

- Compatibility: While this is the reason many want to update their software, legacy support for various lines must be maintained. And this is one of the reasons that even when a factory does have the latest capabilities to use IPC-2581, et. al., they still trust and rely on 274X.
- Learning curve: New features and user interfaces require retraining, taking staff and lines off the floor, so the return on investment in training must be worth it.
- Data migration: Files from 15 years ago still need to be able to be processed and built, and if the designers aren't sending new formats, the old formats have to be workable.
- Stability and reliability: Having multiple file formats with different information and capabilities means factories' frontends must support multiple different processes for handling and managing data, which can lead to inconsistencies and errors. Many factories have automation scripts integrated into their flow and now the factory needs to verify they still work.
- Bug risks: Bugs in the factory's software in reading the new format, bugs in the designer's software in writing the new format and bugs in the file format itself. Even different interpretations of file formats by the various software vendors can cause issues.
- Security: IT security is extremely important for PCB design and fabrication, and when new software tools are introduced, security holes are often patched closed, but new vulnerabilities may be introduced.
- Cost: Software updates generally come with additional licensing maintenance fees, upgrade expenses, training and factory and employee downtime.

In production environments, no one wants to be the science project. I cringe every time my SUV attempts a software update as I don't know if in fixing old bugs they will introduce new ones. Will my brakes work after this update? Will my speedometer show the correct speed? Now imagine those concerns on the factory floor. It isn't so easy to just "update" the software to the latest version.

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Behind the Scenes

Meeting drawing requirements may be more complex than you think.

AS A DESIGN is completed, the CAD data and drawing define all the important dimensions and requirements. It is the expectation that when the first shipment is received – and every one after that – the parts will meet all dimensional requirements. But has thought been given to how the manufacturer makes that happen?

It all starts with the CAD data the designer supplies. That data sets the standard. Now it is up to the manufacturer to create the tools to build the part. As it does, keep in mind that the manufacturer does not build a part, it builds a panel of parts. So unless the part is very large, the production panel will hold multiple parts. To accomplish this, the fabricators need to ensure all the features are aligned on all the layers across the entire panel.

As the number of circuit layers increases, so does the challenge of getting everything to align and finish at nominal. The first thing to consider is the materials used to make a circuit are not made of granite. They move in all dimensions, and different materials move differently. Manufacturers need to compensate for the movement. This is done with two techniques: alignment tooling and scaling.

Tooling pin systems help stack together all the pieces of material without movement during lamination, but they only do so much. If the materials are not the same size, tooling holes in the material will be prone to distortion and the result will be layer misalignment.

The key is to make sure all materials are as close to the same size as possible at the lamination step(s). All materials have residual stress from their creation. The pressure of lamination imparts a slight stretch in the copper-clad laminate as it is made. Once it is etched, some of that stress will be released, and the layer will shrink. Of course, the layers never seem to move the same; fabricators need to compensate for this movement.

This is done by scaling the artwork on each layer at the image and etch stage. Each manufacturer has rules of thumb for scaling. The factors include copper thickness, copper coverage, laminate thickness and laminate type and laminate manufacturer. While the rigid material moves, the glass weave does constrain it in the x and y directions to some degree. Non-reinforced materials such as flex laminates move more, however, and not necessarily linearly. This can create some real mismatches as layers are stacked in rigid-flex constructions.

So how do fabricators scale a part for the first time? Well, designers get the benefit of all the parts that went before. Scales are applied based on experience with the material set being used. Each layer in the stackup will receive a different scale factor based on material specifics and the processes the layer will see prior to being laminated to other layers.

When the first panels reach the drilling stage, the fabricator can analyze the panel. We can see how well the layers align to each other. We can see how square or skewed the panel is. We can also see how close we are to a nominal scale across the entire panel.

We can now determine our drilling strategy – creating a best fit adjustment of the drilling for maximum annular ring. The systems will adjust the drill pattern to hit all layers in the stack across the full panel. In fact, the analysis can even determine no drill solution will achieve minimum annular ring and set that panel aside. Now we can move forward with the panels with drilling and complete processing.

Just because we were able to drill, however, we may not be well optimized. We may see layers misaligned to some degree. We may also see that we are barely achieving annular ring. In the spirit of continuous improvement, we want to make adjustments for future builds. So we review the collected data to determine which layers are out of place and how close to nominal the panel is. With enough panels to create meaningful data, we can adjust the scales on just one layer, or up to all layers if needed.

Often, certain layers will be an outlier from the rest of the pack. For example, a pair of layers on a flex core is likely to move much differently than the rigid layers. Or a layer set with a low percentage of remaining copper may contract substantially, especially if it is a single-layer core.

The system reports on targets placed in the four corners of the panel. Essentially, it looks like a bullseye target, and we can see how close each layer is to the bullseye in all four corners. With this information, adjustments in scale can be made on the x and y axes. With updated scales, we can evaluate the impact on the next production lot. Depending on the results, we can adjust further, or lock in a workable solution.

These data are added to preexisting data for the particular material and board construction. In this way, initial scales become more accurate over time, resulting in higher first-pass yields.

Using a new material set or combination introduces a wild card. As a manufacturer, we won't have history on how the new material performs. First-pass scales with a new material set will have a higher risk of failure to achieve annular ring. We may process a "scout" lot to confirm alignment before committing a full production volume to the shop floor. Over time, we'll build up a new data set to support the new material.

Hopefully, this helps you understand that behind the scenes, a lot of science is behind producing a part that meets the drawing requirements.

NICK KOOP is director of flex technology at TTM Technologies (ttm.com), vice chairman of the IPC Flexible Circuits Committee and co-chair of the IPC-6013 Qualification and Performance Specification for Flexible Printed Boards Subcommittee; nick.koop@ttmtech.com. He and co-"Flexpert" **MARK FINSTAD** (mark.finstad@flexiblecircuit.com) welcome your suggestions. They are speaking at PCB West at the Santa Clara (CA) Convention Center in October.

NO DISTORTION

Managing Signal Integrity in High-Speed PCBs

Nine considerations to prevent signal degradation due to crosstalk and EMI.

by AMIT BAHL

With demand growing for AI chips the need for high-speed PCBs is on the rise. As operating frequencies increase over 10GHz, the risk of reflections, crosstalk and EMI increases.

For optimal performance, all frequency components of a signal should maintain consistent amplitude changes. Additionally, signals must reach their destination simultaneously to prevent phase discrepancies. Understanding these aspects will help the design of circuits without signal distortion.

Here we review the nine factors that lead to signal integrity issues and ways to mitigate them.

Downsides of poor signal integrity in high-speed PCBs. Inefficient signal transmission in high-speed circuit boards might affect the system's overall functionality and reliability. **Figure 1** depicts how noise hampers signal quality.

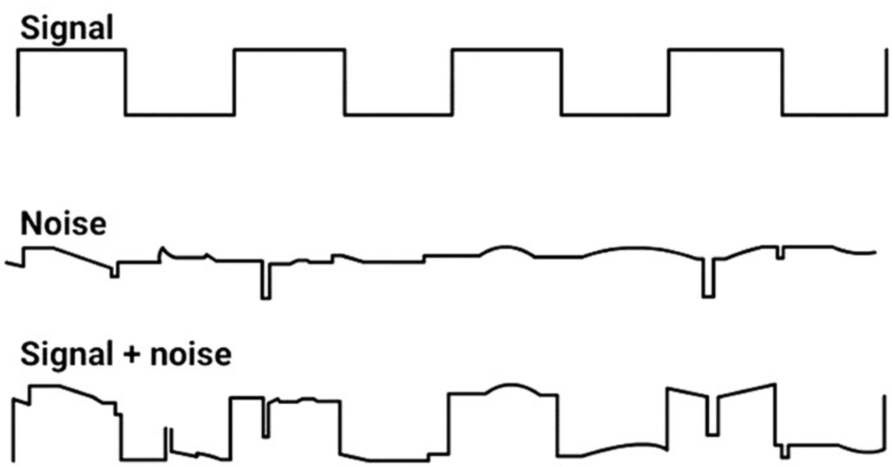


Figure 1. A signal with noise waveform at the receiver.

Here are three adverse effects of poor signal integrity in high-speed PCBs:

- **Low signal-to-noise ratio (SNR).** The SNR measures signal strength relative to noise level. When signal integrity is compromised, the ratio decreases significantly.

- **Mismatched propagation delay (t_{pd}).** Propagation delay variation is a major concern when dealing with a group of signals. Poor signal integrity in high-speed PCBs can lead to inconsistencies in the time taken by signals to travel from source to destination.
  Elevated electromagnetic emission and susceptibility. If a signal becomes susceptible to electrical noise, its quality worsens. Additionally, a distorted signal can induce EMI in the neighboring or connected electrical circuits.

Causes of Signal Degradation in PCBs

1. Impedance discontinuity. When transmission line impedance changes abruptly along its path, a part of the signal reflects toward the source rather than continuing to the destination.

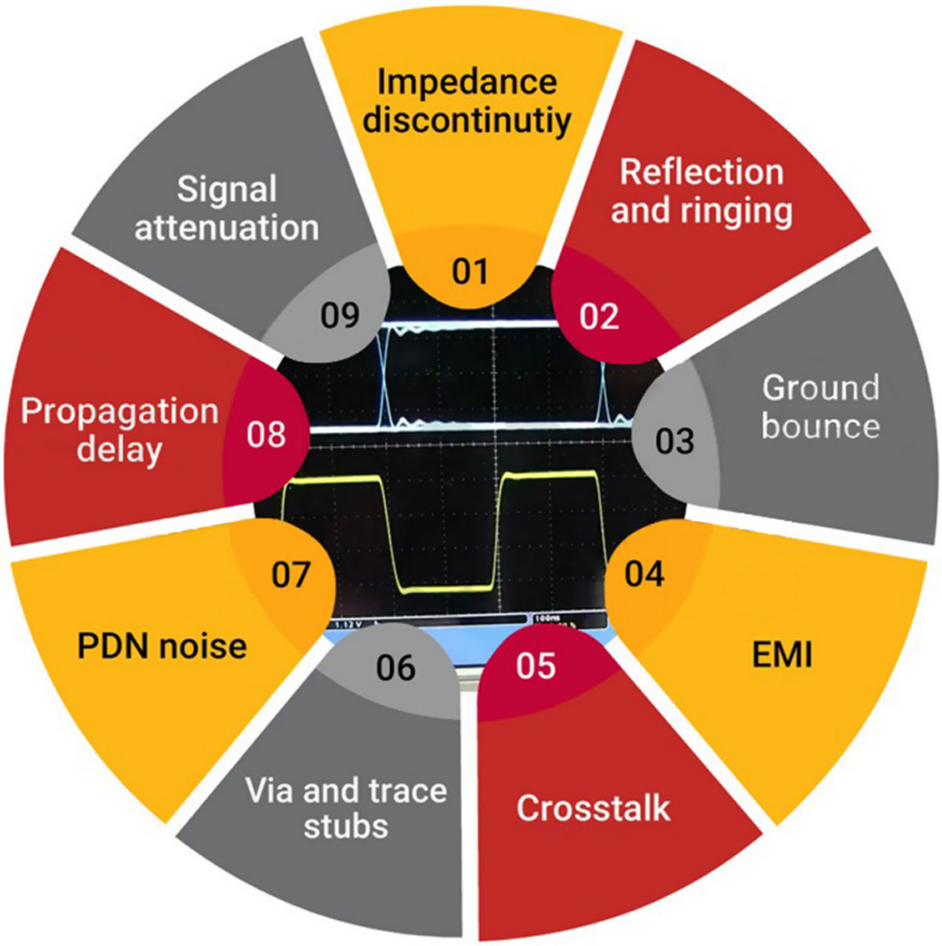


Figure 2. The nine factors that can cause signal degradation.

Impedance mismatches generally occur in these locations.

- Starting and terminating ends of a signal
- Intersection points of a signal with a via or connector pin
- Signal branches

- Via and trace stubs
- Splits in the return path or reference plane, as shown in **Figure 3.**

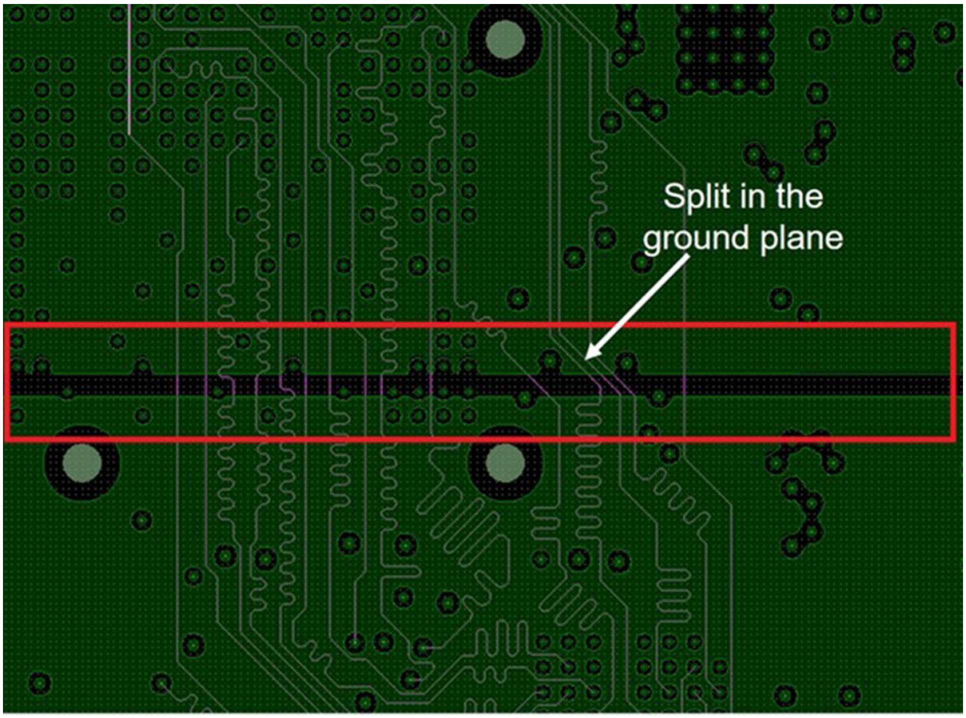


Figure 3. A layout image showing splits in the ground plane. This causes impedance discontinuity.

How to achieve uniform impedance in a PCB layout:

- Ensure consistent trace width, thickness and spacing along the signal transmission path.
- Route traces in a daisy chain fashion. A daisy chain trace routing refers to connecting components in series, one after the other, rather than multi-drop branches.
- Incorporate a series termination resistor at the source end and a shunt termination resistor at the load end for signal integrity.
- When routing signals over two reference planes, incorporate stitching capacitors to achieve a continuous signal return path **(Figure 4)**.

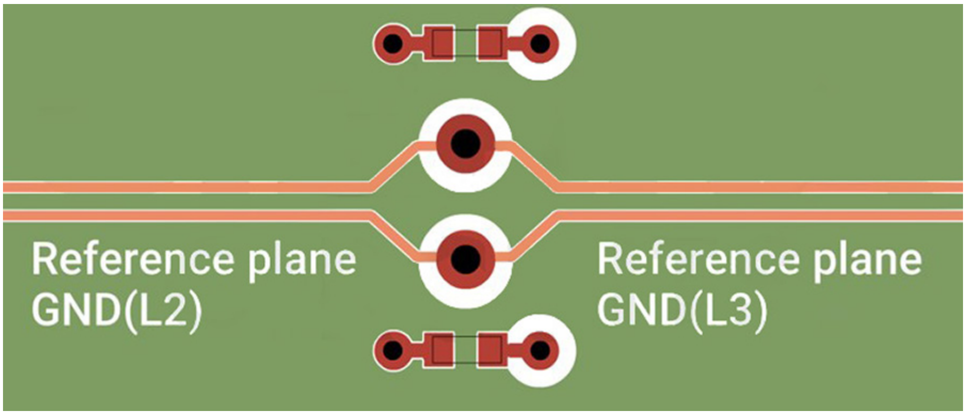


Figure 4. Adding stitching capacitors over two reference planes can achieve uniform impedance.

2. Reflections and ringing. When impedance is not consistent in a circuit, signals can reflect toward the source and interfere with the transmitting pulses. This interference can cause oscillating voltage or current, leading to ringing, overshooting (the signal exceeds its steady state), and undershooting (the signal is lower than its final value).

Consider these strategies to reduce reflections in a design:

- Place a damping resistor near the source to reduce reflected signal amplitude and prevent it from interfering with the original signal.
- When a signal changes its reference plane, place transition vias close to signal vias to maintain a continuous return path **(Figure 5)**. Transition vias provide direct routes for signals to switch between different reference planes.

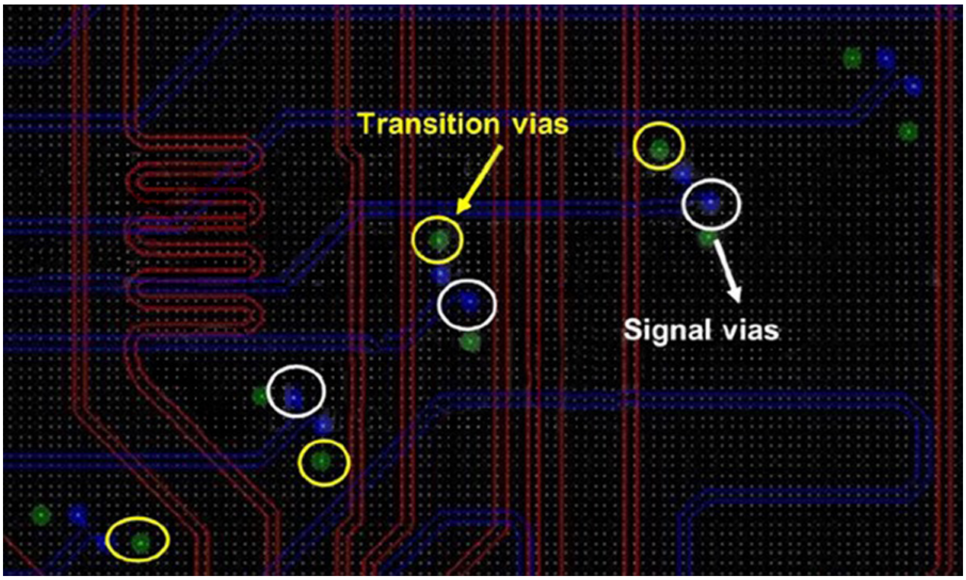


Figure 5. Transition vias near the signal vias.

- Keep trace lengths as short as possible, especially in high-frequency circuits where even small inductances can cause substantial issues. Long traces can act as antennas, increasing inductance and causing reflections.

- Use series or parallel termination resistors to match the transmission line impedance with the impedance of the connected components.

    1. Series termination: Place a resistor in series between the driver and transmission line. Position the resistor close to the source to match the driver's impedance with the trace characteristic impedance.
    2. Parallel termination: Place a termination resistor in parallel with the receiver to reduce signal reflections at the load end **(Figure 6)**.

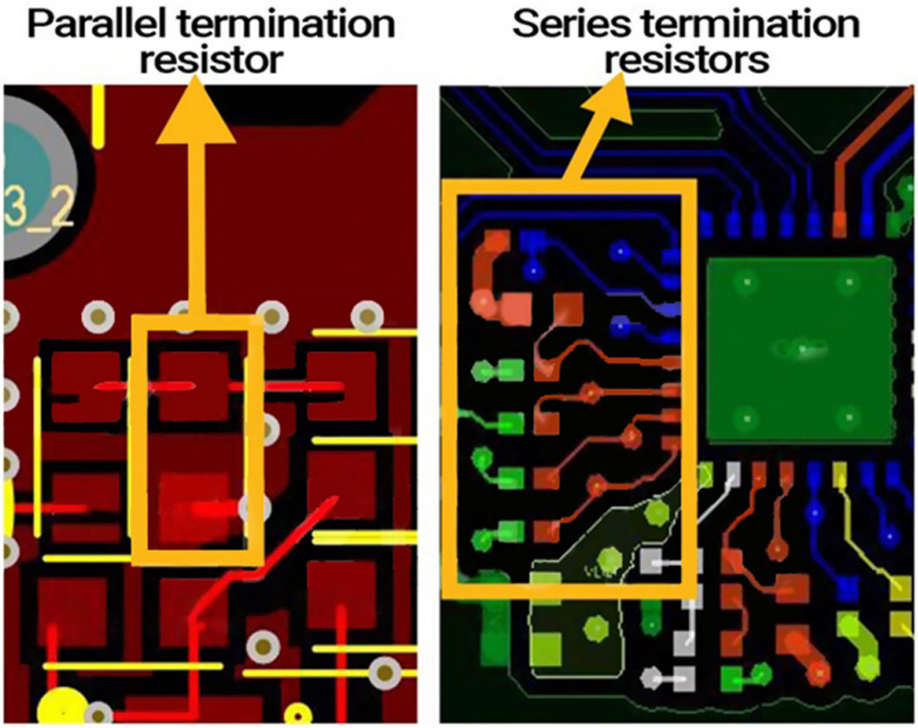


Figure 6. Parallel termination and series termination resistors to prevent reflections and ringing.

3. Ground bounce. Ground bounce occurs during transistor switching, causing the circuit's reference level to shift from its original state **(Figure 7)**. This shift is primarily due to impedance mismatches between ground rails and signals.

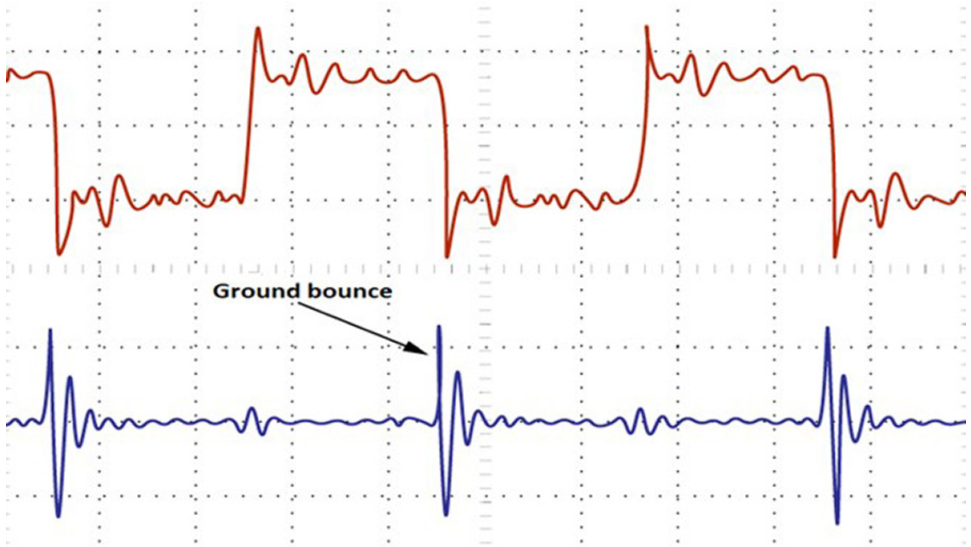
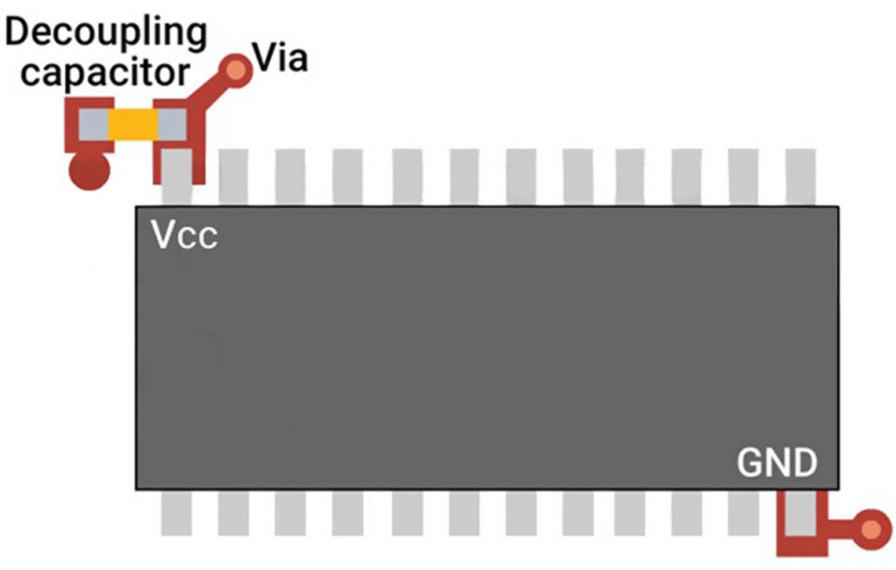


Figure 7. Ground bounce in an oscilloscope waveform.

Techniques to decrease ground bounce:

- Place decoupling capacitors near the power pin to stabilize voltage levels **(Figure 8)**. These capacitors act as local charge reservoirs, providing instantaneous current to the circuit during switching. They reduce voltage fluctuations and the impact of ground bounce.



- Incorporate current-limiting resistors in series with switching transistors. These resistors limit the current flow during switching events, reducing voltage drop across the ground rails.
- Provide dedicated vias and traces for ground connections to ensure a low-impedance return path. Shared vias and traces can introduce additional impedance, leading to significant ground bounce during switching.

4. Electromagnetic interference (EMI). EMI occurs when energy is transmitted through radiation or conduction from one electronic device to another. It is caused by

- Electromagnetic emissions, or energy radiated from an electronic device, and
- Susceptibility to EM radiation, or the tendency of an electronic device to be affected by external electromagnetic energy.

To lower EMI in a circuit board layout

- Employ a Faraday cage, or a continuous copper fill around sensitive circuitry. It acts as a shield and blocks electromagnetic fields from escaping or entering the confined circuit.
- Implement via stitching along the edges of a ground plane or around critical signal traces to provide multiple low-impedance paths to the ground.
- Avoid discontinuities in the ground plane. Any splits or gaps can create unintended antennas that emit or receive EM radiation.
- Shield cables with conductive material that acts as a barrier to electromagnetic fields. This reduces the likelihood of interference.

5. Crosstalk. Crosstalk occurs when two adjacent conductors are close together, permitting energy to couple from the aggressor to the victim trace **(Figure 9)**.

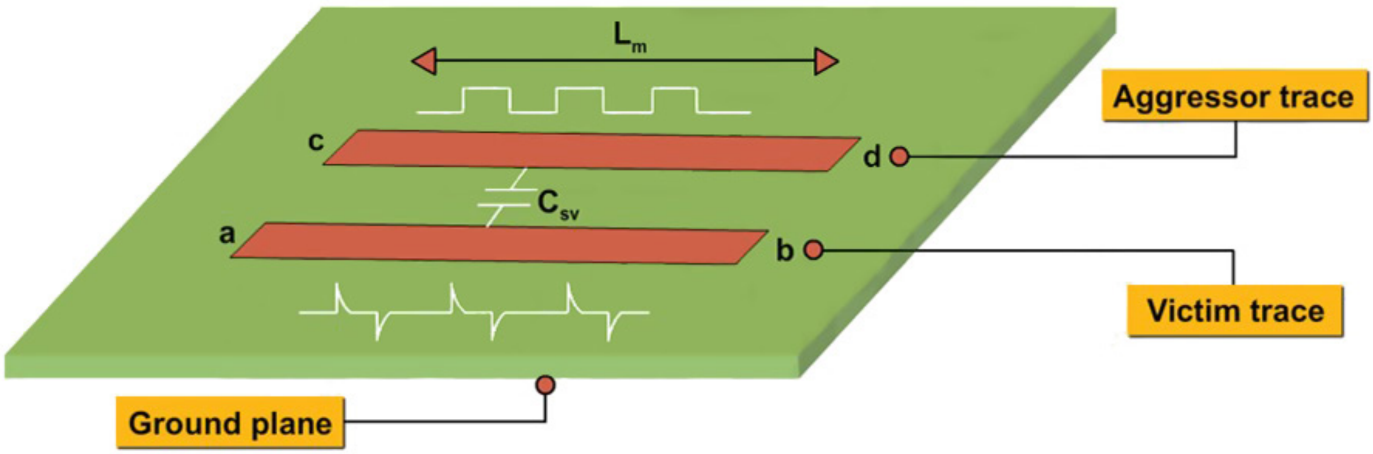


Figure 9. Mutual coupling between aggressor and victim traces.

When current flows through a conductor, it generates a magnetic field around it. If another trace runs parallel to the first one, the changing magnetic field induces a voltage in the adjacent trace. This effect is more pronounced when the traces are close together. High-speed digital signals, clock lines and analog signals are particularly susceptible to crosstalk.

The best practices to reduce crosstalk include

- Ensure sufficient spacing between adjacent signal traces. The recommended clearance is typically three to five times the trace width to minimize electric field coupling **(Figure 10)**.

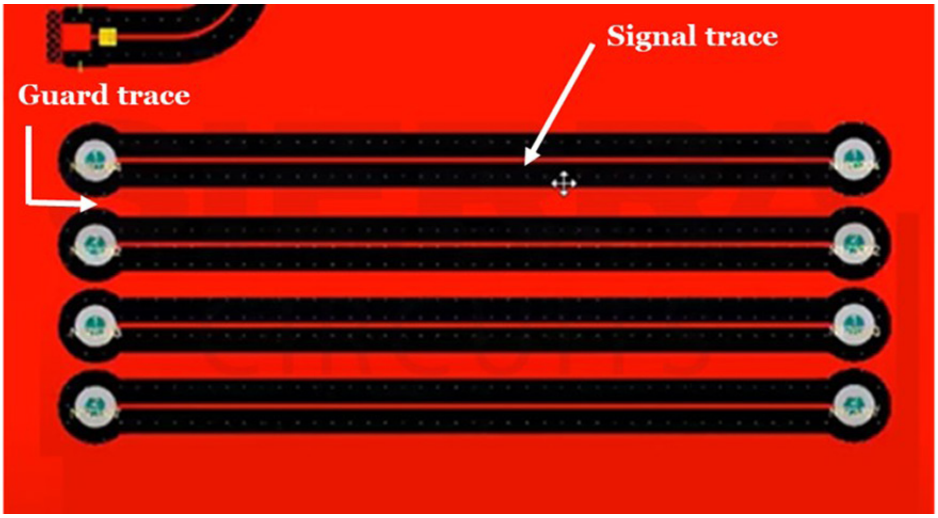


Figure 10. Spacing of 3W to 5W between guard and signal traces can avoid crosstalk.

- Place signal planes close to ground planes (preferably one dielectric away). Ground planes act as shields, providing a low-impedance return path.
- Route traces perpendicular to each other between layers to further reduce the chance of crosstalk.
- Avoid overlapping critical signals (such as clock lines or data buses) on adjacent planes.
- Add guard traces next to critical signal lines. They are beneficial when dealing with sensitive, high-frequency signals.

6. Via and trace stubs. Via stubs are the unused portions of vias that can act as resonant circuits, leading to reflections and signal attenuation.

To avoid via stub impact

- Ensure the maximum frequency is far less than the fundamental resonant frequency of the stub.
- Back-drill the vias with a slightly larger drill bit to remove the unused via portion.

Trace stubs act like antennas, radiating energy and causing reflections. To avoid trace stubs

- Adopt daisy chain routing. This involves routing the traces in a continuous chain, connecting each component in series rather than creating branches or stubs.
- Use series termination resistors at the driver end of transmission lines.
- Keep trace lengths as short as possible. Shorter traces reduce the potential for stubs and the associated signal integrity issues in high-speed circuit boards.

7. Power distribution network (PDN) noise. PDN noise arises due to the switching activity of devices' output signals and internal gates. To avoid this

- Place power and ground planes in proximity. It reduces parasitic capacitance and inductance between planes.
- Choose IC packages with shorter lead lengths. Shorter leads reduce inductance and resistance in the PDN.
- Use multiple low-inductance decoupling capacitors of the same value **(Figure 11)**. Place them as close as possible to the ICs' power pins. These capacitors filter noise and provide a stable power supply to the ICs.

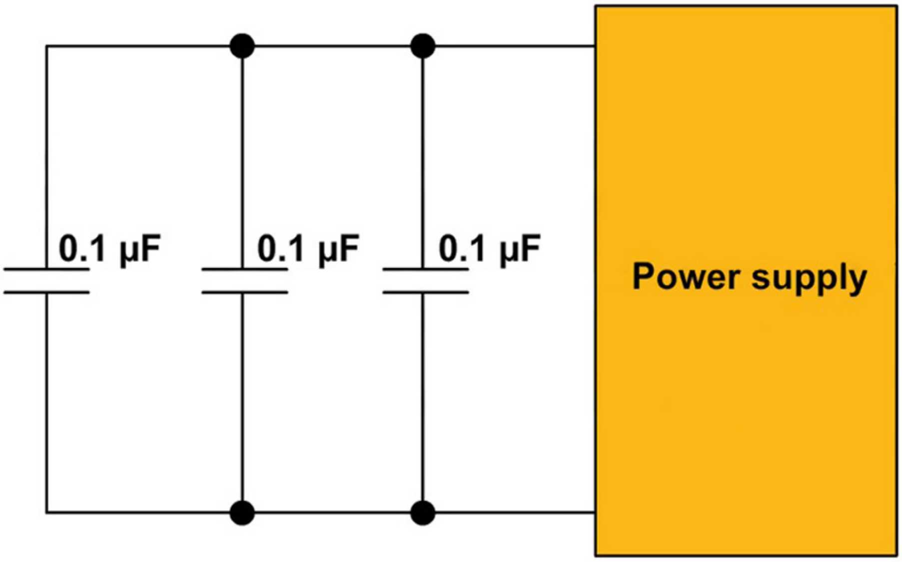


Figure 11. Placing multiple decoupling capacitors in parallel with a power supply to prevent PDN noise.

8. Propagation delay. Propagation delay occurs when data signals and clock signals do not arrive at the receiver simultaneously, causing signal skews. Excessive skew can lead to signal sampling errors.

Strategies to reduce propagation delay include

- Adjust trace width and spacing to ensure uniform impedance.
- Match signal lengths using serpentine traces **(Figure 12)**. This ensures signals traveling through different paths reach their destination at the same time, minimizing skew and reducing the risk of signal sampling errors.

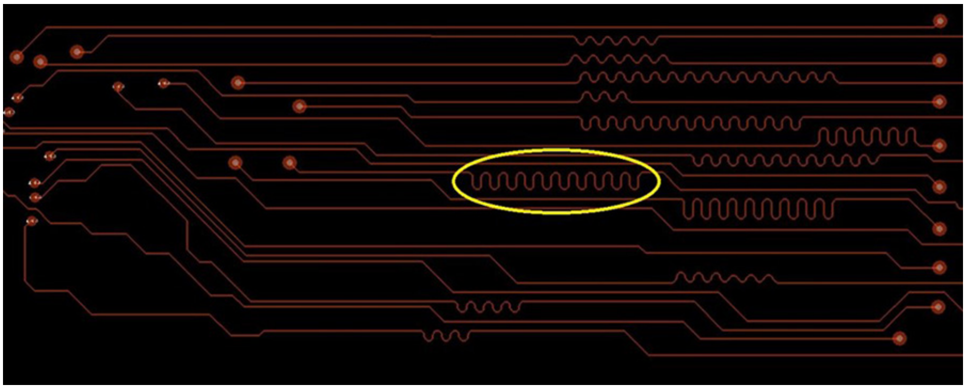


Figure 12. Adding serpentine traces to match line lengths.

9. Signal attenuation. Signal attenuation refers to the reduction in signal amplitude caused by conductor and dielectric losses. Conductor loss increases with trace resistance and frequency, while dielectric loss is influenced by the dissipation factor and loss tangent **(Figure 13)**.

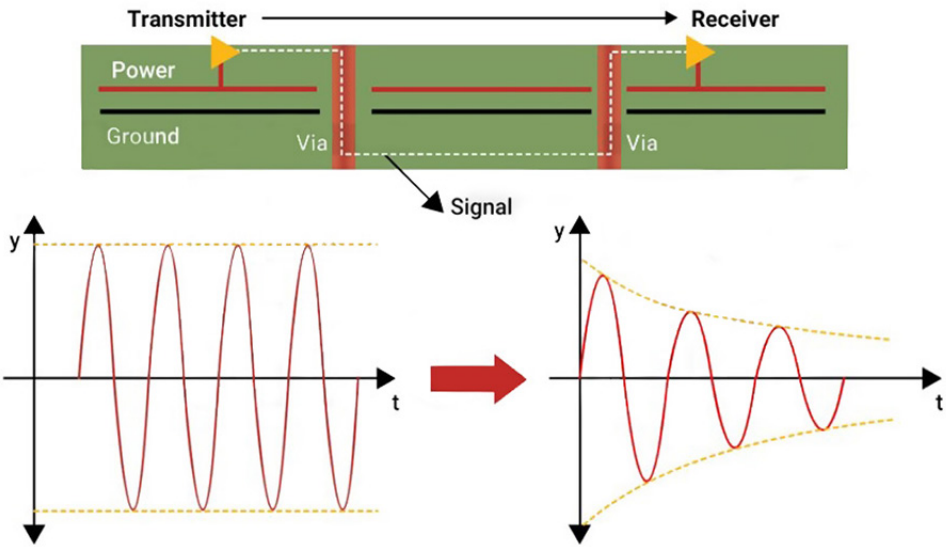


Figure 13. Signal attenuates with time while traveling from transmitter to receiver.

Design tips to mitigate signal attenuation include

- For signal integrity in high-speed PCBs, use a PCB material with a low-loss tangent and a low dissipation factor. Materials such as FR-4 might be suitable for lower frequencies, but for high-frequency applications consider advanced materials.
- Using very-low roughness profile copper foils, such as very-low-profile (VLP), hyper- very-low-profile (HVLP) and reverse-treated foil (RTF). These foils have smoother surfaces, reducing skin effect losses at high frequencies.

Signal integrity analysis using simulation and an oscilloscope (Figure 14). Simulation helps demonstrate the circuit board's actual behavior before fabrication. It identifies root causes of signal degradation early in the design process, saving time. S-parameters, eye diagrams and a time-domain reflectometer can be used to perform signal integrity analysis.

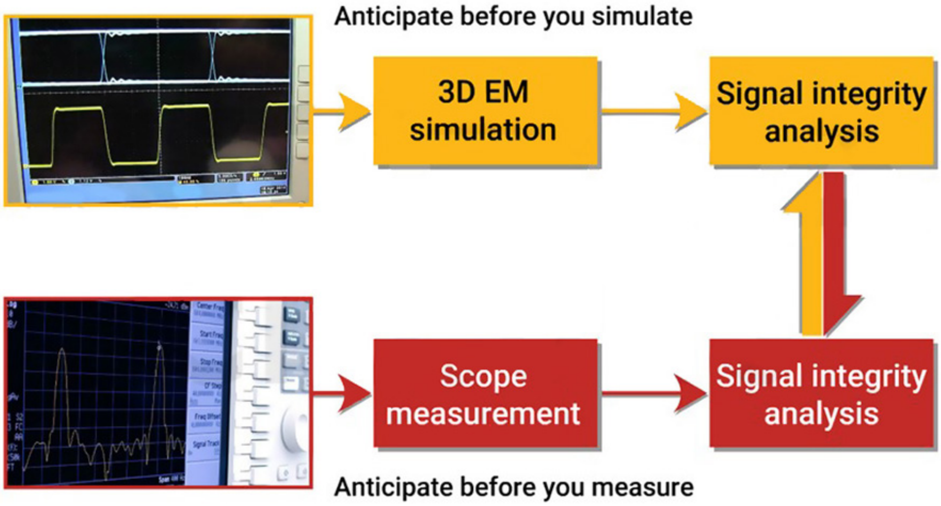


Figure 14. Signal integrity analysis using simulation software and oscilloscope.

S-parameters show how a signal propagates through an electrical network and represent its bidirectional behavior at input and output ports. They are saved in Touchstone files, standard formats for storing network parameter data. Their significance and application in signal integrity analysis are as follows:

- **S_{11}: reflection coefficient:** S_{11} represents the reflection coefficient at port 1. It indicates how much of the input signal is reflected to the source (return loss). A high return loss (low S_{11} value) means that most of the signal is transmitted through the network with minimal reflection.
- **S_{21}: transmission coefficient:** S_{21} represents the transmission coefficient from port 1 to port 2. It shows how effectively the signal is transmitted through the network. A high S_{21} value (low insertion loss) indicates efficient signal transmission with minimal loss.

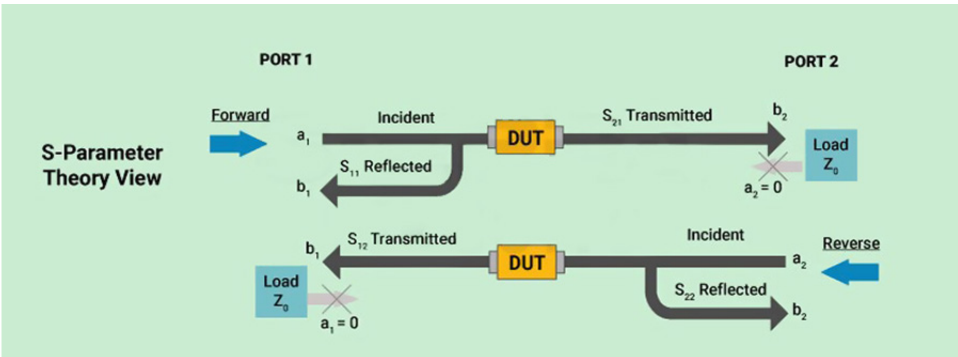


Figure 15. 2-port S-parameter analysis for signal integrity measurement.

Mixed-mode S-parameters provide insights into differential and common-mode behavior of differential signals. **Figure 16** shows a four-port measurement with 16 S-parameters.

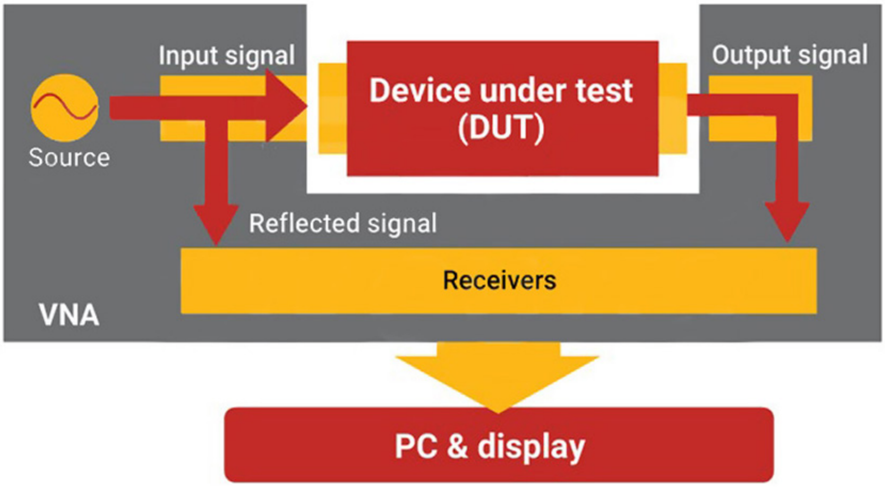


Figure 16. S-parameter measurement using a VNA.

- S_{31} = Near-end crosstalk from port 1 to port 3
- S_{32} = Far-end crosstalk from port 2 to port 3
- S_{41} = Near-end crosstalk from port 1 to port 4
- S_{42} = Far-end crosstalk from port 2 to port 4

A vector network analyzer measures the power of high-speed signals that enter and exit a component or network, capturing both amplitude and phase information. A VNA works like this:

- **Step 1.** The source generates a known signal that is sent through the device under test (DUT).
- **Step 2.** Receivers detect how the DUT alters the signal, measuring both the reflected and transmitted signals.
- **Step 3.** The VNA captures the signal's amplitude and phase at every point, providing a detailed picture of the DUT's behavior.

Eye diagrams assess how a signal degrades through a transmission channel. They are composite images created by overlapping multiple bits of a signal. Consider a channel with a transmitter and a receiver:

- **Transmitter side.** The eye diagram is open, and the "0" and "1" levels are clearly distinguishable.
- **Receiver side.** The eye diagram is almost closed, making it difficult to differentiate between "0" and "1." This indicates a signal integrity issue where the receiver struggles to interpret the signal correctly.

Eye patterns help PCB design engineers identify issues such as

- **Slow rise times.** Eye diagrams can show if the signal transitions are too slow, affecting the timing.
- **Inter-symbol interference (ISI).** Overlapping of signals from previous bits can be detected, indicating ISI.

- **Attenuation levels.** The height and clarity of the eye-opening indicate how much the signal has been attenuated.
- **Jitter:** Causes horizontal blur, indicating timing variations in the signal.
- **Noise:** Causes vertical blur, indicating amplitude variations.

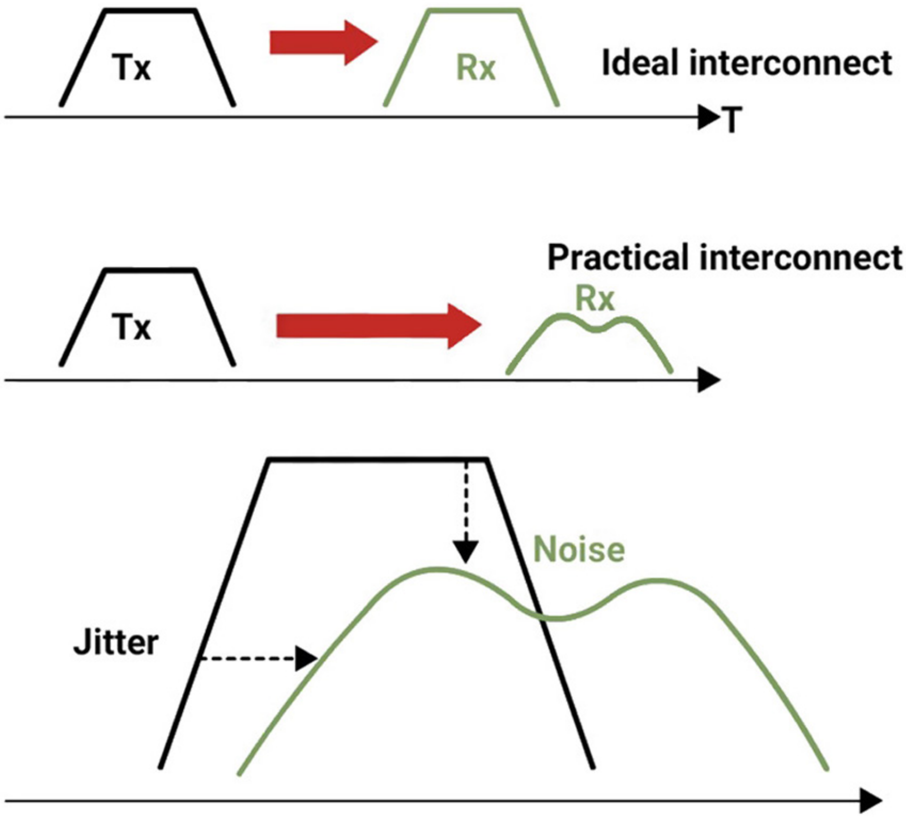


Figure 17. Jitter and noise in an eye diagram.

Time-domain reflectometry (TDR) can pinpoint where impedance mismatches occur and provide insights into the integrity of the transmission line, helping designers address issues such as signal reflections and losses. How it works:

- A TDR tester sends a signal into the device under test (DUT).
- It measures signal reflections as they pass through the transmission medium.
    - Uniform impedance. If the conductor has uniform impedance and is properly terminated, there will be zero reflections.
    - Impedance variations. Some incident signals will be reflected to the source.
- TDR compares the reflections with those generated by a standard impedance. It generates a graphical representation showing the reflected waveform's timing, phase, and amplitude and accurately identifies the location and nature of electrical discontinuities.

Maintaining signal integrity in high-speed PCBs becomes more challenging in today's fast-paced technological landscape. Unidentified signal integrity issues in a PCB design might question product accuracy and reliability. Consider these guidelines when designing the next high-speed board.

AMIT BAHL is chief revenue officer at Sierra Circuits; amit@protoexpress.com.

BOARD CONSTRUCTION

Balancing Stackups and Circuitry

A symmetrical build is one of the keys to minimize board warpage.

by **AKBER ROY**

A stackup's construction should be balanced to keep board warpage within IPC specifications. In general, the following parameters must be symmetrical with respect to a fictitious center plane of the board:

- Dielectric thickness
- Buildup of the dielectric
- Pattern density (layer to layer)
- Thickness of copper foil
- Number of layers.

Figure 1 shows a symmetrical eight-layer build. The following notes clarify points on symmetry from the numbers shown on the stackup in the figure.

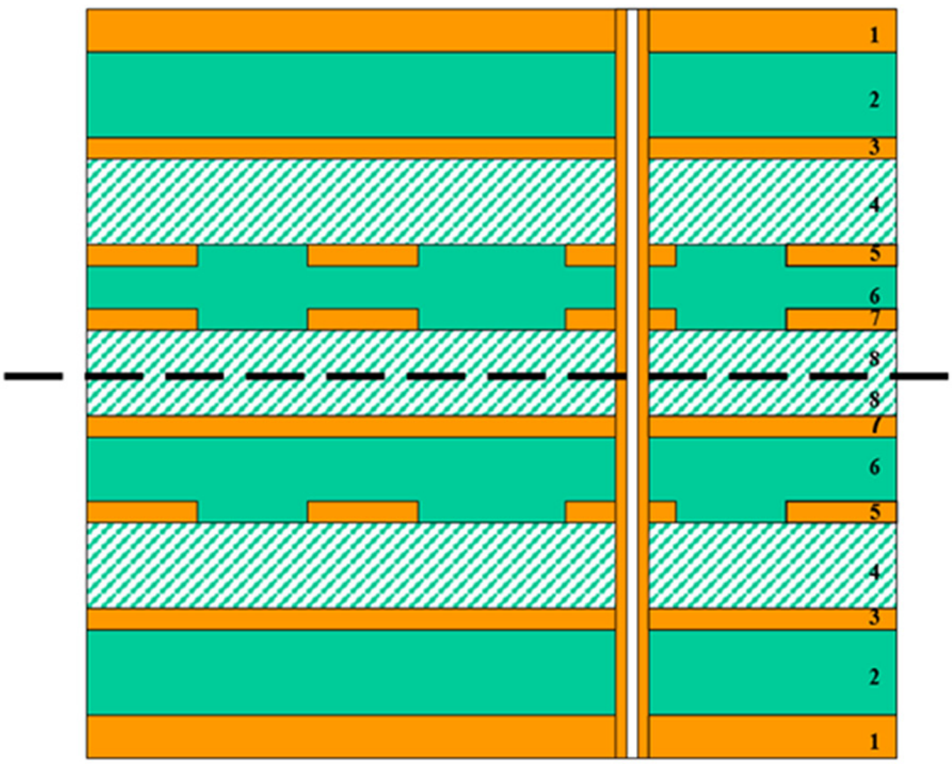


Figure 1. An illustration of symmetrical features in a stackup.

1. This is the base copper weight of outer layers, where the starting foil thickness for each side must be identical and is typically 0.5 oz.
2. Identical prepreg plies at these locations are highly recommended. Use of the same prepreg throughout the stackup will improve manufacture and reduce mistakes in this manual layup process.
3. Copper plane layers should be the same copper weight, typically 1 oz.
4. Identical cores are highly recommended to improve manufacturability.
5. Copper signal layers should be the same weight, typically 0.5 oz.
6. Identical prepregs are highly recommended, and could be different from those in note 2 to accommodate impedance constraints or overall PCB thickness.
7. Innerlayer plane and signal layers can be different provided two criteria are followed. First, the copper weight must be the same. Second, the signal layer must have even copper distribution. Thieving pads may be added to help achieve copper balance with the symmetrical plane feature. Doing so helps to avoid excessive resin loss during lamination.
8. The fictitious center of the board is in the middle of this core. This material could be different from the core in note 4 to accommodate impedance constraints or to meet the overall thickness requirement.

Core and Prepreg Recommendations

Within a given design, minimize the number of different cores and prepregs. And across all designs, standardize and minimize the number of different cores and prepregs used.

Copper Weight Recommendations

- 0.5 oz. outer layers
- 0.5 oz. or 1 oz. innerlayers
- Finer geometry may require thinner copper
- The most common cores have the same copper weight on both sides. This is recommended and these are most likely to be in stock for PCB fabrication.

Thicker innerlayers are sometimes required for heat dissipation or current carrying capability. Copper thicknesses of 2 oz. or more have limitations on minimum geometries.

Hybrid Construction

For cost reasons, use low-loss material only where required in the design, with cheaper material for general purpose routing and planes. Our experience with mixed substrates (PCBs with more than one material) has proven mixing materials is not as easy as it appears. Be aware of the risks and possible alternatives before proceeding. Because of issues with this type of build, it is recommended only on an exception basis. The following are points to consider before choosing a hybrid construction:

- Ensure a detailed cost understanding of a mixed material build, compared to one with high-performance cores all the way through. Generally, it only makes sense if three-quarters or more of the board thickness is the cheaper material.
- Research the supplier's claims that they have experience with the requested hybrid construction. Inquire how many parts they have done. The board could be their R&D project. Be careful.
- The supplier must have UL approval for each specific mix of materials. If UL approval must be obtained, it can significantly delay the PCB turnaround time.
- Be aware of quality issues with this type of build beforehand, as it can be difficult to determine the actual root cause of the problem.
- Never rely on a single vendor. Always get input on hybrid builds from additional sources.

Hybrid Materials

Be aware of the following material properties and their implications for hybrid materials:

- Glass transition temperature
- Coefficient of thermal expansion, particularly z-axis expansion
- Dimensional stability
- Process incompatibility between materials.

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NTI-100

Can Thailand Pad its PCB Gains?

2023 saw only a handful of fabricators gain ground, but SE Asia is primed to boom.

by DR. HAYAO NAKAHARA

Small it was, but the Thailand Electronics Circuit Asia exhibition held in Bangkok in late July was extremely informative as to what is happening in the Southeast Asian nation. According to the Thailand Board of Investment (BOI), the PCB output in Thailand may become the third or even second largest in the world. From 2022 to 2026, about $6 billion to $7 billion will be invested in PCB capacity in Thailand (at this moment, 40-plus fabricators from Taiwan and China are pouring into Thailand). Calling Thailand the second-largest PCB-producing country may be a bit of a stretch, but the third largest is not an exaggeration. From the view of "nationality," however, Thailand-based KCE and a few other small ones will account for less than 10% of the total output. Taiwan-, China- and Japan-based companies will hold the lion's share of the PCB output in Thailand.

The author wrote this report at Bangkok International Airport while waiting for a flight to Penang, Malaysia, where he was scheduled to visit several PCB fabricators before returning to Bangkok. He was then planning to visit 10 new PCB plants in Thailand before heading home to New York.

Thailand is just the latest in a string of geographical disruptions to the printed circuit manufacturing landscape over the past three decades. What was once the provenance of Japan and the US gave way to Taiwan, China, Vietnam and now Thailand as major hubs of production. But is it reflected (yet) in the latest NTI-100 rankings of the largest printed circuit board manufacturers?

The annual NTI-100 list attempts to ascertain just that. The author looks at the growth of manufacturers with revenues of $100 million or more. He also provides a look at the overall PCB market and how those companies – which now number 134 – fit within the global picture.

Obtaining the printed circuit board output from top fabricators is not so difficult if they are publicly traded, although public companies in China and South Korea pose a challenge because their financial statements are often blurred. Then, many manufacturers whose outputs are presumably more than $100 million per annum are privately owned and normally do not publicly disclose their financial status. Finding the specific PCB revenues of some large companies is not easy either; Sanmina and Amphenol, for example. As such, the author must make certain assumptions and guesses.

Table 1. NTI-100 Largest PCB Fabricators, 2023

Rank	Maker Name	Country	Local Name	2022	2023	Growth
1	Zhen Ding Technology	Taiwan	臻鼎科技	5,440	4,918	-10.6%
2	Unimicron	Taiwan	欣興電子	4,510	3,340	-25.9%
3	DSBJ	China	東山精密	3,085	3,289	6.6%
4	Nippon Mektron	Japan	日本メクトロン	2,361	2,539	7.5%
5	TTM Technologies	US	TTM Technologies	2,495	2,232	-10.5%
6	Kyocera	Japan	京セラ	2,573	2,220	-13.7%
7	Compeq	Taiwan	華通電脳	2,453	2,153	-12.2%
8	Shennan Circuits	China	深南電路	1,978	1,913	-3.3%
9	Tripod	Taiwan	健鼎科技	2,112	1,890	-10.5%
10	AT&S	Austria	AT&S	1,938	1,730	-10.7%
11	HannStar Board	Taiwan	瀚宇博德	1,997	1,646	-9.9%
12	Kinwong	China	景旺電子	1,487	1,521	2.3%
13	Kingboard PCB	China	建滔集団	1,531	1,493	-2.5%
14	Young Poong Group	S. Korea	영풍그룹	1,507	1,487	-1.3%
15	Wus Group (TW+CN)	Taiwan	楠梓電子(滬士電子)	1,347	1,377	2.2%
16	Nanya PCB	Taiwan	南亜電路	2,076	1,356	-34.7%
17	Ibiden	Japan	イビデン	1,769	1,346	-23.9%
18	SEMCO	S. Korea	삼성전기	1,599	1,345	-15.9%
19	Meiko	Japan	メイコー	1,181	1,268	7.4%
20	BH Flex	S. Korea	베에이치플렉스	1,286	1,223	-4.9%
21	Victory Giant	China	勝宏科技	1,115	1,121	0.5%
22	Flexium Technology	Taiwan	台群科技	1,287	1,051	-18.3%
23	AKM Meadville	China	安捷利美維	1,169	1,025	-12.3%
24	LG Innotek	S. Korea	LG이노텍	1,297	1,012	-22.0%
25	Gold Circuit (GCE)	Taiwan	金像電子	1,054	965	-8.4%
26	Shinko Electric Ind.	Japan	新光電気工業	1,248	902	-27.7%
27	Kinsus	Taiwan	景碩科技	1,362	861	-36.8%
28	Suntak	China	崇達科技	830	816	-1.7%
29	Simmtech	S. Korea	심텍	1,299	798	-38.4%
30	Shenzhen Fast Print	China	深圳興森快捷電路	757	758	0.1%
31	Nitto Denko	Japan	日東電工	809	738	-8.8%
32	Daeduck Electronics	S. Korea	대덕전자	1,009	697	-30.9%
33	Sumitomo Elect Ind.	Japan	住友電気工業	664	652	-1.8%
34	Olympic	China	世運電路	626	639	3.1%
35	CMK	Japan	日本シーエムケー	592	639	7.9%
36	ASK PCB	China	奥士康	645	612	-5.1%
37	Taiwan Techvest (TPT)	Taiwan	志超科技	682	608	-10.8%
38	Fujikura	Japan	フジクラ	680	605	-11.0%
39	Chin Poon	Taiwan	敬鵬工業	565	538	-4.8%
40	SI Flex	S. Korea	에스아이플렉스	312	529	70.0%
41	KCE	Thailand	KCE Electronics	588	521	-11.4%
42	Murata Manufacturing	Japan	村田製作所	525	505	-4.0%
43	Dynamic Electronics	Taiwan	定穎電子	491	505	2.9%
44	Hongxin Electronics	China	弘信電子	395	492	24.6%
45	Sun & Lynn	China	深聯電路	471	482	2.3%

46	Unitech	Taiwan	燿華電子	559	480	-14.1%
47	Shengyi Electronics	China	生益電子	500	463	-7.4%
48	ISU Petasys	S. Korea	이수페타시스	493	445	-9.7%
49	Ellington	China	依頓電子	432	440	1.9%
50	Founder PCB	China	方正印刷電路	476	427	-10.3%
51	GD Keixiang Kingshine	China	広東科翔電子	373	419	9.7%
52	Guangdong XD Group	China	広東興達(佳康集団)	373	419	12.3%
53	Bomin Electronics	China	博敏電子	412	412	0.0%
54	APEX International	Taiwan	泰鼎電路	479	405	-15.4%
55	Kyoden	Japan	キョウデン	372	404	8.6%
56	Gul Technology	Singapore	Gul Technology	455	391	-14.0%
57	CCTC	China	汕頭超声印製板	419	390	-6.9%
58	Delton Technology	China	広州広合科技	267	379	41.9%
59	China Eagle (CEE)	China	中京電子	432	371	-14.1%
60	Wuzhu	China	五株科技	420	363	-13.6%
61	Guangdong Junya	China	広東駿亜電子	369	348	-5.7%
62	Sanmina	US	Sanmina	340	340	0.0%
63	Red Board	China	紅板	311	332	6.8%
64	Career Technology	Taiwan	嘉聯益科技	473	316	-33.2%
65	DAP	S. Korea	디에이피	255	308	20.8%
66	Toppan Printing	Japan	凸版印刷	225	300	33.3%

Continues on next page

Source: Dr. Hayao Nakahara/N.T. Information Ltd., September 2024. $100M revenue min.
(Unit: $US million with avg. 2022 exchange rates)

Rank	Maker Name	Country	Local Name	2022	2023	Growth
67	Ichia Technology	Taiwan	毅嘉科技	246	275	11.8%
68	Lincstech	Japan	リンクステック	290	270	-6.9%
69	MFS	Singapore	MFS Singapore	261	270	3.6%
70	FICT	Japan	エフアイシーティー	275	260	-5.5%
71	Transtech	China	江蘇伝芸科技	283	251	-11.3%
72	Würth Elektronik	Germany	Würth Elektronik	224	250	11.4%
73	ACCESS	China	珠海越亜半導体	237	242	2.1%
74	Somacis	Italy	Somacis	200	241	20.5%
75	Summit Interconnect Tech	US	Summit Interconnect Tech	200	240	20.0%
76	Shenzhen Sunshine	China	深圳明陽電路	278	229	-16.2%
77	Taihong Circuit Industry	Taiwan	台豊印刷電路工業	387	218	-24.0%
78	STEMCO	S. Korea	스템코	241	210	-15.0%
79	Onpress	China	安柏電路	208	208	0.0%
80	Shirai Denshi	Japan	シライ電子	233	204	-12.4%
81	APCB	Taiwan	競国実業	234	192	-13.9%
82	Amphenol PCB	US	Amphenol PCB	180	190	5.5%
83	Camelot PCB	China	金淥電路科技	211	188	-10.9%
84	Haesung DS	S. Korea	해성디에스	223	187	-19.0%
85	Shihui Fushi	China	四会富仕電子科技	172	186	8.1%
86	Hyunwoo	S. Korea	현우	161	182	13.0%
87	Daisho Dennshi	Japan	大昌電子	201	181	-10.0%

88	Jiangxi Union Gain	China	江西聯益電子科技	168	181	7.7%
89	APCT	US	APCT	120	180	50.0%
90	Synopex (Vietnam)	S. Korea		157	180	14.7%
91	SZ Jove Enterprise	China	深圳中富電路	173	175	-19.6%
92	Kyosha	Japan	京写	173	173	0.0%
93	Putian Technology	China	中電科普(広州杰賽)	187	206	2.0%
94	Jia Li Chuang	China	先進電子(珠海)	174	158	-9.2%
95	Liang Dar	Taiwan	良達科技	167	174	4.2%
96	Palwon	Taiwan	競華電子	113	174	54.0%
97	Ji'An Munkan	China	吉安滿坤科技	146	172	17.8%
98	Leader-Tech	China	深圳上達電子	156	165	5.8%
99	SZ Topreach Sci-Tech	China	深圳至誠合電子	150	160	6.7%
100	Changzhou Auhong	China	常州澳弘電子	163	153	-6.1%
101	Glorysky	China	惠州市特創電子	163	155	-4.9%
102	SZ Konka Circuits	China	深圳康佳電路	165	155	-6.3%
103	NTK	Japan	日本特殊陶業	163	156	-4.3%
104	SZ Minzhenhung	China	広東明正宏電子	155	150	-3.2%
105	Schweizer Electronics	Germany	Schweizer Electronics	142	151	6.4%
106	Kunshan Huanxing Grp	China	昆山華新電子集団	187	150	-19.8%
107	New Flex	S. Korea	뉴플렉스	187	150	-25.0%
108	Jiangxi ZLE	China	江西中絡電子	144	149	3.5%
109	First Hi-Tech	Taiwan	高技企業	104	140	35.0%
110	Kunshan Wanyuanton	China	昆山万源通電子科技	125	139	11.0%
111	Xusheng Electronics	China	江西旭昇電子	128	138	7.8%
112	Brain Power	Taiwan	欣強科技	119	138	16.0%
113	Jiangxi Xusheng PCB	China	江西旭昇電子	138	138	0.0%
114	Jinagsu Difeida	China	江蘇迪飛達電子	137	125	-8.8%
115	SZ Xinyu Tengye	China	深圳新宇騰跌電子	137	125	-8.8%
116	Oki Printed Circuit	Japan	沖PCB	146	135	-7.5%
117	TLB	S. Korea	티엘비는	170	132	-22.3%
118	KSG	Germany	KSG	150	128	-14.7%
119	Forewin FPC	China	福菜盈電子	142	128	-9.9%
120	Dongguang Hongyuen	China	東莞康源電子	155	127	-18.0%
121	Xiamen Guangpu Elec.	China	光苒電子股份	117	126	7.7%
122	Fuchnagfa	China	信豊福昌発	125	127	1.6%
123	Aikokiki	Japan	愛工機器	145	124	-14.5%
124	Jiangsu Suhhang	China	江蘇蘇杭電子集団	122	116	-4.9%
125	Welgao	China	江西威尔高電子	118	116	-0.8%
126	Longteng Electronics	China	湖北龍騰電子	102	117	14.8%
127	Trustech	China	深圳全成信電子	113	113	0.0%
128	HT Circuit	China	永捷電子	111	113	1.3%
129	Zejiang Leuchtek	China	浙江羅奇泰克科技	105	113	7.6%
130	Shinko Manufacturing	Japan	伸光製作所	106	110	3.8%
131	Song Shan Electronics	Taiwan	松山電子	143	107	-25.2%
132	SZ Star River	China	深圳市星河電路	100	106	6.0%
134	Shenzhen QD Circuit	China	深圳強達電路	104	104	0.0%
	Top Total			**85,092**	**77,735**	**-8.60%**

Source: Dr. Hayao Nakahara/N.T. Information Ltd., September 2024. $100M revenue min.
(Unit: $US million with avg. 2022 exchange rates)

The NTI-100 list uses the US dollar as the baseline currency. Exchange rate volatility, then, can affect the rankings. For instance, the declining exchange rate of the yen against the US dollar toppled Japanese fabricators from their previous positions. From 2000 to 2018, the average yen to dollar value was ¥110:$1. In 2023, the average yen value rose to 142. Therefore, using, say, the 2015 exchange rate, the Japanese fabricators' output would have been 30% higher and their relative rankings would rise accordingly with the increase. Exchange rates are beyond the author's control. (At the time of this writing, the exchange rate is ¥156:$1, which is drawing more tourists to Japan than before the Covid pandemic.)

Along with the 2023 NTI-100 list, the 2022 rankings are provided for comparison (2022 revenues were converted using 2023 exchange rates). This year, no analysis such as the number of entries by nationality, etc., is provided. Sorry. Readers can make their own assessments. Roughly speaking, the fabricators in Taiwan, China, Japan and South Korea have the lion's share (more than 90%).

Exchange Rates

As noted, the Japanese yen lost value in 2023, and is still dropping **(Table 2)**. (Now ¥142:$1, like a yo-yo.) Financial experts claim the Japanese government kept its zero-interest rate policy too long while other major countries increased their interest rates; this, they say, is one of the major reasons for the slippage. When the author traveled to Japan in June bringing US dollars, goods seemed much less expensive compared to a few years ago.

Table 2. Average Exchange Rates, Local Currency/USD

Currency	2017	2018	2019	2020	2021	2022	2023
China yuan (RMB)	6.758	6.615	6.910	6.903	6.402	6.732	7.072
Japanese yen	112.93	110.44	109.01	106.77	108.98	131.43	141.70
Taiwan NTD	30.44	30.16	30.93	29.47	27.64	28.98	31.15
Korean won	1,131	1,101	1,166	1,180	1,136	1,292	1,306
Thai baht	33.92	32.32	31.03	31.27	31.76	35.06	34.77
Singapore dollar	1.33	1.35	1.36	1.38	1.33	1.38	1.34
Malaysian ringgit	4.32	4.04	4.12	4.20	4.11	4.40	4.56
Vietnam dong	22,721	23,001	23,203	23.20	22,879	23,121	23,815
Philippine peso	50.44	52.70	50.82	49.62	49.94	54.52	55.61
Indonesia rupiah	13,440	14,236	13,799	14,559	14,195	14,851	15,238
Canada dollar	1.28	1.30	1.33	1.34	1.22	1.30	1.35
Indian rupee	64.87	68.43	70.39	71.12	73.36	78.01	82.57
Mexican peso	18.95	19	19.25	21.50	20.13	20.12	17.74
Russian rouble	58.31	62.78	64.69	72.41	73.12	76.50	85.31
Swiss franc	0.98	1.002	0.99	1.38	0.97	0.99	0.90
UK pound	0.81	0.75	0.78	0.78	0.72	0.81	0.81
Euro	0.89	0.84	0.89	0.87	0.84	0.95	0.92

Source: NTI summary, based on exchangerates.com

Ceramic Circuits

Readers will notice that the output of Kyocera jumped from 2022 with the inclusion of its ceramic package substrate output. NTK is a new entry. The inclusion of ceramic circuits is in preparation for glass substrates in the future. The author regrets his inability to search for other ceramic circuit fabricators which might otherwise qualify for the NTI-100. The list, therefore, is not as accurate as the author wishes.

2023 Considerations

Compared to 2022, aggregate revenues of the "top" fabricators in 2023 decreased 8.5%. Listening to the voices of PCB fabricators, material and equipment fabricators, 2024 is "expected" to gain 7-8%, meaning the world output is expected to return to 2022 levels **(Table 3)**.

Table 3. Preliminary Estimate of World PCB Output (US$ Million)

Region	2021	2022	2023
North & South America	3,400	3,520	3,210
Europe	2,025	2,160	1,980
Middle East & Africa	145	155	200
West total	**5,570**	**5,835**	**5,390**
China	54,205	56,720	54,000
Taiwan	10,900	11,930	10,200
Japan	5,945	6,560	5,590
S. Korea	7,220	8,570	7,760
Thailand	3,175	3,350	3,050
Vietnam	3,110	3,200	2,900
Other Asia & India	1,250	1,340	1,200
Asia total	**85,805**	**91,670**	**84,700**
World total	**91,375**	**97,505**	**90,090**

Source: N.T. Information Ltd., January 2024.
At variable exchange rates. Note: Approximately $8 billion comes from assembly.
Russia not included (estimated $250 million-$300 million, but uncertain)

Of the 25 largest fabricators, DSBJ, Nippon Mektron, Kinwong, Wus, Meiko and Victory Giant are the only six that showed increased revenues in 2023. Several fabricators dropped from the 2022 list since their revenues were less than $100 million. A few Japanese fabricators dropped out because of the exchange rate.

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MIDWEST **MANUFACTURING**

Driving PCB Manufacturing Innovation and Efficiency

Can a production fabricator thrive in Middle America? Through its novel automation, Summit's Chicago plant is proof-positive.

by MIKE BUETOW

In 1979, Eagle Electronics laid its foundation in printed circuit board manufacturing, and by 1985, it established its current site in Schaumburg, IL, just a few miles from Chicago's O'Hare Airport. The journey since then has been one of resilience and transformation, a pivotal moment coming in 2001 when the company faced a crucial decision: close its doors, become a broker or remodel. The decision to overhaul operations marked a new chapter, altering workflows to the point where work-in-progress inventory became a rare occurrence.

Now operating as part of Summit Interconnect, which acquired the company in 2021, the Chicago site stands as a key player within an eight-facility network that spans North America, with 90% of its business coming from within the US and additional customers in Malaysia, China and India. Summit Interconnect has positioned itself as a PCB manufacturing powerhouse, with an extensive customer base that spans over 400 businesses, primarily serving the electronics manufacturing services (EMS) sector, which makes up about 70% of its revenue. Quickturn projects, often requiring turnaround times between 24 and 72 hours, and medium-volume production are the site's specialty.

Figure 1. Summit's PCB plant in Schaumburg, IL.

The EMS industry saw a surge during the pandemic-induced downturn as manufacturers increased orders in response to a semiconductor shortage. This bubble is now beginning to deflate, with demand leveling off and laminate supplies improving.

“We’re starting to see the effects of that overordering unwind,” says Brett McCoy, vice president and general manager of the Chicago site, when we visited in late July. While Schaumburg primarily focuses on quickturn and medium-sized production lots, it plays a vital role in Summit’s larger strategy. In particular, the Chicago facility works in tandem with the company’s sites in Toronto and Denver, which offer high-volume and assembly prototyping, respectfully. Each location within the Summit network brings unique capabilities, McCoy notes, ensuring customers’ needs are met efficiently, regardless of the project’s complexity or scale.

At the Schaumburg facility, 85-90 employees – ranging from engineers to operators – produce up to 100 panels per project. With 42,000 sq. ft. of production space, the site is equipped to handle a broad range of technologies.

Says McCoy: “Layer count isn’t an issue anymore. We could do 40 layers, but there isn’t demand for that. Most of what we’re seeing now is 2-8 layers.” The Chicago team frequently works on via-in-pad and stacked microvias down to three layers and employs MacDermid’s Eclipse direct metallization for microvias. (All microvias are copper-filled; no epoxy is used.)

Figure 2. A Mach 6630NP lamination machine.

Enhancing Technology and Automation

Summit's Chicago site has continually adapted to technological advancements, with laser drilling capabilities added about three years ago to handle thin dielectrics. The site's commitment to innovation is evident with its use of equipment like Orbotech and Schmoll LED for direct imaging, Schmoll MDI TT for solder mask imaging, and multiple Orbotech Fusion AOI, complemented by a range of advanced deburring, coating and printing systems.

The plant layout is unusual for an American PCB fabricator in that it practically matches the process steps in order. McCoy and team's attention to detail has managed to generate more output from the same footprint over time, and there's more capacity to be had if needed, he says.

Other lines include two Schmoll MXY CCD drills/routers, with optical cameras capable of +/-50µm features and backdrilling; a Schmoll LIN2 CCD flex router; a Schmoll XRX x-ray drill; a Schmoll Combi UV/CO_2 laser drill; and a Schmoll Speedmaster six-spindle drill. Scoring is performed via two Accusystems AccuScore V machines.

Figure 3. Among the many Schmoll lines are ones for drilling and routing …

The site's robust infrastructure, which includes a six-panel tank system for panel plating and advanced routing and drilling capabilities, permits efficient and high-quality production. This setup gives the flexibility to manage different boards simultaneously, improving throughput and reducing bottlenecks.

Summit Chicago offers an array of finishes including MacDermid immersion silver and OSP, Uyemura ENIG, HASL (SnPb and Pb-free) and gold tabs. It uses an Orbotech Sprint 200 inkjet for printing legends.

The facility's digital transition started in 2009 and is now fully digital for both inner- and outer-layer and solder mask imaging. Post-etch panels are still used, but the full switch to DIS is imminent. Further investment in tools like MacDermid's Multibond for multilayer adhesion and TrueChem software for chemical analysis underscores its focus on staying ahead in the competitive PCB landscape.

Operators perform 100% electrical test and visual inspection on all boards built onsite, keeping with McCoy's goal to avoid "inspect to reject."

Despite the growing technological demands, McCoy emphasizes that the focus remains practical. "We're not doing science projects," he says. "We add technology where it makes sense."

Figure 4. … and solder mask imaging.

Staffing and Industry Challenges

The workforce at Summit's Chicago facility reflects the larger challenges facing the PCB industry; namely, finding skilled operators and engineers is increasingly difficult. With two full shifts Monday through Friday and a half shift on Saturdays, the site operates as lean as possible.

"The PCB industry needs more engineers. That could come if (the industry) were more automated and had a cleaner environment," McCoy suggests, a nod to the growing push for automation within Summit's operations.

Summit's attention to operational efficiency and process control is visible in its extensive use of key performance indicators (KPIs). From production throughput to individual operator performance, everything is tracked and analyzed to ensure optimal performance.

McCoy underscores that automation is not just a future goal, but an ongoing process that's essential to the company's success. "The issue isn't so much about the technology decision, but the automation. How do we drive automation and eliminate dependency on activities that require a higher skill level that are harder to develop and train?"

Environmental Stewards

Environmental responsibility is also a priority at Summit. The Schaumburg facility treats 100% of its wastewater onsite and generates its own deionized water. This is part of Summit's broader commitment to sustainability, with a vision that looks three to five years out (and perhaps a nod to McCoy's observation about enticing new blood). Capex investments are made with this long-term view in mind, ensuring that the Schaumburg plant – and all of Summit's locations – are equipped for future industry demands.

The Road Ahead

McCoy is optimistic about the future, noting that initiatives like the Chips Act have provided much-needed support for the US electronics manufacturing sector. "The government is starting to come around," he says, acknowledging that while it's a good first step, more must be done to fully realize the potential of the American PCB industry.

As Summit Interconnect Chicago continues to evolve, the site's integration into Summit's broader network will be key. With ongoing process developments across its various locations, the company is focused on harmonizing its operations while delivering cutting-edge technology to its customers. The Schaumburg facility will remain a critical part of that strategy, contributing to Summit's leadership in the PCB industry through a combination of technology, automation and a relentless focus on quality and efficiency.

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SOLDERING

Reflow Profiling in PCB Assembly

Optimizing temperatures will ensure the best possible conditions for soldering.

by TIMOTHY O'NEILL

Verifying and optimizing the temperature profile of a reflow oven ensures an ideal thermal environment for solder paste to melt, flow and solidify, forming robust solder joints.

Calibrating the oven temperatures and ensuring they are set correctly involves sending a so-called "golden board" through the oven. Ideally, a "golden board" is supplied as part of the work kit by the customer or design team. This board **(Figure 1)** will be a sacrificial, fully populated assembly with (ideally five to seven) thermocouples attached via high-temperature solder in strategic locations across the assembly. It is processed through the reflow oven, collecting detailed information that technicians can use to make adjustments, ensuring the components and areas on the board stay within specified temperature constraints.

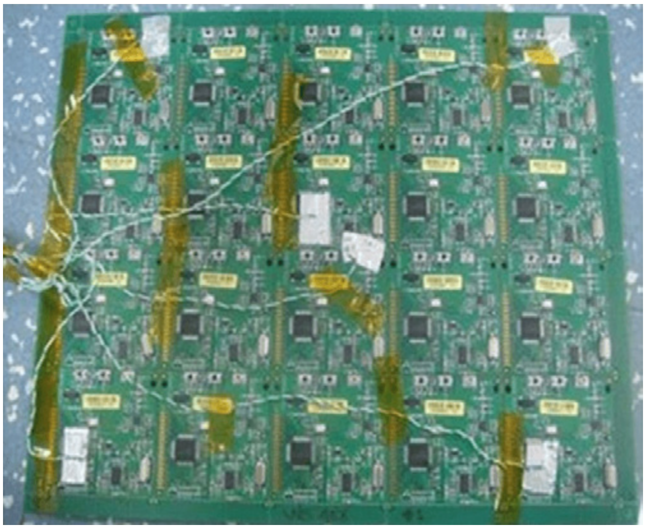


Figure 1. The golden board: expensive, but worth it?

Reality Check: Constraints in Reflow Profiling

The above describes an ideal scenario. The reality on the production floor is often much different. The engineer is often lucky if they can get one bare board to attempt a reflow profile. Frequently, profiles are an educated guess due to time and material constraints.

Also, many assume that because a modern reflow oven is very effective at introducing thermal energy into the assembly, the need for good profiling practice is less critical. In many cases, one can "set it and forget it" and still obtain acceptable results … until they are not. This is when good practice comes into play.

Problems with Improper Profiling Practices

Suppose an electronics manufacturing services (EMS) provider has a 1,000-piece build on a high-margin, high-visibility client. One of the QFN components has a void percentage specification of less than 30%. The acceptance run was performed on the NPI line; everything was within spec, and the customer was happy.

But the production run is performed on a production line with a smaller, older and less-capable oven. The voiding on the subject component exceeds 50% on the production run, and there is a scramble to pull together the information to understand and fix the issue **(Figure 2)**.

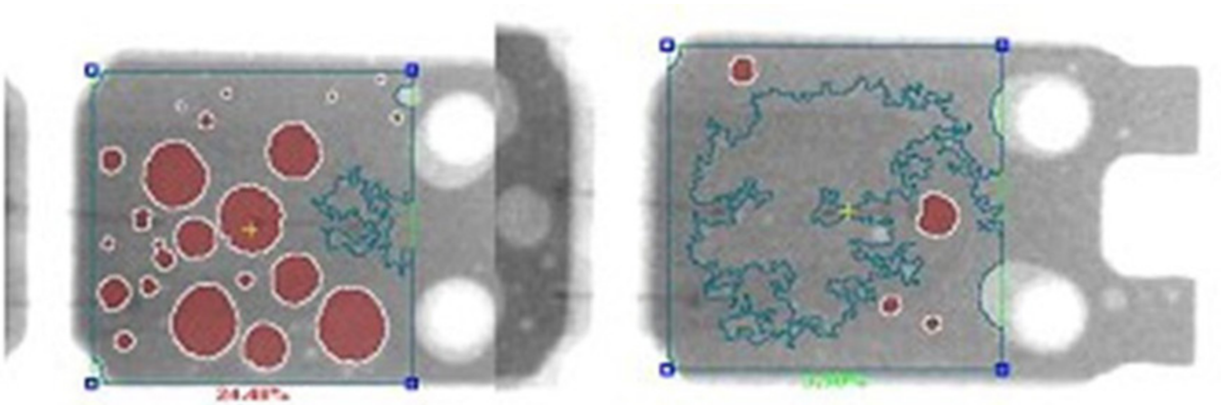


Figure 2. Voids can be reduced with profiling techniques.

This scenario highlights several reasons why profiling is so important. The first reason is simple recordkeeping. In this case, a record of the profiles used on the NPI line could immediately be compared to the production line, making it easy to tell if the problem was in the settings or the oven's calibration.

Reflow Profiling Best Practices

Proper reflow profiling can improve or eliminate defects. Void reduction (BTC and BGA) is one, as mentioned in the earlier anecdote, but also head-in-pillow (HiP) defects, wetting defects, residue characteristics and even flux cleaning, to name a few. Regular profiling also reveals how equipment interrelates to solder paste chemistry and other materials.

The following are some best practices to consider to avoid or mitigate potential problems.

Perform strategic profiling for every SKU/part number. The importance of meticulous record-keeping cannot be overstated. In a line-down scenario, every minute counts. Maintaining a comprehensive record of reflow profiles for every SKU/part number is not just about compliance, but about building a knowledge base that can significantly mitigate risks and improve the troubleshooting process.

Perform daily and production run profiles. Run a confirming profile at the beginning of each day and production run. This will identify any issues before the day's production process has been compromised due to a failing fan motor or heating element.

Capture expertise and spread it around. Oven profilers are becoming more sophisticated, making profiling less arduous. Complex algorithms and software can make collecting and analyzing data more meaningful and faster.

But even with these advancements, profiling expertise is accumulated over time and experience. This expertise is often lost with personnel changes. Because of this, make reflow profiling part of the production environment's culture; don't rely on an individual expert.

Unlike other fixed variables in the PCB assembly process, such as solder paste formulation, PCB design and component placement, reflow profiling stands out as a dynamic element. It is the only place in a production line where the outcome can be impacted in real time. Assuming the print and placement processes are optimized, the oven profile is the only process that can be manipulated "on the fly" **(Figure 3)**.

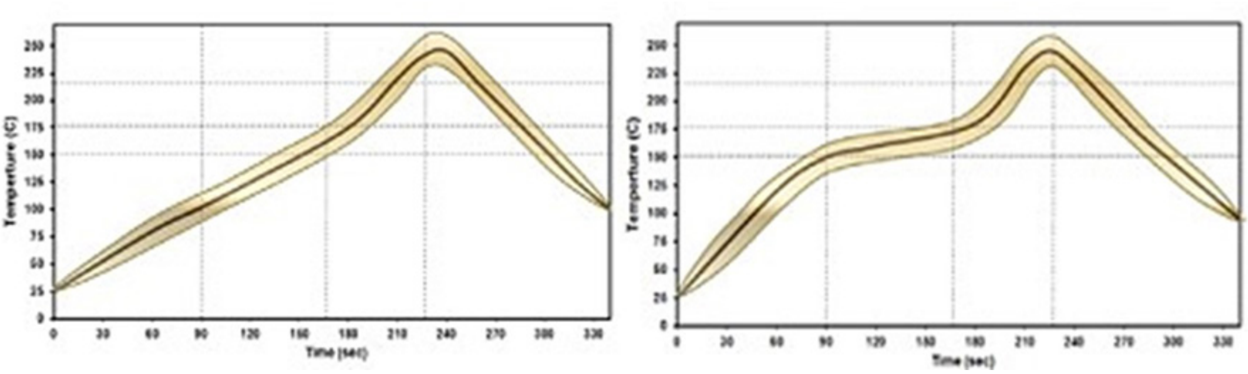
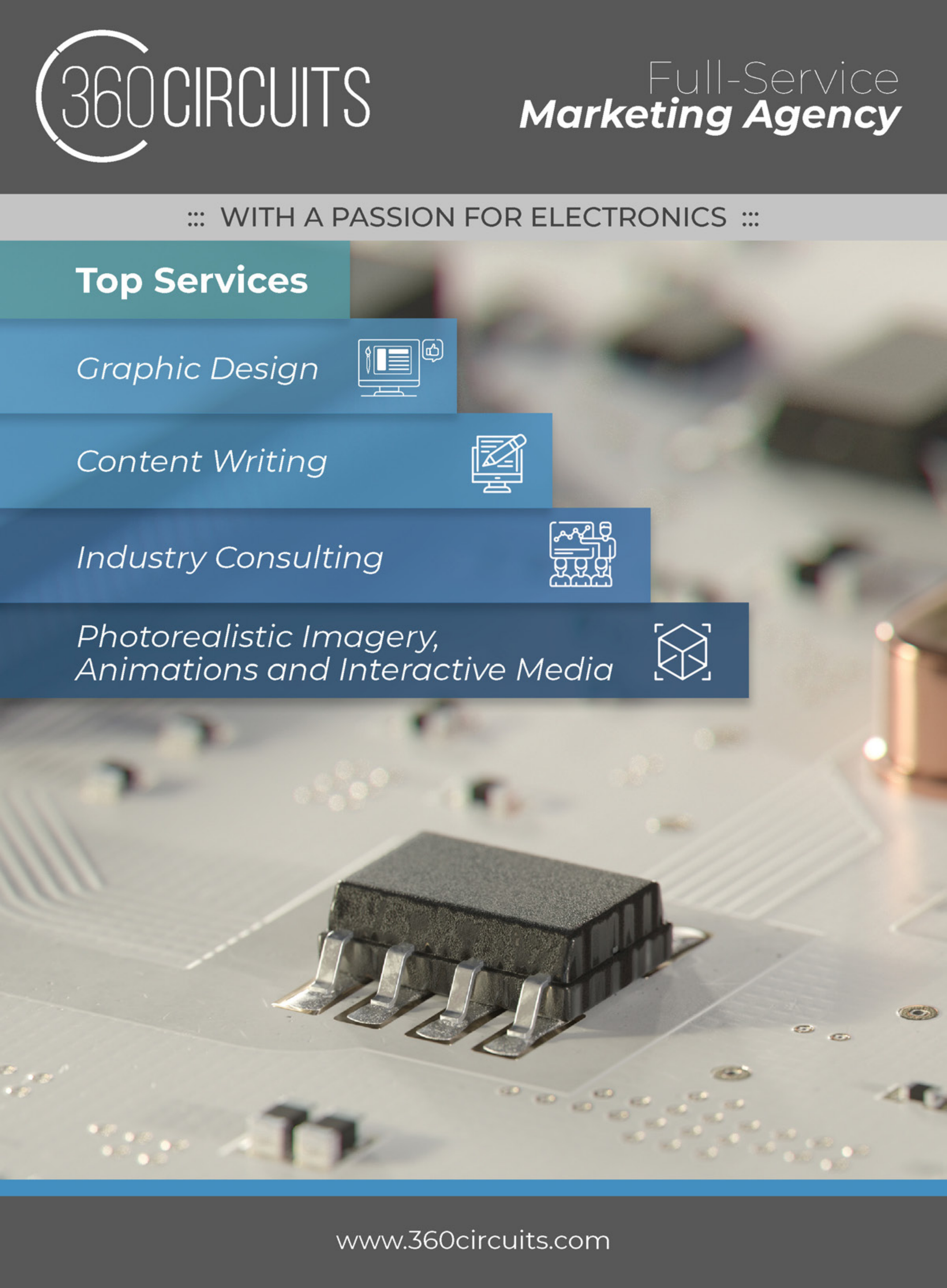


Figure 3. Understanding reflow profiling concepts can improve results in real time.

Have your paste or oven vendor spend a day on the floor for an oven audit and to educate your team on best practices. It's painless and can pay big dividends.

TIMOTHY O'NEILL is director of product management at AIM Solder (aimsolder.com); toneill@aimsolder.com.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ADCO CIRCUITS ADCOPROTO 2.0

ADCOproto 2.0 is for PCBA prototype development and features upgrades focused on speed and user friendliness to streamline functionality, cost transparency and efficiency. Costs user's uploaded BoM instantly, and PCBA manufacturing costs are quoted in real time as assembly details are entered into the site.

ADCO Circuits

adcocircuits.com

FANUC 500I-A CNC

500i-A CNC features five-axis integrated technology and supports users' evolving needs for easier operations, security and efficiency. Dual engine architecture permits 2.7 times higher CPU processing power than previous models and comes with updated modern hardware and graphically enhanced software. Improves block processing time and macro program processing that are designed to help drive down cycle times with faster speeds and improved productivity. Also features a modern iHMI2 interface with a 1:1 task-to-screen simplified display, eliminating the need to switch between screens, and a battery-less system for easier maintenance.

Fanuc America

fanucamerica.com

FANUC ROBODRILL A-D28LIB5ADV PLUS Y500 VMC

Robodrill α-D28LiB5ADV Plus Y500 vertical machining center features an extended y-axis stroke (500mm) and increased table size, without increasing its footprint. Speeds drilling and tapping operations via a rapid z-axis acceleration (2.2G) and traverse rate (60m/min) and features an expanded tool capacity of 28 tools and fast changes to boost productivity.

Fanuc America

fanucamerica.com

HIROSE FH82 SERIES FPC CONNECTOR

FH82 FPC connector offers space savings that enables a reduction in size of automotive, consumer, medical, smart home, wearable and other electronic devices. Features a pitch of 0.25mm, height of 0.65mm and thickness of 0.2mm, and is commonly used for connecting displays and sensors in devices. Can connect with no touching of the actuator, preventing damage, and features reduced work time and operation steps for an increased production capacity. Is designed for automatic assembly and features a large taper on the opening for smooth insertion and a unique spring design to produce a low-insertion force and a high-retention force, for easy operation for humans and robots.

Hirose Electric

hirose.com

OMRON G5Q-HR POWER RELAY

G5Q-HR 10A PCB power relay comes in single stable and latching variants and meets the TV-8 standard at 10A class. Is 20.3 x 10.3 x 15.8mm in size, and compatible with a wide range of capacitive loads as well as ramp loads of up to AC 120V, Inrush 117A. Has been tested to last a minimum of 25,000 cycles and meets UL Electronic Ballast Rating at 3A 277VAC and 5A 277VAC over 6,000 cycles, and meets IEC60669-1 at 3A 250VAC over 5,000 cycles. Is compliant with high input load standards exceeding 100A, such as lighting and power supplies.

Omron Electronic Components Europe

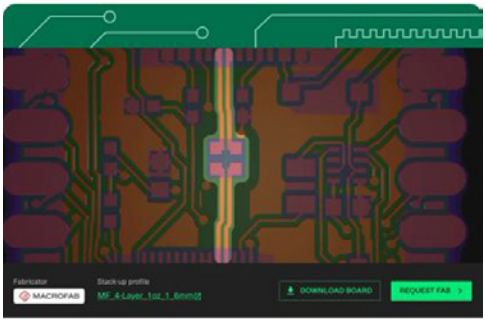
omron.com

POLAR INSTRUMENTS SPEEDSTACK V24.09 STACKUP TOOL

The newest update for Speedstack stackup design tool is a major update for drill documentation. Now allows flat drills, routes, and capped backdrills to be documented, and supports new import/export XML STKX v25.00 and SSX v15.00 file formats to support the new back drill type and capped drill options. Also includes improvements to drilling by retaining pan position after the add drill and drill properties are dismissed, as well as printing, with an improved isolation distance (summed) column calculation that offers better support when the stackup contains single-sided cores.

Polar Instruments

polarinstruments.com

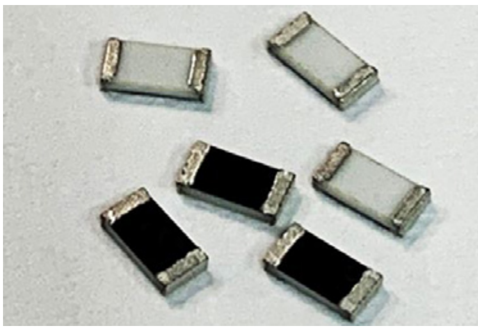


QUILTER DIFFERENTIAL PAIR CAPABILITY

Quilter automated PCB design tool now automatically detects, calculates and custom-routes differential pairs. Now automatically detects physics considerations in a design, with plans to do the same for a growing list of constraint types. Defines and exports impedance-aware stackups for each design, drawing from a library of dozens of fabricator-defined layer stacks, and can complete customized physics calculations for each candidate it generates to optimize and validate its designs.

Quilter

quilter.ai



STACKPOLE RMCA RESISTOR SERIES

RMCA series of chip resistors now comes in an 0201 package for smaller consumer and industrial handheld electronics. Manufactured to automotive grade specifications, which provides exceptional test performance to all AEC Q200 tests as well as reducing the typical failure rate by a factor of 10 or more.

Stackpole Electronics

seielect.com

VICTORY THICK COPPER INLAY PCB

Thick copper inlay PCB is said to offer exceptional stability, a compact size and reduced energy consumption. Also features innovative thermal management optimizations to ensure excellent heat dissipation even under high-load conditions and an extended lifespan.

Shenzhen Victory Electronics Technology

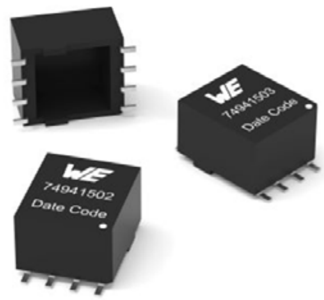
victorypcb.com

WÜRTH WE-EMIP EMI ABSORBER SHEET

WE-EMIP EMI absorber sheet features an integrated adhesive layer that makes the patch easy to stick on. Offers attenuation exceeding 40dB over a wide frequency range and is available in both isolated and non-isolated versions with latter version offering the option of earthing. Available in the following sizes: as a sheet in 105 x 74mm or 297 x 210mm, or as a roll in 15m x 50mm. Offers up to 12 times higher attenuation than previously available absorber sheets and helps achieve attenuation values otherwise attainable only with shielding cabinets.

Würth Elektronik

we-online.com



WÜRTH WE-PLC TRANSFORMERS

WE-PLC transformers are for galvanic isolation of the power line communication system from the power supply. Are for data signals between 500kHz and 30MHz and reliably isolate the low-voltage range from the high-voltage range. Offer a test voltage of 4500VRMS for transformers of this package size (13.6 x 9.9mm footprint) and a maximum leakage inductance of 0.2µH. Are available with turn ratios of 1:1:1 and 1:4:3 for EV charging and AC interfaces for grid communication and feature an operating voltage up to 250VAC.

Würth Elektronik
we-online.com

WÜRTH WR-SMA PCB SOLDERLESS CONNECTOR

WR-SMA PCB solderless connector permits quick and easy assembly without damage to the PCB. Requires no soldering equipment and can be reused multiple times, making them suitable for prototyping or temporary use. Uses brass instead of stainless steel, which is said to provide a cost advantage while maintaining the same electrical performance and providing a robust mechanical connection. Also allows easy repairs and hassle-free replacement in the field without special tools or knowledge. Is suitable for strip and multistrip lines, as well as coplanar waveguides. Complies with the MIL-STD-348 standard, is designed for 50Ω and supports up to 27GHz, and is recommended for test equipment, evaluation boards and applications with an operating temperature range from -65° to +165°C.

Würth Elektronik
we-online.com

ZUKEN HARNESS BUILDER 2025

Harness Builder 2025 for E3.series software includes new features and enhancements designed to elevate the precision, flexibility, and efficiency of wiring harness design and manufacturing. Transforms the process of drawing a backbone or segment to a specific length by introducing a new dialog for entering precise point coordinates, angles and lengths, substantially enhancing design precision and speed. Also features extended design variation support utilizing harness configuration information and modular harness design updates, enhancements to wire length calculations, additional automation for manufacturing documentation and advanced equipment integration for manufacturing and quality.

Zuken
zuken.com

CA

ezCLIP Prototype units installed on PCB Magazine Rack

COUNT ON TOOLS EZCLIP RACK SYSTEM

ezCLIP system allows users to distinguish required spacing between boards in PCB magazine racks, significantly reducing the risk of damage to critical components. Allows operators to quickly and accurately identify correct spacing for boards with tall components or critical devices, is universally compatible with any PCB magazine rack on the market and does not require any modifications to existing racks. Can prevent damage during the electronics manufacturing process with bright red finish and flared design that make it easy for operators to distinguish available rack slots based on pre-determined board and component heights. Is available in various configurations to suit different manufacturing needs.

Count On Tools

nozzles4smt.com

GLENBROOK TECHNOLOGIES RTX SERIES X-RAY

RTX Series modular, real-time systems meets a variety of production requirements including circuit board components. Well-defined path permits easy upgrading, while numerous options permit customization of any RTX model to specific applications. All hardware and software elements are fully compatible. RTX-113 is designed for heavy production environments where x-ray is used to inspect PCBs and assembled PCBs containing advanced components such as BGA, micro BGA, QFN and other devices. Features patented x-ray camera technology that generates high-resolution, high-sensitivity images, revealing defects as small as 0.001" with a full 1.0" diameter field of view. RTX-113 MicroTech is compact enough to fit in a lab or on production floor. Employs an 80kV, 10-micron focal spot tube with patented XRTV x-ray camera technology now enhanced for higher contrast. Permits up to 100x geometric and 225x optical magnification. RTX-113HV is for inspecting BGA packages, including those that contain dense metal heat sinks that require a higher voltage x-ray source to clearly identify and troubleshoot production faults. Cabinet design permits integration into production environments and is totally upgradeable. Recommended for lead-free inspection requirements. RTX Backplane accommodates boards up to 36" x 42" and weighing up to 40lbs. Can inspect up to 32-layer, 0.4"-thick PCBs and detects innerlayer errors and checks for hole-pad alignment during drilling. Inspects solder bond integrity of BGAs, LEDs, die attach and flip chip locations, and drilled holes on both small and standard boards.

Glenbrook Technologies

glenbrooktech.com

KEYSIGHT ELECTRICAL STRUCTURAL TESTER

Electrical Structural Tester is a wire bond inspection solution for semiconductor manufacturing designed to ensure the integrity and reliability of electronic components. Creates a capacitive structure between wire bond and sensor plate, which enables identification of defects such as wire sag, near shorts and stray wires to enable comprehensive assessment of wire bond integrity. Enables throughput of up to 72,000 units per hour through the ability to test up to 20 integrated circuits simultaneously.

Keysight Technologies

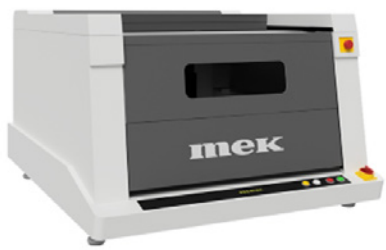
keysight.com

KEYSIGHT INFINIIVISION HD3 OSCILLOSCOPE

InfiniiVision HD3 series 14-bit analog-to-digital converter oscilloscope reportedly delivers four times the signal resolution and half the noise floor of other general-purpose oscilloscopes. Features high vertical resolution through a 14-bit ADC and a 50µVRMS low noise floor that can detect the smallest signal anomalies and covers bandwidths between 200MHz and 1GHz. Also features a custom-built ASIC that gives higher sample rates and memory under typical testing conditions, a high waveform update rate and hardware-based functions such as mask, zone and serial decode. Can capture longer time spans at full sample rate for better measurement/analysis results and offers a new UI enabling versatile functionality, including full ADC and vertical resolution on every channel, several bandwidth limiting options, HD mode support and custom measurement thresholds. Introduces automatic fault hunter software for general debugging, which analyzes glitches, slow edges and runts while engineers complete other tasks, and automates measurements with a large selection of serial bus protocols and application software.

Keysight Technologies

keysight.com



MEK POWERSPECTOR JSAZ 550 DESKTOP AOI

JSAz 550 selective 3-D desktop AOI accommodates PCBs up to 550x550mm. Features completely redesigned chassis with upgraded motors, drives and spindles to handle larger PCBs, and can be equipped with nine cameras: one top and eight side cameras. Selective 3-D laser measurement technology ensures accurate and reliable height measurements. Is optimized for SMT with a top clearance of 30mm, side cameras with 10μm resolution, and four-angle lighting. Accommodates taller through-hole technology components with a top clearance of 60mm, larger field of view side cameras, and 15μm resolution.

Marantz Electronics

marantz-electronics.com

OMRON AUTOMATION X850 3DCT AX

X850 3DCT AXI permits comprehensive inspection of power semiconductors by leveraging advanced x-ray capabilities. Is said to detect defects such as voids, insufficient solder and misalignments. Produces x-ray inspection results for heavy and thick samples. High-powered tube provides x-rays with enough intensity to penetrate samples with extremely dense shielding or enclosures. Redesigned mechanical system uses servo motors and drivers to tackle complex motion for sharp 3-D CT images. AI software algorithms enhance detail and enable accurate and repeatable feature measurements.

Omron Automation

automation.omron.com

PVA UPDATES PATHMASTER X DISPENSING SOFTWARE

PathMaster X software for Direct Series Delta 6 and Delta 8 dispensing systems allows users to create their own canvas images from any substrate, enabling greater flexibility and precision in programming; provides ability to configure custom MES for compatibility and seamless integration with existing production environments; has motion view and a cycle time calculator for running virtual program simulations offline; and allows programming of custom area shapes, improving adaptability to complex production needs.

PVA

pva.net

SAWA SC-SA1 STENCIL CLEANER

SC-SA1 pneumatic air-driven fully automatic stencil cleaner enhances efficiency and safety of cleaning processes for SMT stencils, printing templates, squeegees and large-size PCB assemblies. Leverages compressed air as its sole energy source, eliminating the need for electricity and reducing fire hazards in the workplace while ensuring a closed-loop cleaning process to prevent gas or liquid leakage. Includes a high-precision three-stage filtration system that effectively extends the life cycle of the cleaning agent and an integrated cleaning and air-drying process that guarantees optimal cleanliness. Hydraulic gauge on operation panel displays liquid pressure for control during cleaning process. Constructed from 304 stainless steel, making it resistant to acids, alkalis and other cleaning solutions, and features pneumatic diaphragm pump, pneumatic timer, air source indicator and pressure-regulating filter.

Sawa

sawa-corp.co.jp

Seika Machinery

seikausa.com

SCS PRECISIONCURE UVC CURING SYSTEM

PrecisionCure UVC is a mercury arc UV curing system designed to deliver consistent and efficient UV radiation. Can be configured for single-sided (top) or double-sided (top and bottom) curing processes and can function as a standalone unit or integrate seamlessly with an SCS PrecisionCoat selective conformal coating and dispense system as well as an SCS PrecisionAdvance conveyor. Is built for continuous operation and minimizes downtime with a low-maintenance design to ensure production lines remain consistently operational. Features programmable curing profiles, adjustable lamp power ranging from 120-300wpsi and a pin-type-edge handling conveyor. Comes with Windows-based software and touchscreen display for easy operation, maintenance timers, top and bottom active fan cooling, integrated exhaust and an exhaust interlocked sensor, as well as options such as right-to-left conveyor travel and an auto-width adjust conveyor.

Specialty Coating Systems

scscoatings.com

SELECTECH GROUNDFLOOR CLASSIC X

GroundFloor Classic X conductive vinyl flooring features a new, pre-applied conductive finish that enhances longevity while simplifying maintenance, so the surface remains in peak condition with minimal effort.

SelecTech

selectech.com

In Case You Missed It

3-D Printing

"Iterative Printing of Bulk Metal and Polymer for Additive Manufacturing of Multi-Layer Electronic Circuits"

Authors: Zeba Khan, *et. al.*

Abstract: In pursuing advancing additive manufacturing (AM) techniques for 3-D objects, this study combines AM techniques for bulk metal and polymer on a single platform for one-stop printing of multilayer 3-D electronic circuits with two novel aspects. The first innovation involves the embedded integration of electronic circuits by printing low-resistance electrical traces from bulk metal into polymer channels. Cross-section grinding results reveal (92±5)% occupancy of electrically conductive traces in polymer channels despite the different thermal properties of the two materials. The second aspect encompasses the possibility of printing vertical bulk metal vias up to 10mm in height with the potential for expansion, interconnecting electrically conductive traces embedded in different layers of the 3-D object. The work provides comprehensive 3-D printing design guidelines for successfully integrating fully embedded electrically conductive traces and the interconnecting vertical bulk metal vias. A smooth and continuous workflow is also introduced, enabling a single-run print of functional multilayer embedded 3-D electronics. The design rules and the workflow facilitate the iterative printing of two distinct materials, each defined by unique printing temperatures and techniques. Observations indicate that conductive traces using molten metal microdroplets show a 12-fold reduction in resistance compared to nanoparticle ink-based methods, meaning this technique greatly complements multi-material additive manufacturing (MM-AM). The work presents insights into the behavior of molten metal microdroplets on a polymer substrate when printed through the MM-AM process. It explores their characteristics in two scenarios: deposited side-by-side to form conductive traces and deposited out-of-plane to create vertical bulk metal vias. The innovative application of MM-AM to produce multilayer embedded 3-D electronics with bulk metal and polymer demonstrates significant potential for realizing the fabrication of free-form 3-D electronics. (*npj Advanced Manufacturing*, August 2024, https://doi.org/10.1038/s44334-024-00001-0)

Flexible Electronics

"Stretchable Arduinos Embedded in Soft Robots"

Authors: Stephanie J. Woodman, *et al.*

Abstract: To achieve real-world functionality, robots must be able to carry out decision-making computations. Soft robots stretch, however, and therefore need a solution other than rigid computers. Examples of embedding computing capacity into soft robots currently include appending rigid printed circuit boards to the robot, integrating soft logic gates, and exploiting material responses for material-embedded computation. Although promising, these approaches introduce limitations such as rigidity, tethers or low logic gate density. The field of stretchable electronics has sought to solve these challenges, but a complete pipeline for direct integration of single-board computers, microcontrollers, and other complex circuitry into soft robots has remained elusive. The authors present a generalized method to translate any complex two-layer circuit into a soft, stretchable form. This enabled the creation of stretchable single-board microcontrollers (including Arduinos) and other commercial circuits (including SparkFun circuits), without design simplifications. As demonstrations of the method's utility, the authors embedded highly stretchable (>300% strain) Arduino Pro Minis into the bodies of multiple soft robots. This makes use of otherwise inert structural material, fulfilling the promise of the stretchable electronic field to integrate state-of-the-art computational power into robust, stretchable systems during active use. (*Science Robotics*, September 2024, https://doi.org/10.1126/scirobotics.adn6844)

Quality Assurance

"PCB Plug-In Solder Joint Defect Detection Method Based on Coordinated Attention-Guided Information Fusion"

Authors: Wenbin Chen, *et. al.*

Abstract: Printed circuit boards (PCBs) are the foundational component of electronic devices, and the detection of PCB defects is essential for ensuring the quality control of electronics products. Aiming at the problem that existing PCB plug-in solder defect detection algorithms cannot meet the requirements of high precision, low false alarm rate and high speed at the same time, this work proposes a method based on spatial convolution pooling and information fusion. First, on the basis of YOLOv3, an attention-guided pyramid structure is used to fuse context information, and multiple convolutions of different sizes are used to explore richer high-level semantic information. Second, a coordinated attention network structure is introduced to calibrate the fused pyramidal feature information, highlighting the important feature channels, and reducing the adverse impact of redundant parameters generated by feature fusion. Finally, the ASPP (atrous spatial pyramid pooling) structure is implemented in the original Darknet53 backbone feature extraction network to acquire multi-scale feature information of the detection targets. With these improvements, the average detection accuracy of the enhanced network has been elevated to 96.43% from 94.45%. This experiment shows that the improved network is more suitable for PCB plug-in solder defect detection applications. (*Scientific Reports*, August 2024, https://doi.org/10.1038/s41598-024-70100-7)

Signal Integrity

"High-Speed Signal Optimization at Differential Vias in Multilayer Printed Circuit Boards"

Authors: Wen-Jie Xu, *et. al.*

Abstract: The number of printed circuit board layers increases with increases in data transmission rates, and the signal integrity (SI) of high-speed digital systems cannot be ignored. Introducing vertical interconnect accesses (vias) in PCBs can realize the electrical connection between the top layer and innerlayers, however, vias represent one of the most important reasons for discontinuity between PCBs and package. In this work, a new optimization scheme for a differential via stub is proposed, with 3-D full-wave numerical simulation used for modeling and simulation. Results show that this scheme optimizes the return loss and insertion loss while making the signal eye diagram more ideal, which can improve the transmission effect of high-speed signals. (*Electronics*, August 2024, https://doi.org/10.3390/electronics13173377)