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June 2021

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JUNE 2021 • VOL. 38 • NO. 6

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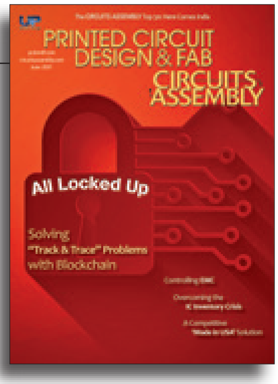
FIRST PERSON

MONEY MATTERS

TECH TALK

DEPARTMENTS

FEATURES



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MIKE BUETOW
EDITOR-IN-CHIEF

EMS Past is Prologue

I'M OFTEN ASKED what I think the electronics manufacturing company of the future will look like. I know this: It will be different than it looks today.

Why am I so confident? In part because today's firms don't look like they did when I entered the industry in 1991 (yikes!). Back then, dominant players were the bluebloods like IBM, Digital Equipment and Hewlett-Packard (you may know them as HP). These were all-in-one firms. They designed chips, fabbed boards, built assemblies, and shipped their own products.

Then someone got the bright idea that "merchant" (the *terme de ce jour,* as opposed to captive, meaning in-house) manufacturing businesses could unlock value by spreading costs of production across many customers and ensuring close(r)-to-steady-state operations. In reality, that never quite happened, but the mass outsourcing that took hold has never ceded ground.

There's a saying in journalism that you should follow the money. As I note in our annual CIRCUITS ASSEMBLY Top 50 listing of the largest EMS companies, which starts on page 36, we track more than 115 publicly traded EMS companies. And that's even after some really large ones like TPV and Shenzhen HyteraEMS have gone private in recent years. While private equity is in the game today in a major way, we've seen this play out before. In the late 1990s and early 2000s, fabricators and EMS companies were the hottest dates at the prom. Then midnight struck in the form of the dot-com bust. Billions in valuation went poof. So did the PE guys. They are back with a vengeance, but it won't be forever.

In the meantime, my hope is some of the current influx of capital gets appropriated for actual capital expenditures and process improvement, not just rebranding and marketing.

Some folks I speak with wonder whether EMS companies should shed any legacy bare board fabrication operations. I feel the opposite. In my view, there are two major non-commodity pieces to the central nervous system of any electronics product: the design and the bare board. Coupled with the very real supply-chain issues we periodically face, assemblers should look long and hard at how they might gain control over those segments. Flex, Sanmina and now Benchmark are among the Top 50 EMS companies that have in-house printed circuit board operations.

Likewise, I see no reason fabricators couldn't tack on assembly, and in some cases they are. Some major fabricators, like Kinwong, have more than 200 SMT lines, and the largest chip-on-flex assemblers, like Zhen Ding and Nippon Mektron, are prominent members of the CIRCUITS ASSEMBLY Top 50. Many smaller flex operations offer assembly, and rigid players continue to join the party.

Others, including Jabil and Kitron, are diving into additive manufacturing. The advantages are obvious: It speeds prototyping, expands the available material sets, and enables all sorts of interesting stress and failure analyses. I fully expect to see widespread adoption of 3-D printers at every tier of the ODM/EMS segment, and likely within the fabricator segment too.

It's true many EMS companies have to make do with tight margins, yet some (generally privately held) EMS companies generate operating margins well into the high teens. Well-run fabrication operations can do the same or better. There's not just a service or supply-chain control opportunity, but real financial potential as well.

I don't expect OEMs or ODMs to suddenly hoover up all the small-run and prototype shops like rebel ships into the Death Star, but there's clearly room for larger ODM/EMS companies – and not just those in the CIRCUITS ASSEMBLY Top 50 – to expand their product offering reach. If and when they do – and I think eventually they will – it's a small step to offering their own branded products. Once that last barrier is breached, tomorrow could look a lot like yesterday.

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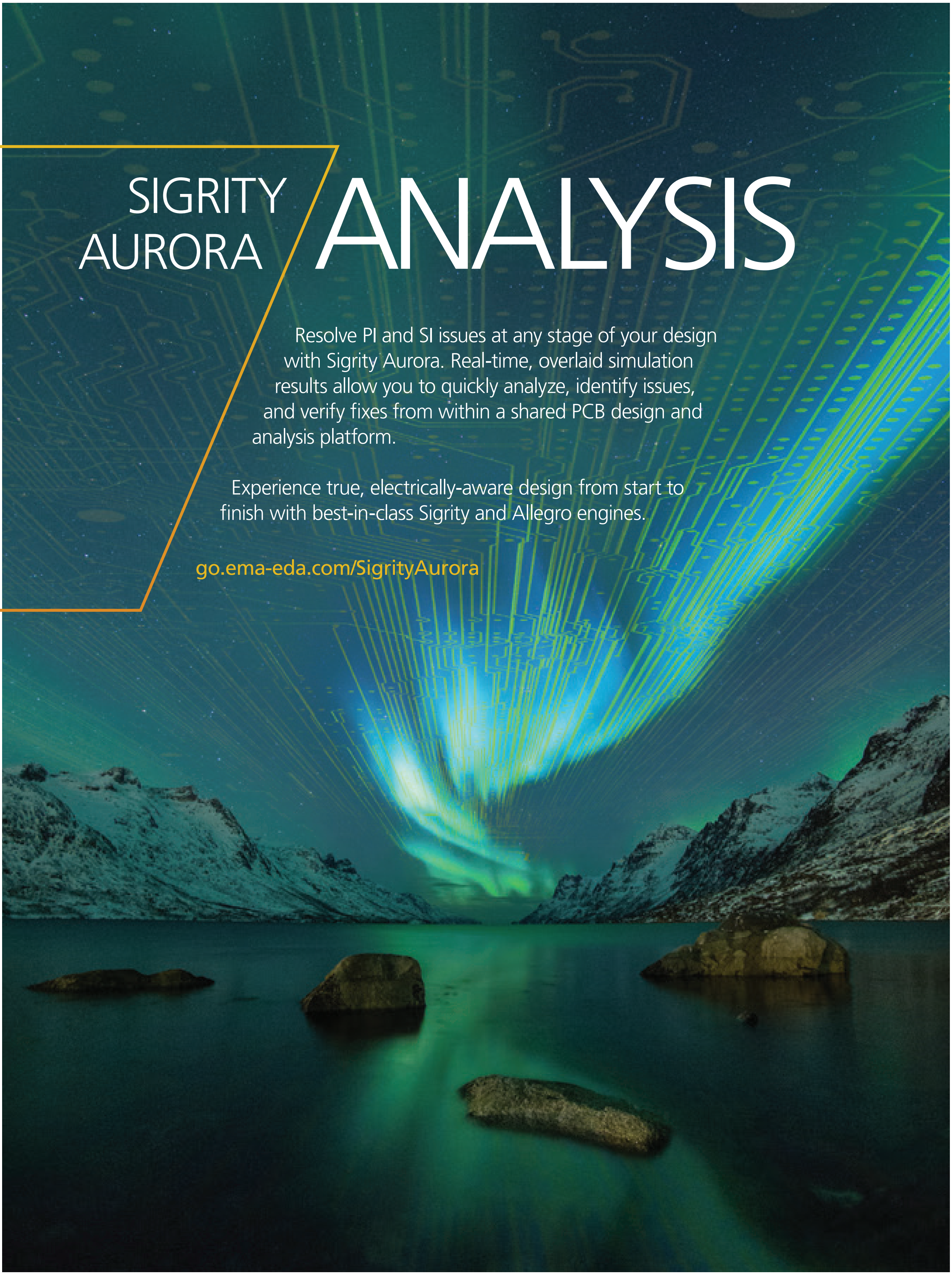
P.S. By the time you read this, Printed Circuit University, our online education platform, featuring tutorials on a range of printed circuit design, fabrication and assembly matters, will be live. Take a look at printedcircuituniversity.com. You may recognize many of the presenters from our PCB East and PCB West conferences. Registration for the latter, which takes place in October at the Santa Clara Convention Center, is now open at pcbwest.com. Check out the program beginning on page 19.



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PCDF People

Firan Technology Group named **Lance Riley** general manager. He has more than 25 years' experience in PCBs with Unicircuit, TTM and Lone Star Circuits.

Insulectro promoted **Michelle Walsh** to vice president of product management.

IWLPC named **Max Min, Ph.D., Jae-Gwon Jang** and **Bryan Kasprowicz** winners of its best paper awards.

Sunstone Circuits named **Kevin Beattie** quality assurance manager. He has more than 25 years' experience in PCB manufacturing.

Tech Etch appointed **Brian Roberts** chief financial officer.

Trackwise named **Steve Hudson** chief operating officer. He has over 20 years' experience in the automotive and aerospace industry with MG Rover, Bentley Motors, Rolls Royce Aerospace, and Williams Advanced Engineering.

TTM named **Roy Alcus** operations manager.

Zuken promoted **Jeroen Leinders** to eCAD-Star business manager.

PCDF Briefs

Apple "believes the SEC should issue rules to require companies disclose third-party-audited emissions information to the public, covering all scopes of emissions, direct and indirect, and the value chain," a company vice president said.

Aspocomp signed project agreements worth a combined 30 million euros ($36.7 million) to supply PCBs to a customer in the automotive industry.

Artificial intelligence is making its way into the PCB industry, says **AT&S,** which has developed an algorithm that recognizes the images of circuit boards, and explains whether they are defective.

Eltek received government approvals to build a second production facility in northern Israel without the need for a bidding process.

Eternal Technologies will hike prices on its North American customers effective Jun. 1, or as contracts permit.

Eurocircuits will invest €7 million ($8.6 million) in its PCB factories in Germany and Hungary.

The board of directors of **Exceet Group** is considering selling **GS Swiss PCB**, its PCB fabrication unit.

EU-Funded Project: Recycling CRMs in PCBs Should be Made Law

ST. GALLEN, SWITZERLAND – End-of-life printed circuit boards are among several electrical and electronic products containing critical raw materials, the recycling of which should be made law, says a new UN-backed report funded by the EU. A mandatory, legal requirement to recycle and reuse CRMs in select e-waste categories is needed to safeguard from supply disruption elements essential to manufacturers of important electrical, electronic and other products, says the European consortium behind the report, led by World Resources Forum.

The CEWaste consortium warns access to the CRMs in these products is vulnerable to geopolitical tides. Recycling and reusing them is "crucial" to secure ongoing supplies for regional manufacturing of electrical and electronics equipment. Today, recycling most of the products rich in CRMs is not commercially viable, with low and volatile CRM prices undermining efforts to improve European CRM recycling rates, which today are close to zero in most cases.

The report identifies gaps in standards and proposes an improved, fully tested certification scheme to collect, transport, process and recycle this waste, including tools to audit compliance.

"A European Union legal framework and certification scheme, coupled with broad financial measures will foster the investments needed to make recycling critical raw materials more commercially viable and Europe less reliant on outside supply sources," says the consortium. "Acceptance by the manufacturing and recycling industry is also needed, as the standards will only work when there is widespread adoption."

The report follows a 2020 EU action plan to make Europe less dependent on third countries for CRMs by, for example, diversifying supply from both primary and secondary sources, while improving resource efficiency and circularity.

"By adopting this report's recommendations, the EU can be more self-sustaining, help drive the world's green agenda and create new business opportunities at home."

The project pinpoints PCBs from IT equipment among the equipment containing CRMs in concentrations high enough to facilitate recycling.

Recovery technologies and processes are well-established for some CRMs, such as palladium from PCBs. For other CRMs, ongoing recycling technology development will soon make industrial-scale operations possible but needs financial support and sufficient volumes to achieve cost-efficient operations.

Of 60+ requirements in European e-waste-related legislation and standards, few address the collection of CRMs in the key product categories, the consortium found. It proposes several additional technical, managerial, environmental, social and traceability requirements for facilities that collect, transport and treat waste, to be integrated into established standards, such as the EU 50625-series.

"Greater CRM recycling is a society-wide responsibility and challenge," says the consortium. "The relevant authorities must improve the economic framework conditions to make it economically viable."

The consortium supports legislation requiring recycling of specific critical raw materials in e-waste, market incentives to spur CRM recovery, and integrating CEWaste normative requirements into the European standard for e-waste treatment and making the whole set legally binding, among other recommendations. (CD)

US Senator Proposes Bill to Track PCBs in US Defense Systems

WASHINGTON – A US Congressman in late April introduced a bill requiring defense contractors to notify the US Department of Defense if China, Russia, Iran or North Korea produce any printed circuit boards used in their electronics systems. The legislation by Sen. Josh Hawley (R-MO) also proposes the government allocate an undisclosed amount over 10 years to fund the domestic electronics supply chain.

Research institute **Fraunhofer IPMS** is working on trusted manufacturing processes of electronics devices, with the goal to develop solution concepts encompassing all areas of electronics development and production.

FTG licensed **Averatek's** A-SAP process.

The **HDP Users Group** will investigate materials that show unexpected behavior of Tg by TMA, and develop guidelines when standard IPC methods do and do not adequately describe their thermo-mechanical properties.

Lenthor Engineering purchased an **ESI** Geode CO2 microvia drilling system. Lenthor also qualified **DuPont** Pyralux HT flex circuit material.

Michigan State researchers are building circuit boards that are better equipped to function in extreme conditions, including on Mars. The team has developed a more heat-resistant silver circuitry with a nickel additive.

Mycronic signed an agreement with **Cohu** to purchase the firm's PCB test group for $125 million. The business, which includes **atg** and **Luther & Maelzer,** reported sales of $53 million for the year ended Mar. 27.

Shennan Circuits is facing increasing pressure on its business operations in 2021 due to losses of orders from **Huawei** for 5G infrastructure applications and rising prices for upstream raw materials, according to industry reports.

Siemens signed an agreement to acquire **Supplyframe,** a design-to-source platform for the electronics value chain, for $700 million. The transaction is subject to customary conditions and is expected to close in the fourth quarter of fiscal 2021. Supplyframe expects fiscal 2021 revenue of about $70 million.

Summit Interconnect opened its newly renovated, state-of-the-art laboratory in Anaheim, CA.

Schweitzer Engineering Laboratories began excavation in Idaho on its 140,000 sq. ft. PCB fabrication plant.

Trackwise Designs has acquired a 77,000 sq. ft. manufacturing plant in Stonehouse, UK.

Tuan Sing Holdings agreed to sell 13% of the shares it holds in PCB fabricator **Gultech (Jiangsu) Electronics** for 435 million yuan (US$67.2 million), according to reports.

Varioprint has converted to **Peters** Elpemer AS 2467 solder resist.

Zero Defects International announced a boundary scan test service.

In a statement in support of the bill, called the PCBetter Act, Sen. Hawley called Chinese-made PCBs "a serious threat" to America's defense systems. "It is imperative that we give the Department of Defense the tools it needs to secure its printed circuit board supply chains, so that our warfighters can have full confidence in the weapons they rely on to protect our nation."

The new bill would require companies that supply the DoD to document the origin of each PCB. The bill would also establish a testing, remediation and prevention regime to address vulnerabilities in IT systems that contain or may contain circuit boards made in those countries.

It is unclear at present how the bill would affect ITAR, the US State Department regulations on sharing defense technology with unapproved nations. The penalties for violating ITAR are stiff and can include fines and jail time.

Moreover, the US DoD, through the Defense Supply Center Columbus, has standards and audits for boards and the companies that produce them. The series, MIL-31032 and its associated qualified manufacturers list, hypothetically narrows the potential suppliers to entities vetted by the US government. That QML includes some foreign makers but none from China.

But, critics point out, there is no mandate that the DoD use boards only from MIL-31032-qualified producers. Moreover, calling out MIL-31032 on all master drawings might add cost. Only a fraction of the 155 fabricators supplying boards to the US DoD are on the MIL-31032 QML, and DSCC was backlogged with pending audits even prior to the Covid-19 travel restrictions.

One longtime US industry expert called the bill "a well-intentioned effort to focus DoD attention on printed circuit boards. At the same time, it targets China, and to a much lesser extent – other 'enemies.' It makes a concerted effort to force Defense contractors to try their best to find where their circuit boards are manufactured."

The bill does raise certain questions, however. The legislation "calls out 'information systems' without total inclusion of all circuit boards used in weapons," the expert noted. "This certainly needs better definition," adding IPC-1782 might help in that regard.

The expert thinks the bill won't succeed in boosting US printed circuit business. US market share today is about 4%, he said to PCD&F/CIRCUITS ASSEMBLY. "Figures I have seen report about 25% of US board production is for Defense, so this is 1% of the world production. I think the needed market share boost is beyond a congressional bill like this."

It is also unclear whether the aim is to ban PCBs from the named countries, or simply track their use.

While Congress has been peppered by US electronics lobbyists seeking support for US fabricators, the proposed bill does not seem to recognize that state-of-the-art commercial board technology is often superior to what is permissible in US Defense Department designs. Whether the bill could hamper the US DoD in terms of the types of PCBs if they are not built onshore remains to be seen.

Ultimately, any legislation is only as good as its enforcement. "We must understand that ITAR regulations are established by the State Department, with only advice from Defense," the expert noted. "ITAR is not a good system, as evidenced by very few enforcement actions." (MB)

SERO Acquires Fellow EMS Semecs

ROHRBACH, GERMANY – SERO GmbH has acquired Solid Semecs BV in a deal that was consummated on Apr. 30 but is retroactive to Jan. 1. Financial terms were not disclosed, but Semecs shareholder Rademaker Beheer has been bought out as part of the deal.

The move is part of SERO's international expansion and growth strategy.

SERO specializes in high-volume manufacturing for automotive and industrial customers. Automotive makes up 85% of the company's sales. The company employs 300, primarily in Germany, and has annual sales topping €80 million ($98 million). Semecs focuses on medium-volume and manual activities, and has ISO 13485 (medi-

cal) and IATF 16949 certifications. Semecs generates 85% of sales in the industrial and medical sectors and 15% in the automotive industry. It has an engineering center in the Netherlands and production in Slovakia. Semecs has annual sales of approximately €70 million ($86 million) and about 460 employees. (MB)

Escatec Acquires JJS to Expand EMS Reach into Europe

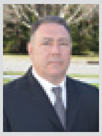
PENANG, MALAYSIA – Escatec acquired 100% of UK-based JJS Manufacturing in a private deal in mid-May. The acquisition adds electromechanical production facilities in the United Kingdom and Czech Republic to Escatec's predominantly Southeast Asia manufacturing locations.

The move permits Swiss-owned Escatec, headquartered in the Bayan Lepas on Penang island, to cater to OEMs requiring products to be manufactured or assembled in the UK or Central Europe, the company said in announcing the deal.

Escatec has annual revenues of more than $200 million, and the acquisition of JJS (annual revenue: $70 million) and an expansion of its Malaysian operations is expected to push yearly revenues to above $300 million. "This acquisition is a direct outcome of our strategic plan to grow Escatec into a major player in the global EMS industry and further demonstrates our commitment to serve our customers' needs," said Patrick Macdonald, CEO, Escatec. (MB)

CA People

Arch Systems hired **Dave Trail** as VP of sales. He has 27 years' experience in electronics manufacturing equipment, processes and MES software.

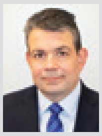


Europlacer Americas named **Craig Brown** regional manager for the south, southeast and central US. He was sales manager for DEK in the late 1990s and early 2000s.

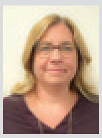
Henkel named **Rodrigo Aguilar Limas** business development manager – Advanced Driving and Safety Electronic Components.

Horizon Sales added **Kyle Keydel** to its sales team.

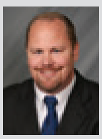
Kimball Electronics named **Jana Croom** CFO, replacing **Michael Sergesketter,** who is retiring.



MicroCare appointed **John Stardellis** chief financial officer. He has more than 20 years' experience in a variety of finance, policy and operational leadership roles, most recently as CFO at i-Health.

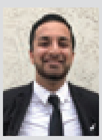


PVA promoted **Jaime Erickson** to director of operations. She joined PVA four years ago as customer success coordinator, and has more than 20 years' experience in electronics manufacturing.



South-Tek Systems named **Karl Pfluke** electronics market manager. He has held roles in sales and engineering with KIC, Heraeus, Indium, and others since 1997.

URtech Manufacturing hired **Michael Wallace** as vice president of business development & customer programs. He began his career in 1983 at Schlumberger.



Whizz Systems appointed **Dan Williams** director, sales & marketing, and **Humza Babar** marketing associate. Williams has over 20 years of experience in the EMS industry, sales, and marketing.

CA Briefs

Acromag installed a **Kurtz Ersa** HR-550 BGA rework system.

Some of the world's biggest chip buyers, including **Apple, Microsoft** and **Alphabet Google,** have joined chipmakers such as **Intel** to create a new lobbying group to press for government chip manufacturing subsidies.

Apple ramped its US investments, with plans to make new contributions of more than $430 billion and add 20,000 new jobs across the country over the next five years. The company's original five-year goal of $350 billion was set in 2018.

Bright Machines, a developer of software-driven automation processes, is being acquired by **SCVX,** a publicly traded special purpose acquisition company. Closing is expected to occur in the second half of 2021. Separately, the company named as manufacturers' reps **PAC Global** distributor in the Southwestern US and Mexico and **MaRC Technologies** in the Pacific Northwest US.

CEM installed a **Yamaha** high-speed placement line.

Engineers at **Columbia University** have demonstrated the smallest single-chip system ever created, which could be implanted with a hypodermic needle to measure temperature inside the body, and possibly much more.

Enics confirmed plans transfer manufacturing from its electronics manufacturing plant in Switzerland to other factories in Europe, a move that will affect up to 110 workers.

Foxconn Electronics is in talks to acquire 6" or 8" semiconductor fabs, according to company chairman Young-Way Liu in response to speculation that the EMS giant is looking to take over a 6" fab from **Macronix.** Foxconn and **Yageo** have announced plans to form a joint venture to develop and sell semiconductors.

IEC Electronics opened its state-of-the-art 150,000 sq. ft. manufacturing facility at the Silver Hill Technology Park in Newark, NJ, and gave an update on another plant in Rochester, NY.

Incap will build a third EMS factory in Tumkur, Karnataka, India.

Gold use is spiking as electronics demand continues unabated.

Katek, the second-largest German EMS provider, is preparing an IPO on the Frankfurt Stock Exchange in the current quarter.

Megger installed two **Europlacer** iineo+ pick & place machines.

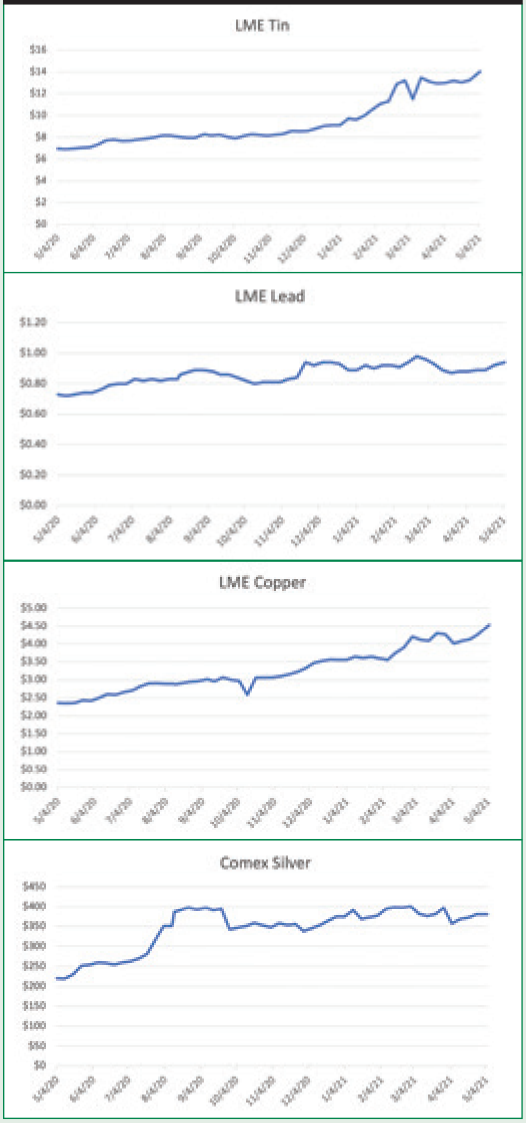
Eight people, including two firefighters, died after a fire at a factory owned by a **Pegatron** subsidiary in Shanghai.

EMS firm **Silicon Forest Electronics** is merging with **ESAM** and **Bay Computer Associates** through a stock purchase agreement with **VergePointe Capital.** The combined group will be merged into **EHC,** a holding company.

UMC Electronics is closing production at its electronics manufacturing factory in Mexico and winding down its business operations in North America, a reaction to the slowing automotive market.

VS Industry (VSI) said construction of its new electronics manufacturing facilities in Johor is on track to be completed soon.

METALS INDEX



Hot Takes

- **Electric vehicles and autonomy** are expected to drive the printed electronics automotive market to $12.7 billion by 2031. (IDTechEx)
- **Tablets** saw first quarter year-over-year growth of 55.2% and shipments totaling 39.9 million units. (IDC)
- First quarter **smartphone shipments** were up 25.5% year-over-year, and smartphone vendors shipped nearly 346 million devices. (IDC)
- Total **North American EMS orders** in March rose 8.9% year-over-year and decreased 8.7% sequentially. (IPC)
- DRAM price hikes for the second quarter are expected to be 18 to 23%, up from a prior estimate of 13 to 18%. (TrendForce)
- **PCB and MCM design software** revenue decreased 0.8% year-over-year to $292.9 million in the fourth quarter. (ESD Alliance)
- **Sales at the top 50 EMS companie**s worldwide accounted for $384 billion in revenue, up 4.6%. (MMI)
- Worldwide sales of **semiconductor manufacturing equipment** surged 19% to an all-time high of $71.2 billion in 2020. (SEMI)
- Global shipments of **traditional PCs,** including desktops, notebooks, and workstations, grew 55% year-over-year during the first quarter, IDC said.
- **The electronics manufacturing industry** accounted for €301 billion (US$360.4 billion) in production value in 2019 and directly impacted €3.8 trillion in European GDP. (IPC)
- Global **server shipments** in the second quarter are expected to increase 20% sequentially, unaffected by material shortages.
- **Taiwan's PCB industry** hit a record high in 2020, with global output reaching NT$696 billion ($24.8 billion). (TPCA)
- Worldwide **semiconductor revenue** grew to $464 billion in 2020, an increase of 10.8% compared to 2019. (IDC)

COMPONENT CRUNCH

Trends in the US electronics equipment market (shipments only)	% CHANGE JAN.	FEB.	MAR.	YTD%
Computers and electronics products	1.2	-0.6	0.3	8.5
Computers	6.5	2.0	-2.6	2.7
Storage devices	20.4	-5.2	-3.8	21.6
Other peripheral equipment	9.9	-2.3	-1.8	17.6
Nondefense communications equipment	-5.5	-0.8	1.5	14.8
Defense communications equipment	4.5	0.0	-1.8	6.9
A/V equipment	17.7	-7.1	2.1	17.4
Components[1]	1.1	-0.1	1.7	8.7
Nondefense search and navigation equipment	3.0	-0.2	-0.5	0.6
Defense search and navigation equipment	4.7	-2.5	-0.4	2.7
Medical, measurement and control	2.2	-1.2	0.9	9.2

[r]Revised. *Preliminary. [1]Includes semiconductors. Seasonally adjusted.
Source: U.S. Department of Commerce Census Bureau, May 4, 2021

US MANUFACTURING INDICES

	DEC.	JAN.	FEB.	MAR.	APR.
PMI	60.5	58.7	60.8	64.7	60.7
New orders	67.5	61.1	64.8	68.0	64.3
Production	64.7	60.7	63.2	68.1	62.5
Inventories	51.0	50.8	49.7	50.8	46.5
Customer inventories	37.9	33.1	32.5	29.9	28.4
Backlogs	59.1	59.7	64.0	67.5	68.2

Source: Institute for Supply Management, May 1, 2021

KEY COMPONENTS

	NOV.	DEC.	JAN.	FEB.	MAR.
Semiconductor equipment billings[1]	23.1%	7.6%	29.8%	32.4%[r]	47.9%[p]
Semiconductors[2]	8.4%	9.55%	13.2%	14.7%[r]	17.8%[p]
PCBs[3] (North America)	1.05	1.10	1.14	1.29	1.22
Computers/electronic products[4]	5.13	5.11	5.05	5.11[r]	5.08[p]

Sources: [1]SEMI, [2]SIA (3-month moving average growth), [3]IPC, [4]Census Bureau, [p]preliminary, [r]revised

Life is Drama, But Work Doesn't Have to Be

Five ideas for being a better worker.

"PEOPLE WHO NEED people, they're the luckiest people in the world," or so the song goes. If that's true, though, why do I feel so unlucky?

For many years, colleagues from virtually every industry imaginable have agreed their Number One need, desire, concern and frustration is finding good people to hire. Regardless of job level or education experience, hiring qualified people is possibly the biggest challenge industry faces globally.

In my little corner of the world, which happens to be close to some of the most prestigious universities and colleges in the world, executives in companies of all sizes tell me the mantra is, "Where are the good people?" (Note: No one asks, "Where are the people?" The operative word here is "good.")

To be sure, colleagues share remarkably similar stories about people who have been hired only to be fired in short order. Such occurrences were once rare, but today are too often the rule. Based on personal experience and countless shared stories, I have identified five issues that individually or collectively are common in today's job applicants:

1. Everyone likes manufactured things but no one wants to be a manufacturer. The image of manufacturing is that of a dirty sweatshop. Yet enter any plant, be it semiconductors or steel or automobiles or circuit boards, and the reality is companies are modern, computerized and clean, and require smart, engaged team players. When recruiting and interviewing, refute the negative image and highlight the opportunities. For job seekers who believe manufacturing is a dead-end job, consider the latest gadget you use – the phone or tablet or even the car – and what it takes to make it. Spoiler alert: There's real career opportunity in manufacturing!
2. Success in any endeavor requires discipline. Discipline is not difficult, but it requires commitment. Discipline means showing up to work on time, not just once, but every day. Discipline means getting up early enough to get ready for work, including that first cup of coffee. Discipline means getting good rest at night so you can wake up in time to get ready for work and arrive on time. Discipline means getting home from whatever you are doing the night before so you can go to bed early enough…. Get the message? Even during this pandemic-influenced time, employers expect employees to be at work on time and put in a full day, and then, OMG, do it again. Too many applicants don't have the basic discipline to keep a good job. Spoiler alert: It's simple; it just requires commitment!
3. Everyone has "stuff" going on in their personal life. A demanding work environment requires focus, however. Employees need to check their personal drama at the door. Do you really need to tell everyone what someone said that made you mad? Spoiler alert: We all have a life; keep yours to yourself and there will be far less drama for all.
4. Is it a job or a career? Many workers live day-to-day and just want a "job." That's fine, but you may be surprised how many jobs you end up at without ever earning more money. Workers change employers more often today than a generation ago, but every change should be considered part of a bigger picture, a life plan, a career. Some "jobs" may seem tough or uninteresting or unprofitable. But is that "job" teaching the essential skills you need to get promoted? Do you even know? The goal should be to get a job, master it, be the best, and apply for the next job – a promotion. Then do it again. Employees are not thinking long-term. Instead, they just do the "job," without aspiring to the next move. A "job" is about the moment. A "career" is about long-term success. Spoiler alert: Success is in your hands, if you think about having a career, not just holding a job.
5. Woody Allen said, "Showing up is 80% of life…." This is true: You can't get a job without showing up (on time every day), but just showing up does not merit a raise. Many have unrealistic expectations on their wages and number of working hours. Most businesses require 40 hours of work. Most businesses offer pay increases based on merit, which means it was earned through output, not appearance. Spoiler alert: Want to make more money? Work harder and smarter than others, and you will be rewarded in the pay envelope!

Many have started out in menial roles but, because of their commitment, discipline and focus on the long-term career regardless of the work environment, made it to CEO. There is no magic formula; it takes commitment. My colleagues agree too few people understand the little things such as looking for opportunity, having commitment, managing your personal life and having a life and career plan. Working hard and smart are essential for success. Equally, too many go through the motions and can't quite understand why they never get "a break."

Many of us are people who need people. Hopefully, some will read this and understand that, if taken to heart, they could become the luckiest in the world. ❑

PETER BIGELOW is president and CEO of IMI Inc.; pbigelow@imipcb.com. His column appears monthly.

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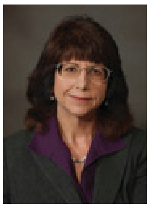
Finding Employees: The Next Big Challenge

EMS companies are undertaking a range of measures to appeal to new recruits.

SUSAN MUCHA is president of Powell-Mucha Consulting Inc. (powell-muchaconsulting.com), a consulting firm providing strategic planning, training and market positioning support to EMS companies and author of *Find It. Book It. Grow It. A Robust Process for Account Acquisition in Electronics Manufacturing Services*; smucha@powell-muchaconsulting.com.



MATERIAL CONSTRAINTS COMBINED with unanticipated spikes in demand and shortages in transportation capacity apparently aren't enough of an electronics manufacturing services (EMS) management challenge for 2021. Labor shortages are also an issue, despite unemployment numbers double what they were pre-Covid. The reasons are complex. While government stimulus payments and more generous unemployment insurance may be incentivizing some to stay home, other factors such as lack of childcare resources or health concerns are also at play. The availability of more remote work options and relocation of previously available workforce due to Covid restriction adaptations are also factors.

In a constrained labor market, the manufacturing sector often finds it hard to recruit. Several decades ago, everyone had friends and family who worked in factories and spoke of the benefits of that career choice. The service economy and offshoring changed that. Today, many potential employees do not even consider manufacturing sector jobs.

How can these trends be changed? I've interviewed executives at Firstronic and SigmaTron International to discuss what works for them. I also interviewed a recent "new to manufacturing" hire at Firstronic to add perspective on what makes factory work appealing.

Innovative hiring practices in place pre-pandemic at Firstronic's Grand Rapids, MI, facility are working post-pandemic too. During a previous hiring spike, the company worked with a consultant to develop an Accumax survey that screens candidates for the right aptitudes and attributes for the job. This tool helped reduce turnover when initially introduced, and continues to help focus recruitment efforts on candidates likely to succeed. Several years ago, it converted to four 12-hour shifts in a 24/7 work schedule, which gives most production operators alternating three- and four-day workweeks. Shifts 1 and 3 are day shifts, and shifts 2 and 4 are night shifts. Two years ago, a "Weekend Warrior" shift was added, which runs Friday, Saturday and Sunday for 12 hours each day, with full benefits and a shift differential premium. It has the least turnover and appeals to the area's college students. Some regular employees switched as well.

Pay was also increased toward the end of 2020.

"We doubled both of our night shift premiums," said Sandy Kolp, VP of quality and program management, Firstronic. "Shift four, which has people working Thursday, Friday and Saturday evenings, pays the most. We've also just added a productivity bonus program for all direct employees."

The efficiency bonus is based on established output metrics for each job. When a worker's output exceeds 85% of the goal, he or she is eligible to earn a sliding scale bonus equaling up to 35% of their current wage. Efficiency rates are input from engineering, and the shop floor control system calculates efficiency against the products the operator is scanning in. A daily report is emailed to each supervisor and the plant manager who details efficiency by operator and product utilizing a stoplight color code system. While there are plans to increase the report automation, currently the plant manager reviews the report and gives accounting instructions for bonus amounts prior to each payroll processing date.

New hires get the full 35% bonus for their first two weeks to motivate them to focus on the benefits of efficiency.

"The initial efficiency bonus helps show entry-level workers how they can bump their starting compensation up to $15 to $17 an hour depending on shift choice," added Kolp.

Firstronic advertises through Michigan Works and local community college and university job boards. A new pandemic-related requirement is all postings must include information on in-house Covid-prevention measures before the job requirements can be posted. All production-related interviews are done onsite.

"We discontinued virtual interviews for production jobs quickly. Candidates need to tour the facility to get a good idea of what these jobs entail," said Kolp.

The biggest recruiting success has been the employee referral program.

"Both our existing employee and the referral candidate get $50 each at hire date. There is another bonus of $200 at 60 days and again at 180 days for both parties. There is $500 apiece at the one-year mark. So, when a referral candidate is hired and stays for at least a year, both people earn a total of $950," said Kolp.

Another successful program has been opening manufacturing jobs to students with work permits (16 or older) on weekends and school breaks.

"We've hired 16 students between the ages of 16 to 18. Some work one weekend day. Some work both days. A few worked their spring break. It is helping to build their job record, and they get the same benefits as our other employees. They have the ability to learn more about potential careers in manufacturing as they are making choices about what they will study in community college or university programs. It helps us

build some affinity for manufacturing in a new generation," said Kolp.

Once hired, all new employees go through an onboarding process that includes Covid prevention training, job skills training and relevant IPC-based certification training. They are also mentored on the production floor for a probationary period. Training class size has been reduced to five plus an instructor due to Covid prevention restrictions, so classes are held more frequently.

> "EMPLOYEES HAVE A **LOT OF CHOICE RIGHT NOW,** AND IT IS IMPORTANT TO **STRUCTURE THE WORK EXPERIENCE** IN A WAY THAT **KEEPS THEM ENGAGED."**

SigmaTron operates US manufacturing facilities in Elk Grove Village, IL, and Union City, CA.

"It is a challenging hiring environment," acknowledges John Johnson, director of HR, SigmaTron. "Pre-Covid, we were very involved in career fairs and activities with local community colleges. Those types of events are no longer happening. We continue to maintain job boards and utilize social media, although we are changing which social media platforms we use."

The employee referral program has generated the most success. Recruiting employees merits a bonus after the referred employee completes 90 days.

"We are working three shifts in both facilities, but have more openings in our California facility. The employee referral program has been very successful in our Illinois facility," Johnson added.

SigmaTron's team focuses on the employee experience very carefully.

"Employees have a lot of choice right now, and it is important to structure the work experience in a way that keeps them engaged," said Johnson.

From rapid follow-up with good candidates to an onboarding process that includes new hire orientation plus supportive interaction from each new hire's first line supervisor, the team works to ensure new employees feel valued.

"The first few days are critical, particularly when employees are new to a manufacturing environment. The feedback we get from our new hires is they appreciate our clear policies and feel our workplace is honest and friendly. We've increased our Covid mitigation policy training because we've found new employees are often concerned about the potential for getting Covid. When they see our social distancing precautions and other mitigation policies, that helps minimize that issue," said Johnson.

There is no question the pandemic, government stimulus efforts, increasing costs and changes in employee lifestyles have increased HR challenges. As these interviews underscore, quality of the hiring and onboarding process, team interaction on the factory floor, and clarity in workplace policies go a long way to attract and retain high-quality employees. The success of employee referral programs underscores the value of using those who understand the positives of a manufacturing career to recruit people with no factory experience. The EMS industry continues to be a great place to work. The challenge continues to be increasing awareness of a career option that many good candidates never considered. ❑

A New Hire's Perspective

Koby Lee

Koby Lee is an SMT operator who, at the time of this writing, had been on the job about 60 days. He initially applied at Firstronic because his mother works at a business next door to the facility and noticed they had openings.

"The fact that I would be building electronics was interesting. I filled out the application and really liked the walkthrough. It was a clean, controlled, upbeat environment. The staff was very welcoming," Lee said.

The speed of on-the-job (OJT) training was also a plus.

"I'd never seen an SMT line in my life, but in two days I was running machines with someone overseeing me. The first day it seems like a lot to learn, but the hands-on training approach builds muscle memory. Everyone is focused on helping me do my job better instead of telling me what I'm doing wrong. It's like being part of a family. I've never seen a workplace run this way," added Lee.

Clear expectations were also attractive to Lee.

"The opportunities came faster than I expected. They gave me the SMT operator role right after I asked about it. The workplace rules and point system they use is easy to understand," said Lee.

He likes the 12-hour shifts because the alternating three- and four-day workweeks provide larger blocks of free time.

The excitement of working in a technology field has also been a positive.

"When I go out with friends, they ask me what I do, and I tell them I'm building electronics — the computer chips that go into products all around us. The world is evolving, and everything is electronic. We build a ton of great products.

"With this job, I get up every morning excited about learning new stuff. I want to prosper in this field," said Lee.

Money-Saving Tips for Printed Circuit Board Design

Raising the topline with good execution will make up for the expense of expediting development.

THERE IS A simple equation when it comes to counting profits. The fixed and overhead costs must be less than the revenue for there to be profit. The first units out of the gate owe the company for all the nonrecurring engineering (NRE) costs. The item will be in the red until all that is paid back by the margin between unit cost and unit price.

In many sectors of the economy, particularly commercial, the cost of goods sold (COGS) is close to the selling price, meaning little margin after overhead is accounted for. (PCB design is among the overhead costs.) Many units must leave the factory and find a consumer before the project hits the breakeven point. Product cycles are such that price erosion puts the squeeze on margins right from the beginning. Consumer hardware is a tough game, no doubt.

Competition among the players keeps us on the path of continuous improvement. Sitting still while others strive to grab your market share actually means moving backward, so let's take it for granted that we have to keep reinventing our products. Those new features, whatever they are, will likely add to the bill of materials (BoM), which increases the variable costs. We can soften that blow with a few money-saving methods.

So much more margin is to be had for the first mover. No one else gets that premium pricing advantage. The risk of someone mirroring your company's blueprint is always there, so that lead is perishable but worth having and keeping. A design win can lead to more design wins but only if we execute on the new product introductions that follow. Winning creates enthusiasm.

I'm not here to think about losing, so keep that energy going with attitude and willingness to do what it takes to stay on schedule. Monitoring progress against expectations will show if the product timeline is beginning to slip. Acting before it gets out of hand is the best way to approach this ongoing concern.

The one thing that might be known at the outset is the expected end-date. Working back from there, establish milestones for completion of library, schematic, placement, critical routing, simulation, etc. Each of those milestones should conclude with a meeting where we can check off all the items needed to proceed to the next gate.

To keep it real, let's say the schematic-complete date is here but the schematic is not. Have that meeting anyway. Use that as a pivot point and figure out how to pick up your coworker by getting a lot of quality board layout work done in a short period.

Some of these things can be done in parallel with additional design resources if your solo efforts are falling short. If you know you need help to get to the tape-out date, it is up to you to get that help. The rate for a service bureau may seem high, likely more than your own rate. The payback comes if everything falls into place as planned. The majority of the revenue comes before the copycats release their versions. The first one in with a similar product might get away with it for a while and might even supplant the first mover. That's not the norm. Be the original and stay the original by developing something better than the previous iteration. Spend money to make money or lag with a me-too product's market share.

Let someone else create the library. Component footprints can be outsourced for a reasonable price. Most of them are available off-the-shelf and, if not, soon after you place the order by providing a data sheet. Some library generators also do schematic symbols and include step models of the parts.

You know the PCB cannot be any better than the underlying component footprints. A wise designer double-checks the new geometry prior to use. If you manage this correctly, you can retire from making footprints and just check them over before adding them to your library.

Tighten the loop between the product designer's data and the PCB data. We get mechanical data in different ways. Typically, a few layers have shapes that define route and component keep-in/keep-out regions. Sometimes, this is okay; most of the time, the mechanical engineer has a few glitches in the data they provide for the first go-around. The things I have seen and accepted over the years could make this a very long story (**FIGURE 1**).

Here's an example. The headroom under a shield was set to zero when it needs to be enough to permit parts that fit but flag parts that are too tall. Flagging all the parts as too tall is not right, but hey, I can work with it. One way is to ignore the design rule checks. Another is to edit the properties so the actual head room is enforced.

Both methods come with risk. By pointing out the glitches as they happen, you can get to a better place where the mechanical data are correct by design. Experience has shown a mechanical outline drawing is rarely available at the start. Some attributes may be in a state of TBD (to-be-determined).

JOHN BURKHERT JR. is a career PCB designer experienced in military, telecom, consumer hardware and, lately, the automotive industry. Originally, he was an RF specialist but is compelled to flip the bit now and then to fill the need for high-speed digital design. He enjoys playing bass and racing bikes when he's not writing about or performing PCB layout. His column is produced by Cadence Design Systems and runs monthly.

SCHEDULE-AT-A-GLANCE

TUESDAY OCTOBER 5, 2021

TIMES	TITLE	SPEAKER
10:00 a.m. - 5:30 p.m.	1: PCB Design for Engineers	*Susy Webb, Design Science*
	2: PCB Stackup Design and Materials Selection	*Bill Hargin, Z-zero*
	3. Design for Manufacturing (DfM): A Foundation for Cost-Reduction Efforts	*Gary Ferrari, EPTAC*
10:00 a.m. – 12:00 p.m.	4: Differential Pair Routing for SI and EMI Control	*Rick Hartley, RHartley Enterprises*
	5: From DC to AC – Power Integrity and Decoupling Primer for PCB Designers	*Ralf Bruening, Zuken*
12:00 p.m. - 1:00 p.m. - LUNCH-N-LEARN, Sponsored by Summit Interconnect		
10:00 a.m. – 2:30 p.m.	6: PCB Design for Implementing 3D and High Density Semiconductor Package Technologies	*Vern Solberg, Solberg Technical Consulting*
1:00 p.m. – 4:30 p.m.	7: Circuit Grounding to Control Noise and EMI	*Rick Hartley, RHartley Enterprises*
	8: The Basics of PCB Fabrication (101)	*Paul Cooke, AGC*
2:30 p.m. – 6:00 p.m.	9: Feeding the Beast: Consumption-Based PCB Design	*Daniel Beeker, NXP Semiconductor*

WEDNESDAY OCTOBER 6, 2021

10:00 a.m. – 6:00 p.m. - Exhibits Open

10:00 a.m. – 2:00 p.m. - Booth Barista, Sponsored by Zuken

TIMES	TITLE	SPEAKER
10:00 a.m. – 12:00 p.m.	10: Routing and Termination to Control Signal Integrity	*Rick Hartley, RHartley Enterprises*
	11: PCB Design Techniques to Improve ESD Robustness	*Daniel Beeker, NXP Semiconductor*
	12: PCB Antennas 101	*Ben Jordan*
10:00 a.m. – 5:00 p.m.	13: Getting to 56Gb/s	*Lee Ritchey, Speeding Edge*
1:30 p.m. – 5:00 p.m.	14: RF and Mixed Signal PCB Layout	*Rick Hartley, RHartley Enterprises*
	15: Placement Choices and Consequences	*Susy Webb, Design Science*
	16: The Printed Board Process for Beginners	*Gary Ferrari, Eptac*

FREE WEDNESDAY SESSIONS

TIMES	TITLE	SPEAKER
10:00 a.m. – 11:00 a.m.	F1: Advancements in Prepreg Enabling New Applications for Millimeter-wave and High Speed Digital	*John Coonrod, Rogers Corp.*
10:00 a.m. – 12:00 p.m.	F2: The 21 Most Common Design Errors Caught by Fabrication (and How to Prevent Them)	*Ray Fugitt, DownStream Technologies, and David Hoover, TTM*
11:00 a.m. – 12:00 p.m.	F3: Secure Data Exchange Between Design and Manufacturing	*Michael Ford, Aegis Software, and Hemant Shah, IPC-2581 Consortium*
1:30 p.m. – 2:30 p.m.	F4: Improving Circuit Design and Layout for Accessibility and Success	*Tomas Chester, Chester Electronic Design*
	F5: Software-First PCBA for Mitigating Risks: Achieving First-Time Right	*Ryan Saul, Tempo Automation*
2:30 p.m. – 3:30 p.m.	F6: PCB Design Optimization: What it Means and New Methods	*Zachariah Peterson, Northwest Engineering Solutions*
	F7: PCB Part Shortage Solutions	*Shane Shuffield and Sebastian Weber, Advanced Assembly*
3:30 p.m. – 4:30 p.m.	F8: Electromagnetic Fields for Normal Folks: Show Me the Pictures and Hold the Equations, Please!	*Daniel Beeker, NXP Semiconductor*

5:00 p.m. – 6:00 p.m. - Happy Hour on the show floor

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SCHEDULE-AT-A-GLANCE

THURSDAY, OCTOBER 7, 2021

TIMES	TITLE	SPEAKER
10:00 a.m. – 12:00 p.m.	17: PCB Layout of Switch Mode Power Supplies	*Rick Hartley, RHartley Enterprises*
	18: An Intuitive Approach to Understanding Basic High-Speed Layout	*Keven Coates, Fluidity Technologies*
	19: Ask the Flexperts with Lessons Learned	*Mark Finstad, Flexible Circuit Technologies and Nick Koop, TTM Technologies*
12:00 p.m. - 1:00 p.m. - LUNCH-N-LEARN, Sponsored by Polar Instruments		
10:00 a.m. – 2:30 p.m.	20: Effective PCB Design: Techniques to Improve Performance	*Daniel Beeker, NXP Semiconductor*
	21: Designing the Signal Return Path	*Susy Webb, Design Science*
10:00 a.m. – 4:30 p.m.	22: Printed Circuit Board Stackup Design for High Performance Product	*Lee Ritchey, Speeding Edge*
10:00 a.m. – 6:00 p.m.	23: PCB 102 - Advanced Process Engineering Defects	*Paul Cooke, AGC*
1:00 p.m. – 4:30 p.m.	24: Heat Management for SMD, LED, and Systems 1W to 50W	*Keven Coates, Fluidity Technologies*
	25: Flexible and Rigid Flex Circuit Design Principles	*Vern Solberg, Solberg Technical Consulting*
2:30 p.m. – 4:30 p.m.	26: Accelerate NPI with Efficient Handoff to Manufacturing with IPC-2581	*Hemant Shah, IPC-2581 Consortium, and Dana Korf, Korf Consultancy*
2:30 p.m. – 6:00 p.m.	27: PC Board Design of Power Distribution and Decoupling	*Rick Hartley, RHartley Enterprises*
	28: Design for Solvability, Performance and Manufacturing	*Michael R. Creeden, CID+, Insulectro*

FRIDAY OCTOBER 8, 2021

TIMES	TITLE	SPEAKER
10:00 a.m. – 12:00 p.m.	29: Signal Attenuation in Very High-Speed Circuits	*Rick Hartley, RHartley Enterprises*
10:00 a.m. – 4:30 p.m.	30: Power Delivery System Design	*Lee Ritchey, Speeding Edge*
1:00 p.m. to 4:30 p.m.	31: PC Board Design for Optimum Fabrication and Assembly	*Rick Hartley, RHartley Enterprises*

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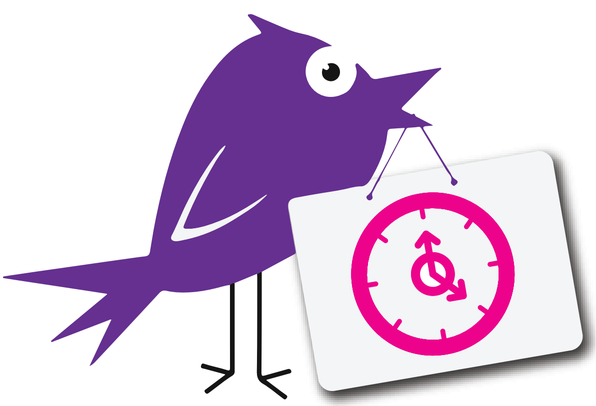

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As these items are ironed out, keep feeding back your edits to their baseline form-factor. The goal here is to reduce the pain of having to capture a slightly different outline down the road. Time is money, so streamline those occasions. The sooner you can get a handle on it, the lower the impact it will have. Schedule-wise, this goes hand-in-hand with cleaning up the schematic early in the game.

You are not being a pest when your aim is to clean up the process. Frame the request as good for the design integrity rather than complying with the particulars of the ECAD tool. Setting aside the gate swapping, we don't routinely alter the netlist. By the same token, we should not make a routine out of "fixing" the MCAD data. Every change can be an improvement, but it's even better if it doesn't come with a self-inflicted setback. Dialogue with that team pays dividends.

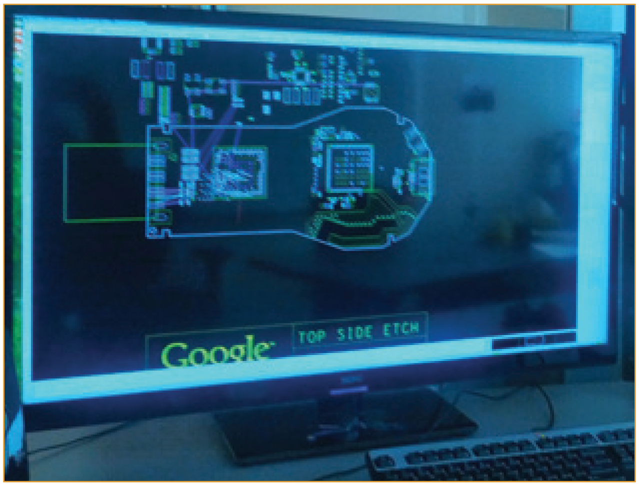

FIGURE 1. Little did I know in 2012 that Chromecast would sell tens of millions of units. Reducing the layer count from eight to six helped enable a low price.

FIGURE 2. Placement is fine-tuned using robotic technology to align an array of lasers in this San Jose factory.

Use one side of the board.

Say it again! Use one side of the board for components. This is probably the biggest favor you can do for your assembler. If the form factor permits populating one side of the PCBA, you will come out ahead of the game versus putting parts on the primary and secondary sides. Most MCUs will function with this arrangement. Explore the possibility if it makes sense.

Single-sided boards make one pass through the reflow oven. In order to solder both sides of a PCB, one side must be populated with the tiny parts only. The first soldering pass on a double-sided board will use a higher temperature solder, so it doesn't melt again when the other side is soldered. Even then, heavier components on the secondary (downward facing) side may require glue to ensure they don't come free.

Limit the BoM to one type of technology.

Again, we're looking at reducing processes. Surface mount is the prevailing technology, and your best bet for an end-to-end solution for your component picks. Mixing surface-mount and through-hole parts is a cost driver **(FIGURE 2)**. The wave soldering process is trickier with surface mount included. Like oil and water, surface mount and through-hole do not mix well.

Avoid or minimize high-density interconnect (HDI).

This can be tricky, too. It is difficult to fill out a BoM without a few ball grid array (BGA) packages where the pin-pitch requires the use of microvias. These tiny vias are formed with a laser, and the fabricator creates them layer by layer. The result is every layer of microvias involves a pass through the lamination press. That's time-consuming, which is to say, money-consuming. The press is a big, expensive machine that uses a lot of power. It can be the bottleneck in a smaller fabricator's flow. It doesn't matter how big they are; they all charge for sequential lamination because it's so much more work.

Getting around all of that will have you shopping for chips that come in quad flatpacks (QFPs) or other packages with perimeter pins only. Finding a second source is another chore. Regarding the assembly line, they will still have to x-ray the board to find voids in the solder joint for the thermal pad in the middle of most of those packages. We're often working with a system of boards where one of the distinctions between the boards is the required technology. Maximizing use of the cheapest boards may help downsize the main PCB of the system.

Creativity and innovation pay off if the execution doesn't get in the way. It's often better to get a set of features into the field and work on yields and costs as you iterate down a list of desirable upgrades. So-called agile development can help steer a product from concept to concrete with calculated steps. Feature creep is the point, but it is tethered to market requirements, so you have the product to win the short game and evolve to the cost-competitive model as the market dictates. ❑

Test for Design: How Do You Measure Up?

The chairman and chairman emeritus describe the past and future.

IN THIS MONTH'S column I convey the value of honing a skillset and the importance of being able to measure that skillset. Next, I hand it off to PCEA Chairman Steph Chavez, who offers a positive outlook on PCEA activities over the summer months. Again, I am happy to provide our readers with a growing list of events coming up in 2021.

PCEA Updates

How do you hone your printed circuit engineering skills? Are your skills measureable? We work in an industry that relies on analysis, checking, measurement, feedback and adjustment to improve process and products.

When we think about PCB engineering, we tend to consider product success in terms of process steps: people defining analysis criteria and working to make the product more useful, efficient and valuable.

But let's pause for a minute and ask, "Who or what is making the people who pull the levers on all these attributes more useful, efficient and valuable?"

Any visitor to a PCB manufacturing facility should be amazed not only by the speed of the operations but the accuracy of the equipment dedicated to forming physical parts out of raw materials using design data. A tour through a fabrication facility may begin in the raw materials department. From there you may stroll down the aisle of a high-speed drilling room, then traverse the building to the plating and etching operations. Perhaps you will move on to view the large-scale lamination press area, where operators "stack" processed layers for insertion into a massive press, which uses heat and pressure to compress the separate layers of the PCB together into a single unified board. Throughout the tour, you will see, feel and smell (definitely smell!) things a large percentage of the PCB engineering community has *never* experienced. You will make use of all your senses, and therefore retain much more knowledge and understanding. Your value as a PCB engineer will increase because you are reaching out to understand the jobs and processes of the important stakeholders of the product. You will observe the machine operators do not specialize in every manufacturing process. You may notice manufacturing operators and engineers are attentive to meeting the design and manufacturing specifications for a particular task. They check their equipment. They measure and provide feedback to management and adjust machinery as required. They are dialed in.

The PCEA salutes our fellow PCB manufacturing stakeholders and considers the PCEA a place for us to collaborate, educate and inspire each other.

A significant point always jumps out at me at the end of a manufacturing facility tour. Our manufacturing stakeholders take a great deal of time training and then executing their day-to-day processes and not a single process step moves forward without inspection, measurement and adjustment.

Our manufacturing community stakeholders are measured, evaluated, trained and retrained on different incoming job requirements most every day.

I must ask of those who are involved in designing and engineering printed circuits: At what point are you required to make adjustments because your design will not move on to the next step of manufacturing? Who facilitates your training and retraining? Who is measuring and evaluating you?

As a PCB designer myself, I often reflect deeply and sincerely on these questions.

Aside from an automatic design rule checking in our software, which we likely set up to suit our perception of what other stakeholders need, likely a holistic measurement for success in our task of laying out a printed circuit assembly will not be available for weeks or months. This won't happen until the design is built and moves on to production. It is highly likely we will not receive all the important feedback because the PCB manufacturing industry takes no pleasure in complaining about our design deficiencies. Unfortunately, it is sometimes considered bad for business.

The PCEA seeks to contribute to a design and manufacturing culture that considers the burden for the measurement of our PCB engineering skillset relies on each of us individually, and on our whole organization. An important key to PCB engineering success is to support education of the design community and support definition of measurable skillsets to complement the entire PCB industry.

If you have caught yourself wondering what you can do to help your designs flow smoothly down the conveyors of bare board and assembly lines; if you detect a void in your ability to discuss what is required to solve EMI challenges in the design layout before it becomes a significant problem; if you are tired of answering manufacturing queries regarding materials, processes and documentation, perhaps design training with a certification program for measurable success is right for you.

Many of us who began the PCEA are deeply involved in supporting and teaching the materials and certification programs offered through the IPC. The IPC Certified Interconnect Designer (CID) and advanced CID+ programs have been around for a long time and

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have served as the electronics industry go-to programs for measurable design and manufacturing knowledge. CID and CID+ certification is commonly cited as a requirement for progressive company PCB designer job postings. You can find out more about the IPC CID and CID+ designer certification training programs at ipc.org/ipc-designer-certification-program.

Additionally, IPC has initiated in-depth, hands-on design training program modules covering introduction to PCB design, advanced packaging, design for rigid-flex boards, design for mil-aero applications, extreme environments and another on design for micro modules. Find out more about these training modules at https://training.ipc.org/design-training-programs.

Recently, some of our own PCEA founders have authored and launched the Printed Circuit Engineering Designer professional development program as a comprehensive curriculum specifically for the layout of printed circuit boards. The five-day course is offered online by Eptac, can be scheduled in the day or evening, and includes a comprehensive textbook. The program helps prepare a student to become a candidate for an optional certification program as a Certified Printed Circuit Designer (CPCD.) The PCEA is happy to be the certifying body for a new Printed Circuit Engineering Designer program. You can find out more about this program at eptac.com/etrainings/printed-circuit-engineering-designer-online-program.

All these programs aim to help those of us in printed circuit engineering see what is possible, what is missing and how to adjust accordingly for continued PCB engineering success.

Message from the Chairman

by Stephen Chavez, MIT, CID+

This month I'm excited to convey our continued positive membership growth, along with new PCEA chapters both in the US and internationally. As the new and existing chapters gain momentum, education continues to be the driving force that brings together existing and new members, creating much excitement, positive energy and member interactions. We continue to gain sponsorships and industry affiliations, adding to the overall PCEA collective. The growth in these two areas adds to the strength of PCEA, more specifically, with the educational content already offered by PCEA. We are seeing great collaboration where several local PCEA chapters are partnering with industry sponsors to offer outstanding educational content to their members.

Over these next few months, we will roll out much more educational content as we continue to integrate and collaborate with our sponsors. Per our mission statement "Collaborate, Educate, and Inspire," partnering and collaborating with sponsors allows us to bring more outstanding industry educational content to the table for anyone who has anything to do with printed circuit engineering.

We continue to remain in the virtual world as many industry events are taking place virtually instead of in person. Unfortunately, some major industry events have been cancelled. Time will tell if more in-person events resume as these next few months unfold.

Even with most still in the virtual world, we are back in full stride to serve up awesome online virtual chapter events. Our education committee continues to work on offering great industry content and updating our website for technical information and educational events. Be on the lookout for new content and activities as we get activities and events locked in.

If you have anything to do with printed circuit engineering, I highly recommend you join the PCEA collective. The industry waits for no one and evolves so quickly. Keeping one's skillset and education up to date and relevant is key to career success. It's important to stay on point and continue your professional development. By joining the PCEA, your percentage of long-term professional development increases significantly. I strongly feel each of us is in control of our destiny and how our careers unfold. As one of my longtime mentors told me early in my career, "You are your own best investment. You will only be as good as how much you invest in yourself. It is your responsibility alone, and no one else's, to continue to grow and develop as you strive to achieve success in your career." So, with that, I highly recommend you take advantage of all PCEA has to offer, potentially setting up better opportunities for success.

I continue to wish everyone and their families health and safety. Best of success to all as 2021 progresses.

Next Month

Spring has sprung and PCB engineers are on the move. Companies are hiring, seeking to fulfill the open positions left by those laid off earlier in the year or who have relocated. We'll take a look next month at the hiring scene and how some PCEA engineers are emerging from their cocoons and flying off to new opportunities.

Upcoming Events

Below is a growing list of upcoming events. It is up to every one of us to do the best we can to follow CDC guidelines and take the precautionary measures when possible – including handwashing, masking and vaccination – to squash the spread of Covid-19 and its variants. We're still in this together!

- **Cadence Live**
  June 8-9 | Online | cadence.com

- **Zuken Innovation World 2021**
  Aug. 4-5 | Online | ziw.zukenusa.com

- **PCB West**
  Oct. 5-6 | Santa Clara, CA | pcbwest.com

- **SMTA International**
  Nov. 1-4 | Minneapolis, MN | smta.org/smtai

- **Productronica**
  Nov. 16-19, 2021 | Munich, Germany | productronica.com

- **Del Mar Electronics & Manufacturing Show**
  May 4-5, 2022 | San Diego CA | manufacturing.show/

Spread the word. If you have a significant electronics industry event to announce, please send the details to kelly.dack.pcea@gmail.com, and we will consider adding it to the list. Refer to our column and the PCEA website to stay up to date with upcoming industry events. If you have not yet joined PCEA, visit pce-a.org and find out how to become a member.

Conclusion

Measure twice, cut once is an adage I heard from my seventh-grade wood shop teacher and never forgot. Sometimes we get caught up measuring others' compliance with our standards when we should be calibrating our own work. Collaboration requires action, communication and a consistent set of standards. May we all reach out and understand the challenges of others first, then measure our outputs to compare whether we need to adjust and calibrate our knowledge, workflows and processes to move ahead.

See you next month or sooner! ❑

Meeting On-time Power Requirements All the Time

In PDN design, maintain a low impedance over a range of frequencies, as opposed to just one.

ACHIEVING A ROBUST and functioning power distribution network isn't difficult if we provide both the capacity and responsiveness needed at each device. Previous columns addressed capacity concerns, discussing the need for sufficient copper (or an alternative conductor) between a voltage source and any load depending on it for its supply. Here, we build on those and examine what's required to maintain that network at a steady voltage. This relies on sufficient "energy stores" and the conduction paths needed to deliver charge quickly to any location on the board experiencing "instantaneous demand."

DC vs. AC (aka static vs. transient). Historically, nearly all power conversations pertaining to printed circuit boards have been lumped into two categories, with the terms "power DC" and "power AC" emerging as almost standard terminology. Power DC is understandable as it addresses PDN capacity issues associated with inadequate copper.

Our experience with DC analysis reveals the simulation process, once thought to be complex, is nothing more than the visualization of Ohm's law. With voltage defined in our DC supplies, and current by the operating requirements of each load, we found tools could readily calculate the resistance by extracting the geometry of the conductors. Using these resistance models in conjunction with the current needs of each IC (defined by their electrical specifications), it is easy to predict the DC voltage available in each chip given its distance from the source. This makes the cumulative resistance from the source the determining factor defining the DC performance each IC experienced.

The voltage loss observed during DC analysis is representative of the reductions expected when each device draws a continuous, unchanging current from its power source. This constant current, when drawn through the resistive network of our PCB, produces a voltage potential in the conductive path, reducing the realized value at the IC's power pins. While this is infinitely valuable in establishing a base voltage, it does not completely define the true conditions. This is where power AC can help fill in gaps.

Adding time to the equation. Power AC is not intuitive; it's not actually alternating current under investigation, but rather transient or changing current. While admittedly a much more accurate representation of the situation, it still obscures the true objective. Our goal is no variants at all: steady, unwavering power rails at each voltage, true to the defined level despite varying demand. Ideally, this should be the condition seen by every dependent IC regardless of the distance from the source or the demands of its neighbors.

To be concise, we want no AC, transients, spikes, droops, dips, or deviations, just rock-solid, steady voltage distribution networks capable of maintaining the voltage while responding to the instantaneous current demands of today's high-speed devices. Power AC is all about eliminating voltage changes.

To fully validate the PDN we must look closer at the *actual* current present at the power pins of a load device. What we find is, while there is often a degree of continuous, steady current, there are also bursts of current at varying frequencies. These bursts are the subject of "transient power analysis," often inaccurately referred to as "AC analysis." With the new understanding that current can also vary over time and keeping our objective of "a steady minimum voltage at the load pins" in mind, we must reevaluate Ohm's law.

Ohm's law redux. We describe resistance using its complex definition: impedance. Impedance is simply the combination of resistance (R), which we know from DC analysis, and reactance. Reactance has both an inductive component, which resists changes in current, and a capacitive component, which resists changes in voltage. In combination, they don't reduce the voltage available at the load pins as we saw with DC losses, but rather they act to restrict or impede the responsiveness to the burst demands we described (FIGURE 1). With the effects of reactance altering the timing as opposed to the amplitude of a power signal, we describe this behavior in terms of the effect on a sine wave, essentially advancing or retarding the signal and quantify it using degrees.

It all comes back to impedance. We now understand that to determine the *actual* voltage at the load

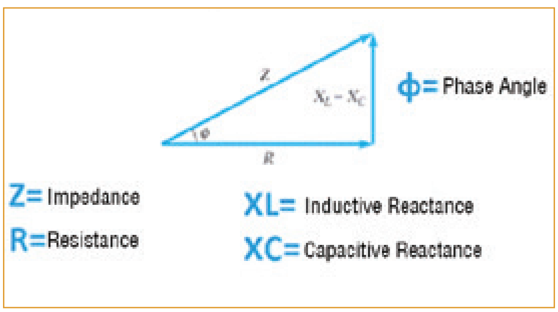

FIGURE 1. The resistance/impedance relationship.

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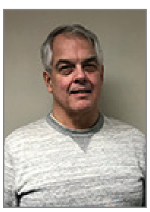

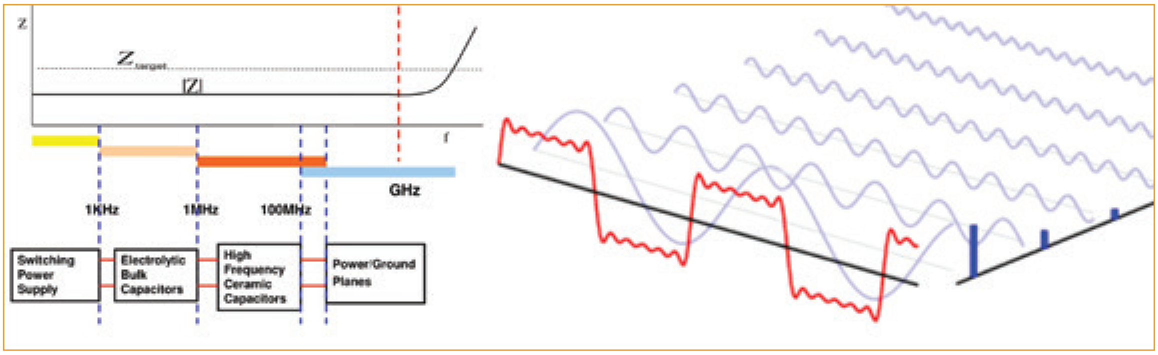

FIGURE 2. Low impedance over a wide frequency range resolves ALL signals.

pins, we must account for losses from both resistance and reactance. Comprised of both an inductive and a capacitive component, both influenced by frequency, we soon find the reactance (and therefore the impedance) changes with the frequency. Initially, this might suggest we would need to determine frequency before the resultant reactance could be known. In practice, however, we approach this a bit differently. With voltage our primary concern, and knowing the loss of voltage results when the current (demanded by the load to operate) flows through the impedance of the PDN, it becomes clear that where impedance stays low, losses stay low. Therefore, our goal in PDN design is to maintain a low impedance over a range of frequencies, as opposed to just one. For example, maintaining an impedance at or below a specific goal (or "target") for all frequencies between 1KHz and 1GHz will guarantee, via Ohm's law, a voltage loss at or below an acceptable loss without concern for the frequency associated with the reactance **(FIGURE 2)**.

This "frequency range" approach has additional benefits. Using the mathematical process of transformation, we can represent any noise on the power plane as a combination of sine waves. Provided each sine wave is within the frequency range for low impedance, the resulting loss from the noise is limited. This essentially defines our design goals for the transient (power AC) aspect of power integrity. Voltage is maintained indirectly by controlling the impedance (frequency-dependent resistance).

Impedance. To some extent the terminology itself is confusing. Transient (AC) power analysis isn't about simulating the time-dependent noise on the power plane at all. Instead, it's about ensuring impedance is controlled. This way, any time-dependent variations in the current pass through a resistance so low it cannot produce a voltage high enough to be concerning. We control variation in the voltage by limiting resistance. Although each device has its own criteria for minimum voltage, as board designers, we determine how much variation we can permit in our supply voltage. Driven by the most demanding devices, acceptable "ripple," or deviation from ideal voltage can be bounded simply by controlling the target impedance **(FIGURE 3)**.

Our ability to meet a design's requirements relies on our ability to control the resistance between a power source and

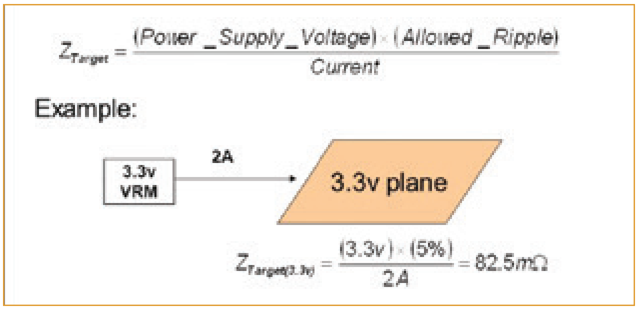

FIGURE 3. Target impedance calculation: satisfy the ripple.

each of its loads. It's partner, inductance, represents the effects of changing current and replaces resistance with impedance in our calculation to include the reactance. The inclusion of reactance makes intuitive sense when we consider the two components from which it is constructed: inductance and capacitance. The goal of any PDN is to provide an adequate current at an unvarying voltage to every load. Therefore, it's not hard to make the connection that a system with greater inductance would be less capable of surging current-to-devices with varying requirements. Likewise, it's not a stretch to see a system with high capacitance would be beneficial because of its resistance to voltage change. While the mechanics of the physics involved is monumentally complex, with current traveling in all directions simultaneously and the signals themselves made from countless sinusoidal building blocks, the design goals are relatively modest. Reduce the resistance to minimize the DC losses and control the reactance by maintaining the impedance below the target over a wide range of frequency. In the real-world setting, where the current required by each device is dynamic (changing with time), the ability for a PDN to perform as intended is controlled exclusively by the systems impedance. Knowing this, the next question becomes how do we use the techniques at our disposal to control it? ☐

The Importance of Logistics and Supply-Chain Management are Still Underestimated

The electronics industry should adopt data-driven planning methods.

FOR MANY COMPANIES, supply-chain management has become a major challenge as the pandemic has continued to disrupt all our lives. As lifestyles have become home-based, for work and leisure, demands have shifted from services to products: materials and tools for lockdown projects, gaming and video equipment, and extra work-from-home IT. There is a global shortage of shipping containers and ships to carry them. As a result, shipping costs have increased sharply. It could take a long time for container costs to return to pre-pandemic levels. Added to that, the spread of the virus has disrupted and depleted workforces, resulting in backlogs and delays.

On top of the misery came the recent blockage of the Suez Canal, adding several days of delay as the backlog was cleared. And, of course, there were domino effects at ports around the world, as cargo was unable to move into or out of the system. The problem has raised questions about the future of super-large container ships and strengthens the argument for using larger numbers of smaller vessels.

Far-flung supply chains, designed to enhance competitiveness and minimize costs, are now under threat and will likely need to change. The world is simply too impatient to wait for things to return to normal. Moreover, there are strong calls for a "new normal" that should, at the very least, strive for environmental sustainability.

Shipping is one of the modern world's most fossil-fuel-intensive activities, and there are strong desires to cut emissions from the heavy diesel fuels that are used. I've written before about moves to introduce hybrid-electric power to shipping. Among other interesting initiatives, the International Windship Association has formed to encourage the adoption of direct wind propulsion systems in commercial shipping. In 2020, the IWA celebrated the fact that the number of wind-assisted ships in operation had reached double figures. That's a small base to build from. I have read that wind-powered shipping has been quite successful in the past, however.

Reshoring is an obvious response to the emerging supply-chain challenges. It's a popular notion for a number of reasons, although I see it as having only limited relevance. Take the PCB industry for example. As board fabrication moved to the Pacific Rim, so too did the supply of essential raw materials. Glass weavers and copper foil suppliers have all but disappeared from Europe. Without that infrastructure nearby, starting up general-purpose PCB fabrication now would be extremely difficult.

Clearly, offshoring is not easily reversed. It moves with the natural progression of economic development. In the same way the West transitioned from the industrial age toward service-oriented economies at the end of the 20th century, the leading Asian economies are now in a similar position. Their rising labor costs appear to support the reshoring argument, particularly when shipping is factored in. More likely the next wave of developing economies will become the new powerful manufacturing destinations.

The European EMS scene offers a different perspective. Labor costs remain relatively low in Central and Eastern Europe, which has permitted EMS businesses to thrive in those locations. The key is they benefit from the large and demanding customer base in Western Europe. Although it's generally too expensive for EMS businesses to be based in the center of their market, distances are short, and communications between customers and suppliers are relatively easy.

I touched on these issues recently in a presentation to the EIPC, in which I described the structural changes in the European PCB industry supply base and the dramatic shift in PCB shipments over the past 20 years. I highlighted the need to tackle the long traveling distances for products and materials among several suggestions aiming to help mitigate supply-chain risks in the future. I also believe the industry can improve logistics management and communications, as well as extend understanding of the supply chain and building in resilience. The key role of logistics in a maturing or commoditized business is still underappreciated. In addition, a lack of robust demand data is preventing suppliers and customers from coordinating their activities. Companies can greatly improve on-time delivery performance in end-user markets by trusting each other enough to share ERP data that lets suppliers understand exactly where materials need to be at any time.

Supply chains will continue to experience pain for at least the foreseeable future. The way forward undoubtedly lies in working smarter, strengthening trust among partners, and building our understanding of the entire supply chain, in particular, studying the vulnerabilities to unusual events such as the Suez Canal blockage and ensuring contingencies such as alternative routes. On the other hand, the effects of a crisis such as the global pandemic are extremely difficult for anyone to anticipate or plan for. A move to more intensively data-driven supply-chain planning, with routine stress testing leveraging the experiences of the past 12 months, could both be aspects of the new normal for our industry. ❑

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HDP User Group International

Webinar

June 23, 2021
9:00 am CDT

Key High-Density Design Considerations for High-Reliability 5G Radio Access Network (RAN)

The advent of 5G promises gigabit per second mobile network access using large deployments of small cells and traditional towers. The use of millimeter wave spectrum bands and massive MIMO (multiple input, multiple output) introduce new product packaging challenges.

As operators seek to optimize performance versus total cost of ownership by deploying virtualized radio access networks (RAN), including the adoption of OpenRAN, a close examination of product design considerations is warranted.

This webinar addresses the challenges posed by the 5G network evolution and key printed circuit assembly design considerations for high-density, high-reliability radio units. This includes RAN deployment and support challenges, and product design considerations.

Speakers
Charlie Martin, RAN Product Management, Dell Technologies
Madan Jagernauth, Marketing Director, High Density Packaging User Group

REGISTER HERE

https://www.hdpusergroup.org/event/key-high-density-design-considerations-for-high-reliability-5g-radio-access-network-ran-webinar/

BGA Rules for Rigid-Flex PCBs

Strategies for vias and routing.

IT SEEMS EVERY new design has at least one BGA component on the board. The 1.0mm pitch BGA has become vanilla. Even the 0.8mm pitch BGA is commonplace. These components are not limited to rigid PCBs; BGAs of all shapes and sizes are implemented in flex and rigid-flex designs as well.

The rules for BGAs are much the same whether the board is rigid or rigid-flex. Due to some of the material differences in a rigid-flex, however, extra care is recommended when it comes to the artwork and the trace routing in the BGA field.

Let's start with pad and via design. For microvias, many suppliers recommend staying at or above 0.005" diameter vias for reliability reasons. Much experience tells us vias smaller than 0.005" tend to have a much lower mean time between failure (MTBF) than vias at or greater than 0.005". In more benign applications, smaller vias may be an option. If the product will experience temperature extremes, however, the conservative bet is to stay above 0.005" diameter microvias. Depending on the design and manufacturer, the associated pads may range from 0.010" to 0.012". Smaller pads risk a via sliding off the edge of the pad. If it does, the risk is the laser may cut through the dielectric and down to the next copper layer.

When using buried and through vias, manufacturers need more room to work on rigid-flex. Pad sizes for drilled vias are typically 0.012" to 0.020" larger, depending on laminating cycles, layer count and annular ring requirements. This is an area where consulting with your manufacturer early can be critical. Certain strategies can help reduce both the via and pad sizes. This will be key to routing the BGA.

Given the additional layer registration challenges on rigid-flex, fanouts and trace spacing can be more critical. As noted, 0.8mm and 1.0mm BGAs are well-established, and routing fanouts is straightforward. As we move to 0.65mm and smaller, down to 0.3mm, however, routing the artwork takes more care.

Things to consider:

- Most fanout layers may be plated layers and thicker than the base copper; thus, resolving tight spaces is a bigger challenge.
- Copper-filled vias and capped vias can drive extra copper plating, adding etch difficulty.
- Staggered vias may permit thinner copper plating, making etching easier.
- In some cases, reducing pad size and therefore annular ring may be preferred to gain spacing from pad to trace.
- An inverted pyramid routing technique is often used for 0.5mm and smaller BGAs.
- Routing traces between pads is rarely done for 0.4mm or smaller BGAs.

The smallest pitch/highest pin count BGA on a board will be the primary driver of the board construction. The 0.4mm and smaller BGAs eliminate many options, as the ways to design these are few. Essentially, the array pattern of the BGA will dictate the number of layers. No traces will run between pads. The inverted pyramid technique is used to work layer by layer and row by row to fan out all the BGA pads. For example, a 12 x 11 array 0.4mm BGA will require six layers to pin out every ball (FIGURE 1). There currently is no other way around this.

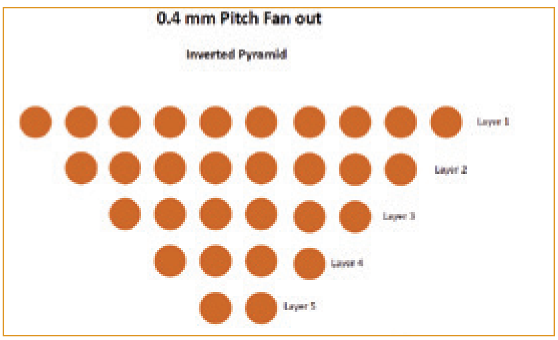


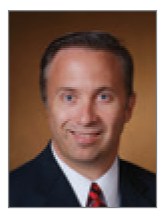
FIGURE 1. An inverted pyramid technique used to fan out BGA pads.

Strangely, an area where designers get into trouble is when working with the larger BGA patterns. Because there is more room, it is more common to see traces routed between pads in the BGA field. This can be fine, provided attention is paid to details. Here are some situations where trouble can occur.

Traces are autorouted, and no extra work is done to truly center traces. The result is traces are often off-center, with minimum pad-to-trace spacing on one side and more spacing on the other. For example, you might see 0.0035" space on one side and 0.0055" on the other. If centered, we could have 0.0045" on both sides. This is a huge improvement, making etching much easier overall. For every design, the tightest spacing on each layer will define how it gets etched.

continued on pg. 29

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.



4 Areas for CONTROLLING EMC in PCB Design

EMC for PCB design is anything but black magic.

by RALF BRÜNING

Electromagnetic compatibility (EMC) problems are often responsible for redesign cycles during the PCB design process, but once engineers and designers understand the basics, they see there's nothing mystical about it.

EMC is the branch of electrical engineering and physics that deals with the unintentional generation, propagation and reception of electromagnetic waves (in the E and H fields). These can cause undesirable effects in electronic devices, including functional interferences, malfunctions, or even physical damage.

Generally, two fundamental aspects are considered. First, the emission referring to the unwanted generation of electromagnetic energy and its transmission to the sinks, along with the necessary countermeasures to reduce such emission. Second, the respective susceptibility to interference relating to the operation of electrical/electronic equipment (or components) that become "victims" of unintended electromagnetic interference (EMI).

To simplify, EMC is the ability of electronic systems to function in a common electromagnetic environment without interfering with or being affected by other systems.

Know the potential EMI sources. On a PCB, various potential sources of interference can cause a variety of possible effects:

- Signal and power integrity (conducted emission).
- Radiated emission.
- Immunity to radiated and conducted emissions.
- Electrostatic discharge (ESD).

Often unnoticed by PCB designers, the ribbon cable on a PCB connector, for example, physically forms the arm of a dipole and thus creates a parasitic antenna. In this case, current and voltage peaks occurring during the switching process of the active components in the power supply can lead to an excitation of this parasitic antenna. This activity can result in an increased radiation pattern.

In addition, the signal shapes in digital signaling are, in theory, ideal rectangles. In reality, they don't exist in such a form. Instead, the signals are created by adding various sine waves containing high-frequency content. These signals are more or less distorted and disturbed while traveling from driver to receivers. The resulting voltage peaks of the reflections and crosstalk will also have a negative effect on the EMC behavior.

Integrating EMC-compliant design into product development. EMC-compliant design is crucial to the success of a product. Products gain approval for customer deployment only by complying with EMC regulations of the specific target market or application (for example, the medical or automotive industry). Problems often only arise during the prototype testing phase, however, often due to a lack of properly integrated EMC verification procedures in the design process.

Several options exist for managing EMC in the design process and detecting problems at an earlier stage. The first step is the systematic definition and use of design constraint processes, especially for signal and power integrity issues.

Tool-supported EMC design reviews ensure adherence to relevant EMC guidelines. Rules in some tools can also be prioritized on a per-user or per-design basis. The circuit designer can classify EMC-relevant signals for such checks early on during the schematic design process. The selected EMC rules suitable for an application are then applied during the PCB design phase.

Direct integration into the CAD process (2-D and 3-D) and automatic generation of reports in the form of DRC checks – familiar to any PCB design engineer – simplify the workflow. These reports should contain images, progress status, or approval information. This information can also be stored in the design data for the joint work on EMC aspects during design.

The rules implemented will contain recommendations for various design issues that enable non-experts to solve signal integrity, power integrity, and electromagnetic compatibility problems. No additional software is necessary to validate the identified potential EMC issues.

For an EMC-compliant PCB design, it is essential to consider the following four areas:

1. **Identify and evaluate parasitic antennas.** Work out where parasitic antennas could form on the PCB. Parasitic antennas are developing electrical or magnetic monopole or dipole structures.
2. **Recognize and account for the current return paths.** An electric current inevitably returns to its source. Therefore, visualizing the return paths and the return loops is critical. Depending on the application, the returning current runs along either the path with the lowest impedance or the path with the lowest resistance. To select a correct return path, do not wire lines across slots if possible, not even in differential pairs.
3. **Understanding various coupling effects**. Coupling paths between the source and the sinks can occur depending on parasitic voltages, parasitic currents, or they june be IO-related. In many cases, their root causes are not immediately recognizable in the layout.
4. **Understanding resonances as potential antennas.** Almost all electrical structures can become resonant. This includes single lines and differential signals, power supply structures, cables, packages, and even vias. Fortunately, it is easy to calculate the resonance frequency for many structures using this formula: $f_{res}=1/(2\pi\sqrt{L \cdot C})$. However, knowledge of the values for the (parasitic) inductances (L) and capacitances (C) is not quite so easy to obtain and often requires complex analysis. Also, it is not possible to completely erase resonances. Know and understand the effect, and avoid excitation where possible.

When it comes down to it, achieving EMC compliance in PCB designs isn't all that difficult. Understand EMC and how and why it can affect the board designs. Then learn how to manage it. □

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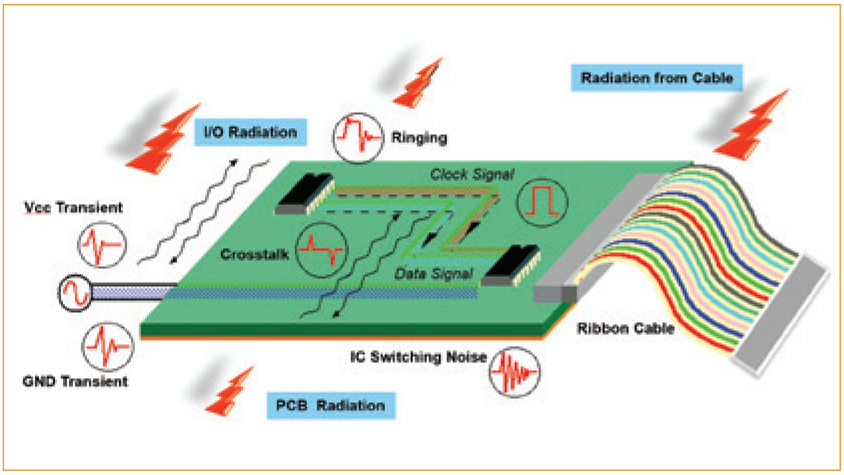

FIGURE 1. Potential noise sources on a PCB.

Flexperts, continued from pg. 27

An additional issue with lack of centering happens on external layers. Traces routed closer to pads on one side have a much higher risk of exposure by openings in the solder mask. This creates risk for an assembly short. Long story short, this is an unforced error that is easy to avoid with a little extra time at layout. It will be time well spent, resulting in higher yields and lower unit pricing over time.

Another issue arises when length-matching differential pairs. Often this can lead to routing serpentines within the BGA field. Keep the serpentine meandering outside the BGA pattern. This avoids tighter-than-needed spacing in an area where space already is at a premium. Also, it is normal to bring pairs into their pads, maintaining designed spacing as long as possible. This can cause one of the two traces in a pair to loop around a pad, rather than more efficiently route into its targeted pad, again consuming precious spacing.

Finally, there is the diagonal route through a BGA pattern. This creates many tight pad-to-trace intersections that could be avoided by finding another path. In general, the shortest path to reach a BGA pad is the best one.

In the end, we are looking for ways to optimize the design. With smaller and smaller BGA patterns, the challenges become more substantial for the designer. Thinking in microns or tenths of mils can make a difference. Optimizing artwork patterns and avoiding unnecessary difficult etch features can lead to a big payoff. □

WHAT IS BLOCKCHAIN, and How Can It Solve Problems for Electronics Manufacturers?

Solving "track and trace" problems, even in reverse.

by QUENTIN B. SAMELSON

To get a sense for how blockchain can address issues in the electronics industry, it may help to start with a story about an earlier technology. A young electrical engineer in 1980 had a job interview with an industry veteran who asked if he had ever heard of a thing called a "vacuum tube." The young engineer admitted his semiconductor class had included a one-hour lecture demonstrating how field-effect transistors worked like vacuum tubes.

"When I was in college, they made us take a semester of tube theory because they thought it might be useful some day!" the veteran exclaimed. His outburst highlighted a common theme in emerging technology. More than 50 years later, it was easy for the next generation of engineers to see the number of new products enabled by vacuum tubes, even though by that time solid-state devices had already largely replaced them. But during the 1920s, when vacuum tubes represented the latest innovation in technology, it was difficult to see they would lead to radar, FM stereo, television, and rock concerts. In the same way, it's doubtful the creators of the internet anticipated using it to watch videos, hail rides, or monitor a newborn baby in the crib. Even those of us lucky enough to apply the latest advancements in technology are unlikely to foresee all the ways new technology will be applied.

Many believe blockchain will have a similar impact, although – since it addresses a somewhat more specific problem set than, say, the internet or semiconductors – it may be a little easier to identify its future applications. But, like all major advances, it has already begun to be used in areas no one could have predicted just half a decade ago. Electronics companies are already using blockchain to solve a variety of problems. In some cases, blockchain provides a far more elegant solution than previous methods. In other cases, blockchain presents the only practical way to solve a particular problem.

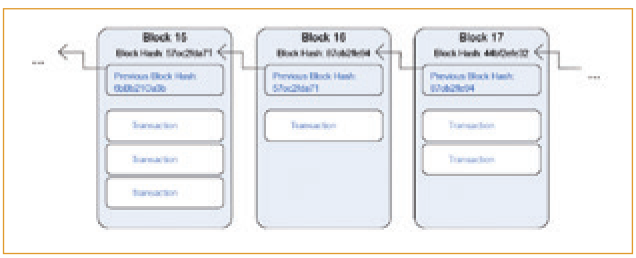

FIGURE 1. Each block's hash code is based on key transaction details, including the date and time stamp and the hash code from the previous transaction.

So, what *is* blockchain?

Blockchain is a "shared, secure ledger that creates a permanent record of transactions." That's a lot to unpack, so it's helpful to parse it out piece by piece.

First, blockchain uses a ledger. A ledger is simply a record of transactions, generally with a set of rules for how those transactions are recorded. A "shared, secure ledger" is, therefore, a record of transactions that is shared between at least two different parties, but is secure from unauthorized access and tampering. Almost all of us have experience with "shared, secure ledgers"; our bank accounts and credit card records are ledgers that are shared between us and those parties with whom we have decided to do business, but not with other parties.

Blockchain adds a critical additional feature: a truly permanent record of the transactions entered onto the ledger. Usually called blockchain "immutability," this feature is important because it ensures all parties that have access to a particular record can view the transactions that led up to it, including mistakes and corrections when those occur. That is often a necessary precondition for ensuring trust between two or more parties (consider the difference between being told something will cost $5,000, and receiving an itemized breakdown of *why* it will cost $5,000).

Blockchain gets its name from the "blocks" of data that are chained together in a unique way.[1] The chain is constructed using one-way hash codes, complex alphanumeric codes constructed from the data in the previous block **(FIGURE 1)**. Each new block includes the hash code from the previous block. It's easy to verify the hash codes, but almost impossible to deconstruct them, and it's easy to determine if a hash code is missing (i.e., if there is a break in the chain). So, the blockchain is essentially "immutable"; it cannot be changed after the fact.

Using Blockchain

Blockchain is extremely helpful at simplifying complex, multi-party, "high-friction" processes. Generally, blockchain is a superior technology when:

- the process involves an exchange of assets of some kind (often a product of some sort, but occasionally also information);
- the process involves more than one party (usually, this means more than one company, but some companies have different legal entities or business units that operate so independently, they function as separate parties);
- the process involves a number of manual, time-consuming steps (often due to a need for verification, to capture different information at different steps of the process, or due to potentially differing viewpoints or standards, missing information, etc.).

Another way to understand how blockchain improves processes is to look at how information is exchanged between parties in a multi-party process **(FIGURE 2)**. Those processes almost always rely on multiple, coordinated, two-way exchanges of information, where it's easy for discrepancies to creep into those exchanges, requiring audits, rework, and extra labor. With blockchain, however, all parties participate in the same transaction. Different parties may have different permissions, so Party D, for instance, can't view data that are proprietary to parties A and B.

Problems ideal for blockchain generally have another characteristic as well, one that should be obvious but often isn't: At least one party has to have a good idea of what the current dysfunctional process is costing them.

Let me use an example. Blockchain particularly excels at "track and trace" applications – processes that manage and verify the provenance of parts. Some companies may find they invest a great deal of time, resources and money verifying the source of components they use to build products, especially if those products are built by an outside assembler. Other companies may find their expenses are in the reverse supply chain – verifying the products coming back to them under warranty are, in fact, the original products they sold.[2]

Blockchain-based provenance applications have been developed and broadly implemented in a number of industries where being able to verify the precise source of supplied items is crucial, especially in the food processing industry. In electronics, we are beginning to see it in the reverse supply chain.

Electronics firms may also find blockchain is the best technology to use to enable a buy/sell process with component suppliers and EMS providers. Manufacturing operations may discover blockchain to be the most effective way to issue Kanban, or pull signals, to remote suppliers. And electronics companies that focus on installing equipment at customer sites (such as network hubs, data centers, weather monitoring installations, etc.), and therefore frequently must find reliable external contractors, can use a blockchain-based "trusted supplier" application.

The key to all these applications is the companies involved were able to recognize their current multiparty processes were time-consuming, resource-intense, and therefore costly. By enabling all parties to participate in the same transaction, blockchain offered a way to automate those processes in a way that would simplify them tremendously. More on that next month. ❑

ENDNOTES

1. Want to explore the key concepts behind blockchain in more detail? IBM offers a free downloadable book called *Blockchain for Dummies,* available at ibm.com/blockchain/what-is-blockchain (with other resources). You can also find a host of videos online that explain the basics of the technology or particular applications.
2. Additional information on supply chain applications for blockchain, including a Forrester research study, is available at ibm.com/blockchain/industries/supply-chain.

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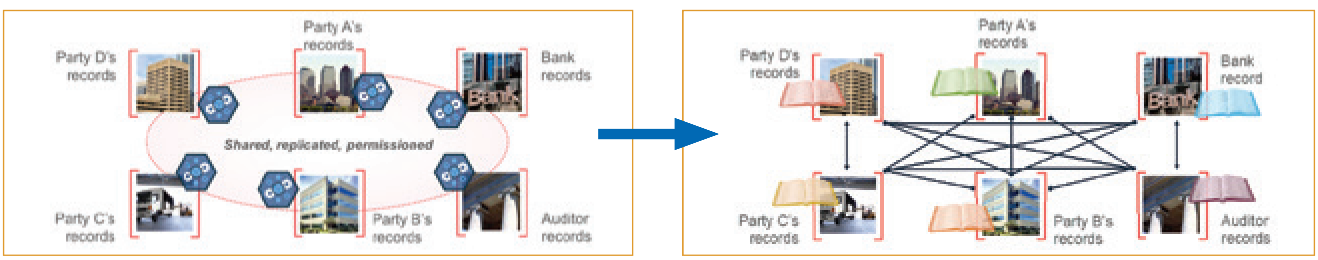
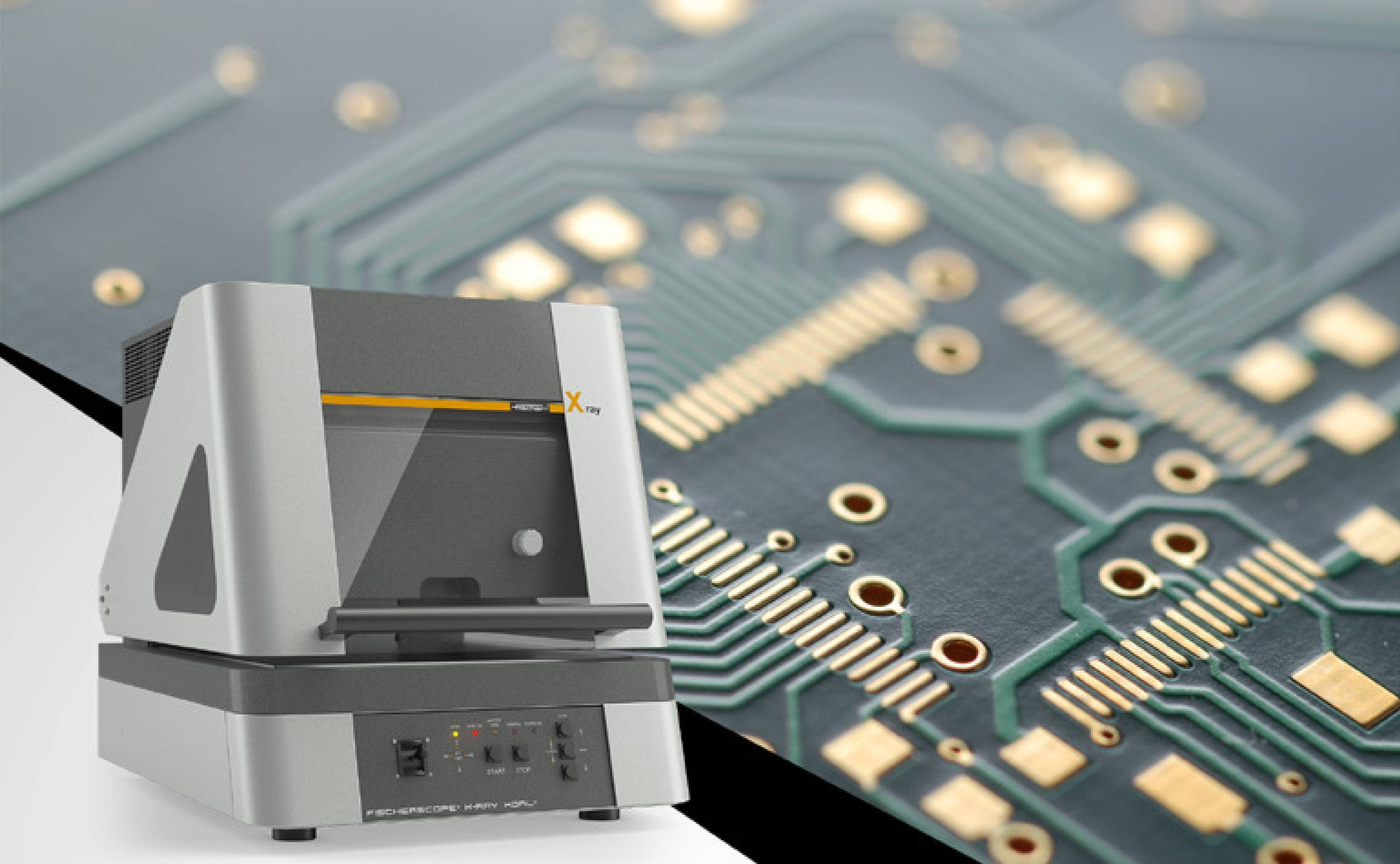


FIGURE 2. Before and after: On the left, a traditional multiparty process consists of multiple two-way exchanges; on the right, the blockchain process permits all parties to access (portions of) the same transaction data.



4 Suggestions for Overcoming the IC INVENTORY CRISIS

As lead times recall the Y2K fiasco, EMS firms and OEMs must share the risks. **by JOE FAMA**

The ongoing IC lead-time crisis is pushing the margins of EMS companies and leaving their OEM customers scrambling. As of this writing, production scheduling under the conditions of withering lead times calls for unprecedented measures riddled with hunches and diminishing hope for acceptable recoveries. For now, production planning is all over the map, with EMS companies working closely with their customers to get through this period without major damage to OEMs' brands and customer loyalty.

Today, lead times for ICs are snowballing up to 25 weeks on average, with some of the harder-to-source components such as tantalum capacitors hitting the 40-week mark **(FIGURE 1)**. TSMC, one of the largest IC manufacturers in the industry, forecasts the global shortages of semiconductors could linger into next year.[1] The ringing note stamped on all lead-time quotes is "subject to change," and in many cases lead times are downgraded to "TBD," leaving manufacturers spinning for short-term solutions.

Lead times are not the only parameter exceeding normalcy. Today, unit pricing increases are the trailing edge of lead-time impacts. We see unit prices quoted in three phases: 1. Quote based on RFQ; 2. New unit price at issue of purchase order; 3. Updated unit price before shipment.

Yes, the practice of IC quotes is subject to a three-step function, with the law of supply-and-demand compounding each step. Unit pricing increases are as much as four or five times the average price established only 12 month ago.

TANTALUM			
Family	Lead Time (weeks)	Family	Lead Time (weeks)
TANTALUM			
(A) 1206 POLYMER	30	(B) 1210 POLYMER	24
(C)2312 POLYMER	37	(D) 2917 POLYMER	33
(E)2917/2924 POLYMER	34	0402 TO 0805 POLYMER	19
CONFORMAL	20	CONFORMAL COTS	24
DIPPED	18	FUSED	32
HIGH TEMP	29	LOW PROFILE/LOW ESR	25
METAL AXIAL	16	MOLD CHIP A-CASE	37
MOLD CHIP B-CASE	41	MOLD CHIP C-CASE	34
MOLD CHIP D-CASE	32	MOLD CHIP E/X CASE	32
MOLD LOW ESR A-CASE	36	MOLD LOW ESR B-CASE	39
MOLD LOW ESR C-CASE	33	MOLD LOW ESR D-CASE	33
MOLD LOW ESR E/X	31	MOLDED AXIAL	16
MOLDED COTS	27	MOLDED RADIAL	24
MULTI-ANODE	26	POLYMER COTS	22
SUPER-TANTALUM	16	WETS	15

FIGURE 1. Component distributor TTI's list of various capacitors shows how lead-times are growing. (Source: TTI)

With lead times and unit pricing ballooning, industry experts are seeking to identify the cause of the market disruption, as well as the need to determine a timely path to regain control of material acquisition.

When lead-time disruptions were first noted, industry watchdogs generally settled on a set of logical causes, with supply-and-demand principles hovering over the adjustments to unit pricing:

- During the Covid-19 period, IC manufacturing output was drastically reduced. The return to normal rates has taken months to recover.
- Projections of the oncoming Covid-19 vaccination approval around the third quarter 2020 and the subsequent rollout provided good news, priming the economic outlook and releasing pent-up product demand, causing production orders to spike.
- Demand for ICs increased as retailers also jumped on reordering to fulfill pipeline inventory.
- China's middle class is flexing its financial muscle, and its size – 300 million people – is almost the same as the total population of the US.
- The annual pre-holiday order spike was unaffected by the pandemic, adding to the surge.
- Before the Christmas bump ends, OEMs prepare for the Chinese New Year shutdown, adding production orders to cover up to four weeks of manufacturing stoppage in the February/March timeframe.

These explanations

have come from seasonal trends, along with recent reports tied to the Covid-19 period. Although the historical cyclicality says industry should be back to normal, on the ground companies are experiencing a chaotic market with no indications the worst of the IC shortages is over.

Why Lead Times Continue to Inflate

As market conditions go from bad to worse, divining the supply picture gets trickier. New causes for slowdowns are being reported, including:

- Short supplies of raw materials required for IC manufacturing due to extensive consumption, as well as lingering impacts of conflict minerals.
- China's OEMs are building inventories as the relationship between China and the US deteriorates. Chinese foundries may be siphoning off ICs to prioritize China's own internal IC usage.
- Worldwide Covid isolation lifestyles created unanticipated (high) demand for new PCs, laptops and home office equipment, not to mention gaming and gaming peripherals, causing huge demand for ICs and other electronic devices.
- As lead times grew, panic buying hit the market. Purchasing now engages in bidding wars as distributors hold inventory for the highest offer.

We can conclude the continued increase of lead-time problems has a multitude of causes, with some influencing the market more than others. One of my sources on market conditions is CCT, a display foundry and modular assembly manufacturer based in Kuala Lumpur. Eric Chan, COO, has taken on the day-to-day hunt for ICs. He states, "There are many causes for lead time increases, and the feedback depends on who you ask and where they are located."

Chan believes the lead-time crisis will continue to worsen due to investment speculation and greed. "In Asia, there is much talk of a few well-funded individuals who are buying and holding product in mass quantities, creating heightened street pricing for popular IC part numbers. For the right price, any IC is available to desperate buyers, and many buyers are searching the supply chain for immediate inventory." Chan is one of perhaps thousands of senior executives now being utilized as IC hunters seeking short-term solutions to the lead-time problem.

Impact on OEMs

OEMs that have seasonal products with annual production schedules to hit retailers' shelves are finding themselves in dire situations. Missed shipments to retailers means lost sales revenue, and this can damage the brand. Late deliveries might not just hit OEMs' topline revenues but could also cost them their investment in premium shelf space positioning at national and international retailers. Today, many OEMs are weighing the choice of paying higher unit prices for ICs or turning to gray market venues where counterfeit components are openly sold as authentic.

Regarding the size of the EMS or OEM, meeting production scheduling is no longer a given. Thus, the collision of desperate IC hunters has created a heterodyne of a bidding war among the contestants, a perfect world for resellers who take advantage of such market conditions. Panic buying has pushed out lead times of some hard-to-find parts well into nine to 12 months. Even with this advance purchasing strategy, no IC SKU is likely to maintain its normal market unit price.

Minimizing Supply-Chain Disruptions

The value relationship between an EMS and OEM must be levered to new heights to create acceptable outcomes for the OEM. Throw out any procedures in place for forecasts, material acquisition and JIT requirements. To start, managing IC procurement and scheduling, with its expectations that EMSs procure components and take liability for long lead-time items, must change. Following this, increased costs of ICs must be handled separately and not in unison with customary "cost plus" pricing models. In essence, the EMS's acquisition role, as well as unit price derivations, must be openly addressed. Here are some suggestions to coordinate a best outcome:

1. The strategy of managing lead times must be a cooperative endeavor between the EMS and OEM. The EMS is to execute normal advanced purchases of ICs covering the usual forecast range of three to four months. For extended lead times, the OEM must share the financial burden of advanced purchasing, along with any risks associated with program cancellation, slowdown of production scheduling, design changes and/or unfavorable financial conditions of the OEM. Thus, the EMS is to be absolved from material risks, while the OEM bears liability of any extended lead-time advance purchases from five to 12 months, or more as we see today. This is a good balance of risk/reward with the OEM taking liability for extended advance purchases.
2. Beyond the lead-time issues, IC unit pricing and other bill-of-materials components are on a steady rise. To avoid a "runaway" EMS assembly unit price, EMSs are advised to put their "partnership" mantra in super high gear. To do so, EMSs are advised to separate added price hikes from normal unit prices that existed pre-lead-time crisis. To do this, the newfound IC, along with any BoM price-adders, is tacked on to the normal assembly unit price with no added overhead or profit margin burden to the bottom line. Here the EMS is conceding extra profit because the overall IC and BoM costs are not subject to internal burden and profit margins.
3. For OEMs that desire to remain in full control of the IC progression, a consignment model is suggested whereby the OEM directly purchases ICs, permitting more visibility and flexibility of IC delegation if a second-source EMS is employed or will be employed in due time.
4. In general practice, an OEM should trail its EMS's suppliers to fully understand the greater supply chain. In this case, the IC suppliers need close monitoring. Working closely with their EMS, OEMs may create solutions with the knowledge of IC situations where lead times and pricing are unpredictable and reaching untenable conditions.

How Long Will the Lead-Time Crisis Last?

No one knows when the IC market will return to normal.

Some are turning to history to shed light on what may be in store for the electronics industry. Tom Sharpe, founder and vice president of SMT Corp., an expert and global evangelist in counterfeit mitigation, compares cause-and-effects of past eras to help understand where disruption in today's market is likely headed.

"The IC lead-time crisis of today has some parallels to what happened during the Y2K fiasco – specifically a strong economy and vibrant stock market. At that time, there was an overly hyped panic based on ICs in fielded products suspect of not having Y2K compatibility. Many OEMs attempted to replace fielded motherboards or full turnkey products having to do with high-rel applications in the medical, aviation, financial, transportation and aerospace industries, to name a few. Previously programmed ICs in WiP or OEM inventories were scrutinized for possible reprogramming or replacement to ensure proper operation at the Y2K turn. Manufacturing and sales of PCs and cellphones were at a historic high. The dot-com boom was nearing its apex, and technology-based stocks were on fire.

"Like we see today, EMS suppliers were severely backlogged, leading to extreme price increases for ICs and other materials."

With that in mind, Sharpe shared his view of when the inventory crunch may return to normalcy. "The Y2K movement started roughly in mid-1999 and ended shortly after Q1 2001." That said, while it took two years to cycle through the Y2K lead-time crisis, he feels that timeline isn't necessarily a proxy for today's situation.

"We cannot use the contributing factors of the Y2K shortage to predict how long today's lead-time crisis will exist, since the dynamics causing the current shortages are very different in nature. And now, China is a significant player in the supply of ICs, which includes the emergence and proliferation of counterfeit ICs invading the global supply chain."[2]

The Counterfeit Industry's Dream

While discussing the subject of the IC market with Sharpe, I took the opportunity to gather updates on the status of counterfeits. The feedback is depressing, albeit unsurprising. "Unfortunately, these market conditions are exactly what the clone manufacturers pray for," Sharpe asserted. "It is logical to see the spike of counterfeit demand when OEMs have little choice other than to turn to the open market to complete their BoMs within reasonable timeframes."

The US government is increasingly worried about its dependency on China, as well as other Southeast Asian nations, Sharpe also noted. *Roll Call,* a periodical newsletter covering Defense Department subject matters, reports China now supplies over 13% of the US Defense Department's semiconductor needs.[3]

"With China's counterfeit network growing in size and capability, our national security is truly in jeopardy, since some of the newly minted counterfeit clones are capable of high performance," Sharpe notes, adding that clones remain untested at extreme temperatures for long periods of time. "The clone-produced ICs remain a question mark insofar as long-term reliability." He reiterated a fear of the clone's ability to conceal embedded spyware, a nefarious threat to national security.

The electronics industry is hanging upside down. Capacity cannot keep up with demand, and IC unit pricing is increasing steadily. The complexity of the global market obscures the eventual end to this lead-time crisis. And on top of this matrix of uncertainty is the human emotion, whereby global panic buying amplifies IC demand beyond any realm of predictability. It is too early to determine when the electronics market will settle down. Until such time when the market resets itself to some form of normality, the EMS and OEM must synchronize, creating unprecedented cooperation to combat the unfolding catastrophe. ❑

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How M&A and India Will Reshape the ELECTRONICS MANUFACTURING Landscape

Covid grabbed all the headlines in 2020, but other longer-term stories began to emerge. by **MIKE BUETOW**

For most, 2020 can be summed in one term, and that term is Covid-19, of course. The pandemic disrupted supply lines, shut down factories around the world, and pushed many companies to the brink of financial collapse, to say nothing of the extraordinary and tragic loss of life.

Covid affected everything, but the rebound was sharp and quick. Manufacturers reconfigured assembly lines to tool up for medical devices like ventilators and face masks. The financial hit from the viral tsunami that erupted from China, which undertook a nationwide shutdown in February 2020, and rippled throughout Europe and North America in the following months, led to ugly June quarters for most. Certain industries, such as commercial aerospace, have yet to recover. Yet by the fourth quarter most markets had returned to life, and balance sheets were for many firms not only looking better sequentially, but even year-over-year.

Still, logistics curtailed some potential growth, and shipping was delayed due to a variety of reasons, including customs delays and lack of personnel throughout the supply chain. Most significant, component availability reared its ugly head.

Some 69% of EMS companies in Europe saw revenues decline in 2020, says market research firm In4ma, based on an analysis of 191 EMS companies.[1] Europe was hit hard thanks to slumps in its core automotive and industrial sectors, adds in4Ma CEO Dieter Weiss. Industrial electronics fell $330 million and auto electronics were down another $243 million, offset in part by a $158 million increase in medtech.

All in all, it was a year as dramatic as any in memory.

While Covid's ills were felt all over, the largest players seemed almost immune. Four of the top five companies in this year's CIRCUITS ASSEMBLY Top 50 reported higher revenues for calendar 2020, as did seven of the top nine. (No. 10 TPV was taken private in 2019 and its revenues are estimated.) All in all, however, only about 40% of this year's ranked companies saw sales climb.

As a truly historic event, the pandemic gobbled up all the headlines last year. In doing so, it overshadowed two emerging stories that will likely have much longer-term effects on the electronics manufacturing services industry.

One was manufacturer migration or, more accurately, expansion. China shows no signs of ceding control over production assembly, but three countries are staking claim to a bigger piece of the ever-growing pie. In order, those are India, Mexico and Vietnam.

The New China(s)

Indeed, supply chains are becoming more distributed, but not necessarily to the West. India is trying to scale into a manufacturing powerhouse. If our predictions are correct, it will surpass Europe as the third-largest market for EMS by 2030, behind China and North America. The domestic government is intent on growing both the indigenous and expatriate business, and Dixon Technologies this year becomes the first homegrown Indian EMS company to make the CIRCUITS ASSEMBLY Top 50 **(TABLE 1)**. If past is prologue, others won't be far behind. Just look how Taiwan and China, other nations with a top-down focus on advanced electronics manufacturing, are making their mark today versus 2007, when there were nine companies from those countries in the *Electronics Business* top 50 rankings.

In philosophy and approach, India is looking more and more like China circa the 1990s. At the top is its Make in India policy, a government-driven policy designed to encourage investment and build world-class manufacturing infrastructure in the country. The stated goals of the program, now nearly a decade old, include a manufacturing sector growth rate of 12 to 14% per year.

It's already paying off in certain sectors. The number of mobile phone manufacturing companies rose from two in 2014 to 268 by 2019, and the share of phones built in the country for domestic consumption is now 95%.[2]

A similar tact is being taken with IT hardware. Under the Production Linked Incentive (PLI) for Large Scale Electronics Manufacturing, introduced in March, India offers incentives of 1% to 4% on incremental sales (over base year) of goods manufactured domestically, to eligible companies for a period of five years.[3] In short, companies building tablets, laptops, PCs and servers agree to invest predetermined amounts in manufacturing plants. India, in turn, pays cash back to those manufacturers. To date, MNCs like Foxconn, Wistron and Dell have signed on, as have local EMS firms, including Dixon Technologies, VVDN Technologies and Syrma Technologies,[4] while Flex (no. 7), Inventec (no. 8) and others are circling.[5]

India's homegrown EMS market remains nascent, but for the first time a local company is ranked in the CIRCUITS ASSEMBLY Top 50. Buoyed by the consumer (key customers include Samsung and Nokia) and industrial markets, Dixon checks in at no. 37. With 14 factories directly or through its Padget Electronics subsidiary in the country so far, and another announced for South India, it shows no signs of slowing. Most of the significant players in the nation remain expats (Foxconn, Jabil, Wistron, etc.), but domestic powerhouses such as VVDN are beginning to crack into EMS, and could well reshape the landscape in coming years.

The PLI is emblematic of the maneuvers governments are making to attract foreign investment and boost domestic manufacturing. Using a mix of tax credits, direct cash payments, or tariffs, governments are transforming the *laissez faire* approach favored under World Trade Organization rules. Expect this to continue to reshape the EMS landscape long after Covid has receded.

Not all countries will benefit from this newfound activism. Mexico looks to be a winner under the new United States-Mexico-Canada Agreement (USMCA) trade pact. (As background, some 23% of US exports go to Canada and Mexico, while Mexico sends more than 70% of its exports north, a figure that could increase as the US tries to cut the cord with China.[6])

Still, a rising tide doesn't always lift all boats. While Foxconn (no. 1) and Pegatron (no. 2) contemplate expanding south of the border, UMC Electronics (no. 24) is shuttering operations there, saying the automotive demand never materialized as expected.

Vietnam is trending as an alternative to China. Foxconn says it will invest $700 million in the Southeast Asian nation, and Pegatron, Compal (no. 3), Universal Scientific Industrial (no. 11), Sumitronics (no. 28), Valuetronics (unranked at $300 million in sales), Wong's International Holdings ($406 million), DBG / Huizhou Daya Bay Guanghong Electronics ($354 million), and Suga Technology ($180 million) are among the larger EMS firms adding factories there.

"The world factory no longer exists," Foxconn chairman Liu Young-way said last August. Reuters reported Liu said about 30% of the company's products were now made outside China,

TABLE 1. The CIRCUITS ASSEMBLY Top 50 EMS Companies, 2020

Rank	Company	Nationality	2020 Revenues (US$M)	URL	Notes
1	Foxconn Electronics[1,2]	Taiwan	$160,010	foxconn.com	Electric vehicles next
2	Pegatron[1]	Taiwan	$50,046	pegatroncorp.com	Selling assets to Luxshare
3	Compal[1]	Taiwan	$37,514	compal.com	Adding $100M plant in Vinh Phuc, Vietnam
4	Quanta[1]	Taiwan	$36,086	quantatw.com	Laptop shipments (60M) up 70%
5	Wistron[1]	Taiwan	$30,222	wistron.com	Stepping into value-added service sectors
6	BYD Electronic[1]	China	$24,328	electronics.byd.com	Now making iPads for Apple
7	Flex[1,3]	US	$22,056	flextronics.com	Nextracker IPO could bring billions
8	Inventec[1]	Taiwan	$18,180	inventec.com	Teaming with Microsoft on 5G networks
9	Jabil Circuit[1]	US	$24,000	jabil.com	Excludes $4.6 billion in packaging (plastics)
10	TPV[e]	Hong Kong	$8,500	tpv-tech.com	Now private
11	Universal Scientific Industrial Co. (USI)[1]	Taiwan	$7,392	usiglobal.com	AsteelFlash acquisition complete; new plant in Vietnam
12	Celestica[1]	Canada	$5,748	celestica.com	How will they grow?
13	Sanmina[1,4]	US	$5,641	sanmina.com	Will they hang on to PWBs?
14	Kinpo Electronics / Cal-Comp Electronics[1]	Taiwan	$4,500	kinpo.com.tw	Expanding in Thailand, maybe India
15	Plexus[1]	US	$3,368	plexus.com	New 400k sf plant in Thailand to open in 2022
16	Shenzhen Kaifa[1]	China	$2,325	kaifa.cn	China gov't connection force US ban?
17	Venture Corp.[1,7]	Singapore	$2,261	venture.com.sg	Extending R&D Labs beyond Life Sciences
18	Benchmark Electronics[1]	US	$2,053	bench.com	Opened PCB fab shop in Arizona
19	Zhen Ding[1]	Taiwan	$1,877	zdtco.com	2022 capex is nearly $790M
20	Fabrinet[1]	US	$1,707	fabrinet.com	Silicon photonics, LIDAR sales booming
21	SIIX[1]	Japan	$1,668	siix.co.jp	Down in all sectors in 2020
22	Taiwan Surface Mounting Technology Corp.[1]	Taiwan	$1,481	tsmt.com	Supply MiniLED screen for Apple
23	Zollner Elektronik[e]	Germany	$1,459	zollner.de	Can family-run firm stay private forever?
24	Kimball Electronics[1]	US	$1,232	kimball.com	Riding ADAS wave
25	UMC Electronics[1]	Japan	$1,227	umc.co.jp	Closing Mexico operations
26	Kaga Electronics[1]	Japan	$1,216	taxan.co.jp	New factory in Hubei Province
27	Nippon Mektron[1]	Japan	$1,056	nok.co.jp	Major flex-on-SMT supplier
28	Sumitronics[1e]	Japan	$1,050	sumitronics.co.jp	Opened Vietnam plant
29	HiTG / Shenzhen HyteraEMS	China	$949	hitg.com.cn	Almost certainly includes non-EMS sales. EMS operations on block
30	Integrated Microelectronics Inc. (IMI)[1,6]	Philippines	$983	global-imi.com	Includes $116M for STI. IPO for Via Optronics subsidiary
31	V.S. Industry[1]	Malaysia	$818	vs-i.com	Expanding Malaysia ops 25% to 2.1M sf
32	VTech Communications[1,5]	Hong Kong	$813	vtechems.com	Acquiring QCS audio plant in Mexico
33	ATA IMS Berhad	Malaysia	$792	ataims.com.my	Merging with Microtronics Technology by mid-2021
34	Neo Tech[e]	US	$740	neotech.com	Took a hit on industrial
35	Pan-International[1]	Taiwan	$735	panintl.com	Parent of P.I.E. Industrial Berhard
36	Scanfil[1]	Finland	$719	scanfil.fi	Shed plants in Hamburg, Hangzhou
37	Dixon Technologies[1]	India	$701	dixoninfo.com	Adding mobile, telecom capacity
38	Enics	Switzerland	$692	enics.com	Moving into medical
40	Katolec	Japan	$668	katolec.com	14 electronics plants worldwide
39	Videoton Holding	Hungary	$660	videoton.hu	Moving into medical
41	3CEMS Group (FIC Group)	Taiwan	$630	3cems.com	Does not include FIC
42	Hana Microelectronics[1]	Thailand	$615	hanagroup.com	1.1M sq. ft. of mfg space in Thailand, China, US and Cambodia
43	Creation Technologies[e]	Canada	$600	creationtech.com	Acquired Applied Technical Services
44	Neways Electronics[1]	the Netherlands	$578	neways.nl	Auto slowed 29% yoy
45	Lacroix Electronics[1]	France	$533	lacroix-electronics.com	Set rev. goal of 800M Euros by 2025
46	Bitron Electronics	Italy	$532	bitronelectronics.com	Manufacturing in Italy, Poland, China, Mexico
47	Katek	Germany	$500	katek-group.de	Acquiring Leesys Group and going public
48	SVI Public Co.[1]	Thailand	$487	svi-hq.com	Could go private in 2021
49	KeyTronic EMS[1]	US	$479	keytronic.com	Grew every quarter
50	Kitron[1]	Norway	$473	kitron.com	New focus on IoT and electrification

(oval) = Largest revenue gainer
(rectangle) = Largest percentage gainer
e = Estimated
1. Publicly held.
2. Excludes sales from PWB, connectors, Sharp, Innolux, etc.
3. Excludes $70 million in PWB sales and $1.2 billion from Nextracker.
4. EMS only.
5. Based on four quarters ended Sept. 30.
6. Excludes $153M from Via Optronics
7. Includes Univac Precision

and the ratio could increase,[7] although such statements from the world's largest ODM should always be met with a healthy dose of skepticism.

Although, at less than 100 million people, Vietnam probably lacks the population base to make a significant dent in the geographical world EMS market share. Nevertheless, its combination of skilled workers, compatibility with Western businesses, and generous tax incentives will spur substantial continued investment in the country. (Income from investment in manufacturing supporting industrial products is exempted for the first four years, then taxed at 50% the standard rate for the subsequent nine years, and at a preferential rate of 10% for 15 years.)

TABLE 2. Currency Conversions

1 USD =	12-Month Change
0.82 euros	-9.9%
6.44 Chinese RMB	-1.3%
7.77 Hong Kong dollars	0%
292.4 Hungarian forint	-9.5%
109.4 Japanese yen	1%
4.12 Malaysian ringgit	-4.8%
1.33 Singaporean dollars	-6.3%
8.33 Swedish krona	-16.1%
27.98 Taiwanese dollars	-7.6%
31.35 Thai baht	-4.1%
73.3 Indian rupees	-3.3%

TABLE 3. Top 50 Entrants by Nation

Canada	2
China	3
Finland	1
France	1
Germany	2
Hong Kong	2
Hungary	1
India	1
Italy	1
Japan	6
Malaysia	2
the Netherlands	1
Norway	1
Philippines	1
Singapore	1
Switzerland	1
Taiwan	12
Thailand	2
US	9

Private Eyes

The problems posed by Covid-19 couldn't stop the world's investment bankers for long. Merger and acquisition activity really heated up, even as the number of deals closed was delayed in part because would-be buyers couldn't perform their due diligence. Buyers were out in force looking for deals, led primarily by private equity firms both with and without longstanding ties to the industry. Among the newsworthy private equity-led deals were the acquisition of SMTC for $171 million by H.I.G. Capital and Creation Technologies' (no. 43) acquisition of Applied Technical Services. As of this writing, Neways (no. 44) and SVI Public Co. (no. 48) are being courted by major shareholders seeking to take them private.

In the US, Emerald EMS (the merger of DataEd, Bestronics, Saline Lectronics and Veris Manufacturing), Virtex (which acquired Altron this year, its fifth deal), Zentech (CAMtek, Trilogy Circuits), Intervala (Varitron-NH, Princeton Technology), and East West Manufacturing (Varitron-Canada, Team Manufacturing, General Microcircuits and Adcotron) are among the smaller-tier companies primarily owned by outside investors that are pushing through acquisition into the higher atmosphere.

The largest transaction, of course, was Universal Scientific Industrial's purchase of AsteelFlash. The combination of nos. 13 and 30 from the 2019 CIRCUITS ASSEMBLY Top 50 did little to change the overall rankings, but symbolically it harkened to the late 1990s and early 2000s, when the big getting swallowed by the bigger was commonplace. Will it presage another round of major buys, and if so, who is most likely to be caught up in the whirlwind?

End Comments

Even as private equity flexes its considerable muscle, there remain more than 115 publicly traded companies offering electronics manufacturing services either primarily or through a subsidiary. Although a growing number are traded on exchanges that such as Taiwan, Shanghai or Shenzhen that don't require the same degree of disclosure as Western regulators, it still adds considerable color to the state and health of the industry.

Most major currencies fell against the US dollar in 2020 **(TABLE 2)**. For those companies reporting revenues in non-US currencies, we converted the numbers using the averages set forth on May 14, 2021. Currency fluctuation will account for why some companies appear on some industry lists and not others. Likewise, CIRCUITS ASSEMBLY attempts in all cases to use the calendar year, not company financial years. Again, differing methodologies explain variances with other rankings.

Some lists rank New Kinpo Group (no. 14) higher than we do here. NKG includes the Cal-Comp ODM/EMS units, plus Kinpo Electronics, AcBel Polytech, Qbit Semiconductor, and XYZprinting, among others. It's a classic example of a company whose reach extends beyond ODM/EMS work. Even within the ODM segment, the lines are muddy. To wit: Kinpo Electronics' Thai factories, of which there are currently 12, with three more to start operating this year, all produce for Compal's (no. 3) European and American customers.

Privately held Beyonics is reportedly on the block. PE owners ShawKewi & Partners reportedly seek $300 million to $400 million for the company, which they bought in 2012 for $95 million. Once a top 20 EMS firm, Beyonics fell considerably and reinvented itself from a maker of hard disk drives to a player in the higher-reliability automotive, industrial and medical sectors. This potential deal should be watched closely.

Automotive continues to reshape the EMS landscape. Between the rise of electric vehicles, which are gobbling up components at an accelerated rate, and the topsy-turvy markets, transportation has shifted the rankings of many of the Top 50 outside of the five largest Taiwan-based ODMs. As Foxconn speeds into the market, having announced deals with Fisker and Byton in the EV space, and with its key customer Apple looming, it serves as reminder that EMS companies that are geared to high-speed, lower-cost production and manag-

continued on pg. 41

Engineering a Competitive MADE IN USA Solution

Backend processes such as routing and coating can be optimized for cost savings. by DAVE McADEN

There is no question a number of countries have manufacturing costs lower than the US. At first glance, the cost differential may make outsourcing in those regions the best solution. When the total costs of logistics, transit time, flexibility and quality of communication are considered, however, the cost differential of a Made in USA solution vs. an offshore or near-shore solution can be small. The engineering team at Electronic Design & Manufacturing, a regional electronics manufacturing services (EMS) provider in Lynchburg, VA, has worked to level that playing field even more.

The engineering analysis starts by mapping the process flow and evaluating the cost drivers in the assembly process. While this level of analysis is routine for high-volume, dedicated line projects within the EMS industry, it isn't always done thoroughly in midrange projects. This typically happens because companies building those projects lack the engineering resources necessary to develop cost-effective custom automation solutions.

While EDM's team looks at the traditional areas of cost reduction through design for manufacturability (DfM) during that analysis, there is also a focus on identifying opportunities where production tooling or custom automation could take cost out of process steps that are manual, time-consuming or challenging. In many cases, custom automation can be achieved with open-source hardware. The team considers solutions that involve no design changes, as well as those that may involve redesign.

Solutions typically fit into five categories:

- Automating a manual process via a custom solution.
- Reducing process time through a combination of panelization and automation.
- Redesigning to better utilize blended process technology.
- Optimizing firmware to reduce the time required for test or a downstream process.
- Utilizing a custom-tooled solution to reduce manual processing time.

For example, in the case of a consumer products manufacturer wishing to bring a product back from China, the cost driver was a relatively small printed circuit board assembly (PCBA), panelized in a 25-up array. The routing, programming and test process following SMT assembly was labor-intensive if performed as separate process steps in multiple work cells, so the team decided to look at modifying the router to combine all three steps.

The modified router programs and functionally tests all assemblies on the panel **(FIGURE 1)**. The team programmed the router to route only the assemblies passing test. As a result, the operator can perform other tasks while the program/test/route process is in progress. Any assemblies failing test will remain attached to tabs on the panel.

In a different case, a PCBA was part of battery packs used in an intrinsically safe environment. Neither a standard automated conformal coating nor manual spray solution met the cost targets. The engineering team developed an automated dip coating solution for a six-up panel array utilizing a robot arm to provide a controlled, repeatable process.

In the test realm, multi-up bed-of-nails test fixtures have been designed to reduce test time. In one example, a six-up PCBA can be completely programmed and tested in a total of

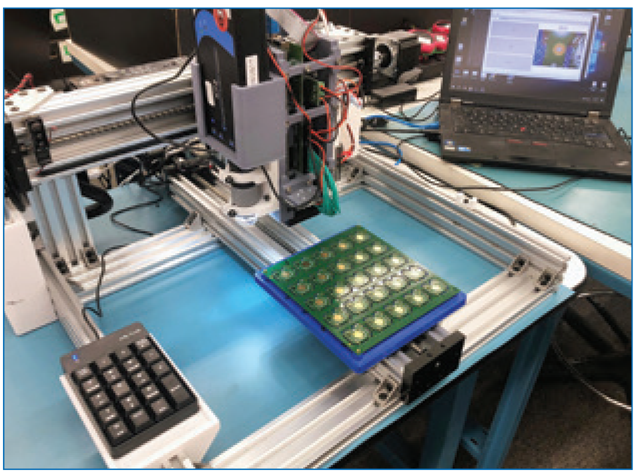

FIGURE 1. This robot automatically programs and tests each of the 25 boards, and positively marks each board that passes.

30 sec., working out to about 5 sec. per unit.

In the case of a PCBA using 18 different through-hole socket pins, the team created a custom odd-form part feeder that used vacuum and compressed air to reliably place the pins during SMT topside placement **(FIGURE 2)**. The stencil design incorporated paste deposition for the pins, and the PCB underwent a standard reflow process, instead of a combination of reflow and selective solder.

Creating test firmware can also enhance test speed. In one case, a product with an operations mode that cycled through multiple lighting features as part of user setup had all inputs/outputs tested in milliseconds via a separate test firmware cycle. In other cases, built-in self-test loopbacks are used to cut test time.

Custom-tooled solutions are also used to cut manual processing time and ensure a repeatable process. The team prints custom jigs using 3-D printers. For example, one product needed a battery spring soldered on the PCBA. The alignment of the custom-formed spring was critical. The PCBAs were routed into 10-up panels and set in a 3-D printed jig that holds 10 springs in exact position for the soldering step. The process reduced time, while eliminating variation during the placement and soldering process.

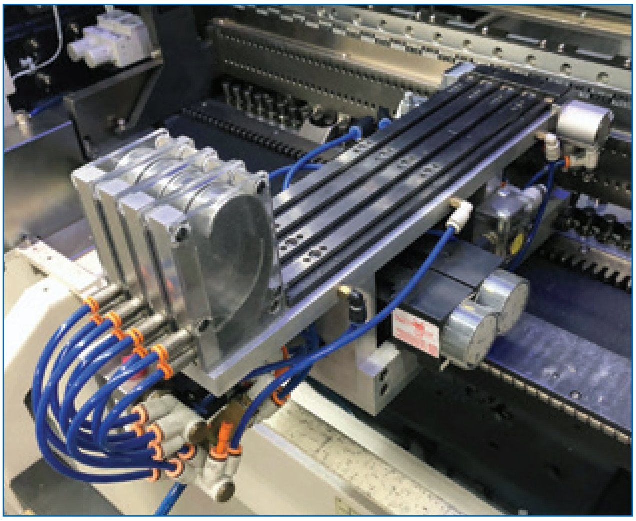

FIGURE 2. To cost-effectively assemble a PCBA with 18 different through-hole socket pins, EDM created a custom odd-form part feeder that utilizes vacuum and compressed air to place the pins during SMT topside placement.

Through-hole to the rescue. Sometimes older technology provides better cost-reduction options. In the case of a high-volume thermostat PCB with surface-mount headers, the team recommended a switch to a through-hole header with a pin-in-paste (PiP) reflow process. The surface mount headers were tall, didn't register during placement and often leaned following reflow. Custom jigs had originally been designed, but the handling time made the process inefficient. The switch to the through-hole PiP process eliminated the need for tooling.

Labeling and packing processes can also benefit from this type of analytical approach.

The team uses automated labeling systems in conjunction with jigs to ensure correct placement. The timing of the process is also important. For example, in a product programmed and tested six-up in a universal test fixture, the team found it worked best to delay the labeling process until the PCBAs were routed. Each unit's memory stores its MAC address and unique information. At the end of the process, the PCBA is plugged in, and the appropriate information prints on a label.

In a packaging situation, costs were reduced by switching PCBAs from anti-static bags to anti-static trays. The project volume was approximately 100,000 units per year, so even a relatively small time difference between time to bag vs. time to place in a tray increased labor cost. The switch to trays not only lowered labor cost, it created stackable packaging that was more convenient for the customer to work with in its receiving process.

It is important to note this type of effort requires a strong EMS-OEM partnership approach. The OEM should have a genuine willingness to consider all ideas for cost improvement and take a total cost of ownership (TCO) approach to evaluating the proposed solution. In some cases, a redesign effort may deliver the best long-term outcome. ❑

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EMS Top 50, continued from pg. 39

ing complex supply chains will find plenty of opportunity to motor on for years to come.

As always, any errors are the author's. ❑

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One for All

Precision mass-alignment of singulated substrates.

DISCUSSION AROUND SMALLER devices, complex designs and manufacturing challenges as a result of miniaturization: a never-ending story, isn't it? Truth is, just when it appears the industry has hit a wall in terms of capability, we find a way forward. Yes, miniaturization is rolling on, and the industry continues to overcome perceived obstacles, this time enabling a higher accuracy approach to mass processing of singulated substrates.

Several years ago, the general thinking was components would keep getting smaller. The prevailing view was that by this time, the metric 03015 and the metric 0201 would be working their way into mainstream production. Although the processes to accommodate these small devices have long since been developed, it will likely be some time before they appear on a majority of BoMs. What is happening, though, is manufacturers are trying to eek out slightly more with standard 01005s by placing them closer together, creating a much narrower gap from the edge of one component to the edge of the next. (See "Screen Printing," December 2020.) These narrow gap designs – which today see pitches of approximately 100µm with 75µm on the horizon – in combination with the other elements of miniaturization require much tighter alignment tolerances in the stencil printing to ensure solder paste hits the pad target.

Achieving pinpoint printing alignment on miniaturized narrow gap assemblies would be completely doable if the standard protocol were to print one substrate at a time. However, to achieve required volumes and cost-efficiencies, boards are most often processed in a panelized fashion; this is particularly the case with smaller, mobile-device-type PCB assemblies. Because FR-4 substrates can succumb to fabrication-induced board stretch, bow/twist and a host of other issues that impact printing alignment, the printer generally conducts a "best fit" alignment routine, taking the global fiducials and aligning the stencil to the entire panel. If the board has no issues, best fit is a very good fit, and it's off to the races. Conversely, if there is stretch on the PCB across the circuits, then a "best fit at best" alignment is the only option. In some cases where board stretch is present, alignment can be up to 100µm off the paste to pad across a 120 mm-long board. Twenty years ago, a 100µm deviation was fine, but definitely not in today's narrow gap, 150µm-wide pad dimensional reality. So, how do we solve the dilemma of multi-substrate processing with individual substrate alignment using a single stencil?

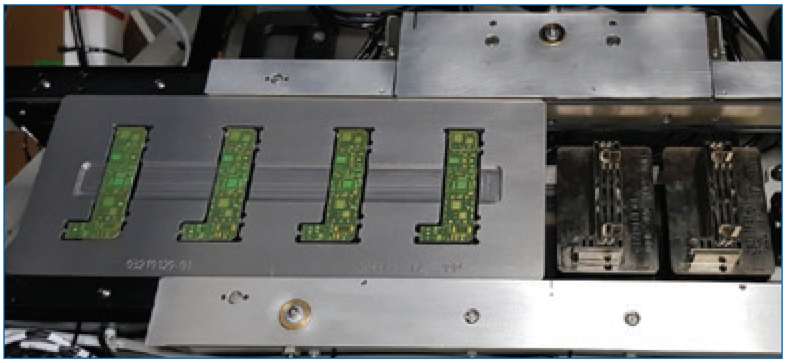

FIGURE 1. Substrates are transported into the printer on a carrier and align with individual towers.

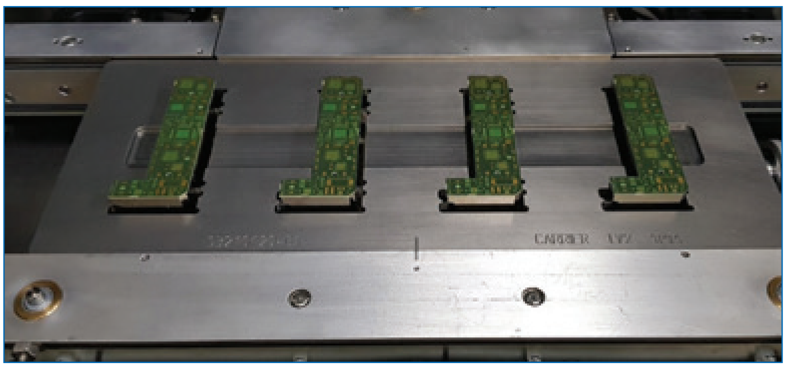

FIGURE 2. PCBs are raised to print height using specialized motors and customized towers to enable precision alignment.

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Singulated substrate, mass printing is the clear solution. Printing singulated substrates in a tray format has been employed in semiconductor packaging for some time. Through use of specialized carriers and tooling, individual substrates organized as multiples in a single carrier are transported and aligned for processing with whatever printing media is required: solder paste, die attach paste, flux or thermal interface materials. Several mechanical solutions exist in this area. For consumer electronics, however, constraints of the substrate thicknesses and outline dimensional tolerances are not compatible with traditional mechanical mechanisms.

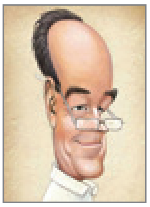
This reality has led to innovations in mass-printed, singulated substrate processing. Using optical alignment and specialized actuators, a high-speed technique for printing multiple substrates with individual alignment in a panel format is one solution for very high-density PCBs. With this technology, PCBs are placed individually into a multi-substrate carrier plate, and each PCB is married to its own tower, which is powered by an actuator facilitating individual movement in x, y and θ. Fiducial measurements of the stencil are taken to ensure stencil to tower alignment, after which substrate-loaded carriers are transported into the printer, PCB fiducials are identified, and individual towers simultaneously raise and custom fit the PCBs to the stencil (**FIGURES 1** and **2**). The printing operation takes place, and the substrates are lowered back into the carrier.

There are, as noted, many approaches to singulated substrate processing, and each has benefits for specific applications. For high-volume, high-speed, precision narrow gap printing, however, the latest development offers a viable solution to the board stretch, miniaturization dilemma. Once again, the electronics industry has enabled small-dimension processing to take a big step forward. ❑

Solder Squishing

When BGAs move during reflow, intermittent shorts can result.

BOB WILLIS is a process engineering consultant; bob@bobwillis.co.uk. His column appears monthly.



THIS MONTH WE look at ball grid array (BGA) opens and solder compression. Intermittent joints and shorts can be caused by package warpage at elevated temperatures. Hence the interest in lowering soldering temperatures commonly used for SAC alloys.

FIGURE 1 was part of an experiment to chart the movement of a BGA package during reflow soldering. Using our reflow simulation, we can see solder ball compression by the package laminate in the image. In many of our video experiments, we see package warpage causes solder shorts and open connections during second reflow. Intermittent open connections have been experienced on double-sided reflow and package rework of adjacent parts. This procedure has been helpful to demonstrate why and how this problem can exist, particularly with smaller packages.

Depending on the available equipment and budget, it is possible to fully characterize components during reflow simulation. This allows engineers to find ways to deal with these issues and compensate for warpage through process modification. Alternately, this information can be shared with designers to demonstrate some components are not worth using.

We have presented live process defect clinics at exhibitions all over the world. Many of our Defect of the Month videos are available online at youtube.com/user/mrbobwillis. Find out how you can share our new series of Defect of the Month videos to explain some of the dos and don'ts with your customers via CIRCUITS ASSEMBLY: https://bit.ly/3mfunlF. □

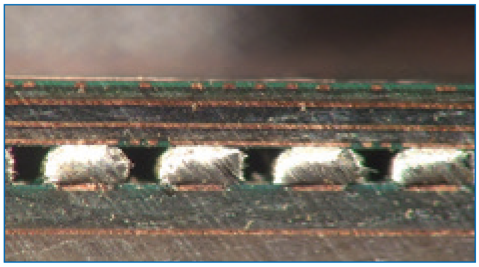
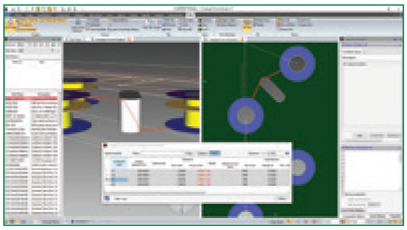


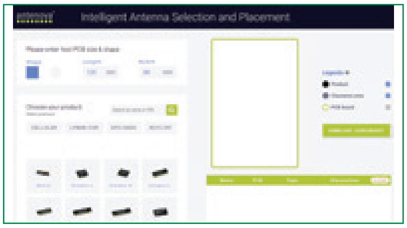
FIGURE 1. The BGA solder balls compressed during reflow. A modified reflow process might be needed.



ZUKEN ECADSTAR 2021

eCadStar release 2021.0 includes 3-D creepage safety checks in PCB design editor, improved bus management and sheet connector cross-references in schematic editor and enhanced scripting in COM interface. Creepage safety checking functionality, for power supply design, analyzes electrical safety of nets and defined regions of PCB design, measuring distance between electrical items across insulating surface in 3-D (according to standards like IEC-62368). Creepage rules are user-controlled in common constraint browser in both schematic and PCB design editor. SPICE controller provides integrated solution for analog circuits simulation.

Zuken
ecadstar.com



ANTENOVA ANTENNA PLACEMENT TOOL

Antenna Placement Tool helps designers place antennas in a wireless design. Displays optimum position for embedded antennas on PCB, depending on dimensions of PCB and specifications of antennas. Places each antenna on PCB in best location for signal strength. Can be used for up to three antennas from different categories or a pair of antennas in a diversity configuration. Displays keep-out area adjacent to antenna.

Antenova
antenova.com

TELEDYNE LECROY HDO6000B

HDO6000B oscilloscope integrates waveform generation and spectrum analysis with 12-bit res and 15.6" display. Brings together high sample rate 12-bit ADCs, high signal-to-noise amplifiers and low-noise system architecture. Sample rate of 10GS/s and memory up to 250 Megapoints. 15.6" 1920 x 1080 display. Optional internal function generator creates standard and arbitrary waveforms. Comes in bandwidths of 350MHz, 500MHz and 1GHz.

Teledyne LeCroy
teledynelecroy.com/hdo6000

OTHERS OF NOTE

KEYSIGHT PATHWAVE ADS 2022

PathWave Advanced Design System 2022 simulation software reportedly reduces design time for DDR5, low-power DDR5 and graphics DDR 6 memory systems. Models transmitter and receiver behavior accurately by generating simulation models of both DDR transmitters and receivers, with flexible equalization and external clock inputs. Optimizes equalization settings to predict design margins.

Keysight Technologies
keysight.com

PCB LIBRARIES 2021 FOOTPRINT EXPERT

2021 Footprint Expert tool auto-generates PCB library parts from package dimensions and personal options. Free full-featured Professional version is available for CADint, DesignSpark, DipTrace, Eagle, KiCad, Pantheon, Proteus, Pulsonix, McCAD, SoloPCB, Target 3001! and Ultiboard CAD tools. All other CAD tool interfaces for Cadence, Mentor, Zuken and Altium are available for a fee. Unlimited seats to the Enterprise version are available to colleges and universities.

PCB Libraries
pcblibraries.com

HIROSE FH63S SERIES

FH63S series shielded flexible printed circuit connector has patented single-action flip lock technology. Features ground pin to work with shielded FFC for EMI prevention and optimum signal integrity. Is 0.5mm pitch and supports HDMI 1.4a, USB 3.0, Embedded Display Pot 1.3, and V-by-One HS protocols. Retention force 19.5N. Rugged two-point independent contact spring design. Operating temp. up to 125°C. Designed for automated pick-and-place assembly processes and offers flux and solder wicking prevention. Has height of 2.8mm and is available in 30-position version that is halogen-free and RoHS compliant.

Hirose Electric
hirose.com

EASYLOGIX PCB-INVESTIGATOR V. 12.2

PCB-Investigator v. 12.2 provides DRC analysis with overlap of copper/silkscreen with profiles; HTML report; full integration of the Gerber to Viscom process plus bad markers; list view export is more secure; bug fixes to DfM; bug fix for rename layers; IPC-2581 B import: revision plus improved side detection; Gerber import: revision plus dynamic text handling extended to handle multiple attributes; Excel import: feasible using two letters (column header); Excellon: adding attributes from comments; resolves DNS name at restart if IP changes; parallelization structured more securely; AOI 2-D update for incorrect component heights; addition of stub half caps; package edit revision; polarity marker update for display; GenCAD export revision.

EasyLogix
pcb-investigator.com

STACKPOLE RMEF

RMEF thick-film chip resistors are RoHS compliant. Offer resistance values from 1Ω to 10mΩ in 1% and 5% tolerances. TCR ranges from 100ppm to 400ppm depending on size and resistance value. Reportedly are ideal substitutes for electronics that must transition to Pb-free components for compliance; provide performance, resistance values, power and voltage ratings of general-purpose chip resistors in Pb-free packages.

Stackpole Electronics
seielect.com

MACDERMID ALPHA EVABRITE

Evabrite WS1 and WS1-E water-based anti-tarnish systems protect functional silver surfaces and connectors from tarnish. Designed to adhere to upcoming regulatory changes and do not contain OPEs/NPEs. Evabrite WS1 is single-component immersion-based process. WS1-E is two-component electrolytic process. Nanometers-thick coating reportedly offers lasting protection to silver surface, while not impacting contact resistance of silver deposit. Baths are stable, easy to maintain, and compatible with reel-to-reel and rack/barrel applications. Maintains wetting performance after exposure to multiple Pb-free reflow cycles.

MacDermid Alpha Electronics Solutions
macdermidalpha.com

ASYMTEK FORTE MAX

Forte Max fluid dispenser offers dual-valve jetting in two modes and patented, real-time correction to accommodate skewed parts. Designed for high volume. Dispenses from two identical or different valves using a single set of hardware. In one configuration, two high-frequency IntelliJets dispense fluid simultaneously for applications with multi-up, panelized, or patterned parts with consistent spacing. In a second configuration, two different fluids are dispensed on the same part from two different valves, such as for dam-and-fill encapsulation.

Nordson Electronics Solutions

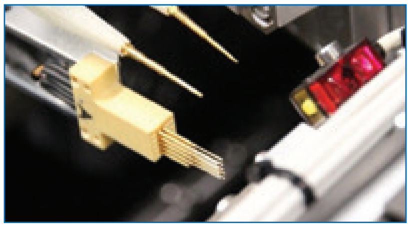
nordson.com/en/divisions/asymtek

LPKF PROTOPRINT S4

ProtoPrint S4 is a manual stencil printer suitable for single-sided and double-sided printing of PCB prototypes and low volumes. Has integrated size-adjustable clamping frame; can use polyimide film or stainless steel stencils. Supports mounting of tiny SMDs on prototype boards. Components are removed from component trays or tape feeders with manual pick-and-place system, guided to appropriate places above PCB with ergonomically formed placement head, and placed with one hand. Has automated nozzle changer with six nozzles and intuitive GUI. Is equipped with CAD editor for nearly all CAD systems.

LPKF

lpkf.com



SEICA FLYPOD

FlyPOD module connects multiple hardware resources to mini fixture installed on flying probe. Is deployed for on-board programming, as boundary scan test interface or as communication interface, e.g., CAN, I2C, etc. Automatic flying prober with four or eight probes with FlyPOD option can be integrated into high-volume automatic production line; integration of up to two FlyPODs on different heads for OBP programming, boundary scan, CAN communication and other purposes. Fixture with min. step of 1.27mm (5 x 5 grid). Max. number of contacts: 14. DUT provides a termination of test points connected to device to be programmed. Mini-fixture is plug-and-play type and will be manufactured according to configuration in use.

Seica

seica.com

OTHERS OF NOTE

PANSONIC SIDEFILL CV5797U

Sidefill CV5797U polymer is for surface mount assembly applications. Reportedly improves reliability and productivity of automotive electronic assemblies. Is temperature-resistant and designed to prevent solder cracking. Under ambient conditions, it has pot life of 72 hr. Exhibits high Tg (160°C) and low CTE (14ppm). Withstands 6,000 cycles between -55° and 125°C. Reportedly reduces reinforcement process time approx. 90% compared to conventional underfill process. Jet dispensable.

Panasonic

Panasonic.com/global

YINCAE SMT 158N

SMT 158N is a non-flow, low-temp., slow-cure, high-purity liquid epoxy underfill and capillary underfill encapsulant. Has high viscosity and can be used as dam material, corner bond, edge bond or encapsulant. Withstand temps. down to -273°C. For flip-chip, wafer-level chip scale package applications. Also suitable for bare chip protection in memory cards, chip carriers, hybrid circuits and MCMs.

Yincae Advanced Materials

yincae.com

INFOTECH DESKTOP DISPENSING ROBOT

Desktop dispensing robot integrates different dispensing technologies: from time-pressure to volumetric dispensers to electropneumatic or piezoelectric jet dispensing. Software and integrated vision system offer intuitive development of dispensing parameters; these are stored in a library with dispensing medium, dispensing technology and respective dispensing pattern. Can be called up or adapted. Combines jetting of sinter paste with pick-and-place of chip. Configuration and parameters can be transferred to an inline-capable manufacturing cell without changes.

Infotech

infotech.swiss/en/

SHENMAO PF606-EP305

PF606-EP305 joint enhanced solder paste (JEP) and solder joint encapsulation material (SJEM) flux SMEF-Z52 are epoxy-based solder materials for very-fine pad size (70µm) soldering. Offer advantages of conventional solder paste and anisotropic conductive paste, i.e., self-alignment and planar insulation. Flux combines capabilities of conventional flux and underfill. Epoxy cures after reflow and provides bonding strength and joint protection. Come in halogen-free versions that meet J-STD standards (≦1000ppm chlorine/≦1000ppm bromine) and IEC standard (≦900ppm chlorine/≦900ppm bromine/≦1500ppm total halogens).

Shenmao

shenmao.com

KOKI T4AB58-HF360, T4AB58-HF360D

T4AB58-HF360 and T4AB58-HF360D solder pastes are for low-temp. reflow soldering processes designed for printing and dispensing applications. T4AB58-HF360 is for printing; T4AB58-HF360D is for dispensing. Activator facilitates reduction-oxidation reaction. Improves insulation resistance and achieves stability in continual application and in holding and securing components during and after the component placement.

Koki Co. Ltd.

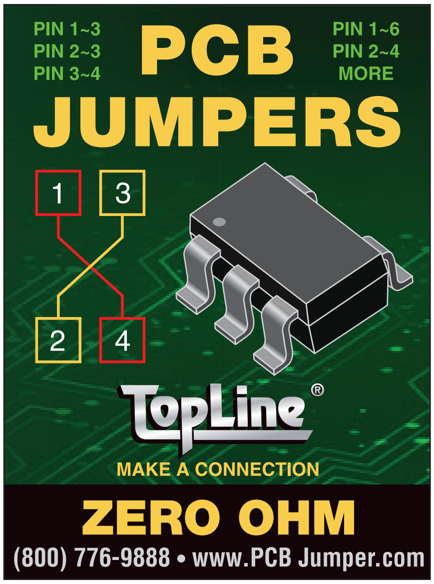
ko-ki.co.jp

VITRONICS SOLTEC CLOSED LOOP PPM

Closed loop PPM control system for Centurion reflow oven is designed to be used in nitrogen environment with Cathox to maintain PPM setpoint range. Maintains setting from 200ppm to 2,000ppm at +/-100ppm tolerance from 200 to 500 and 20% tolerance from 500 to 2,000. In production mode, it ensures stable PCB quality. In idle mode, it reduces nitrogen consumption and automatically recovers to PPM setpoint before machine returns to production. Cathox reduces maintenance requirements while keeping clean process environment. Removes volatile compounds from process tunnel during reflow. In thermal oxidation, organic vapors are converted to hydrocarbons, captured by a filter.

Vitronics Soltec

itweae.com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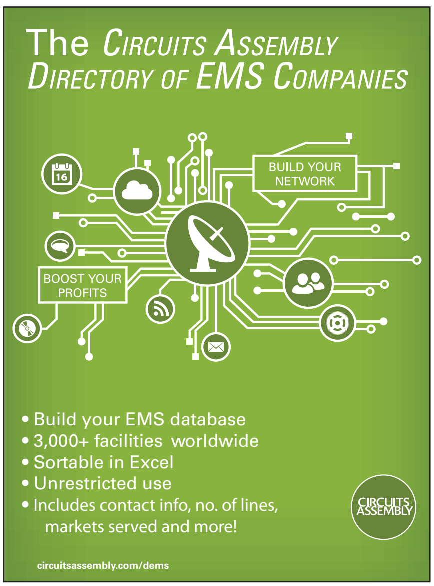
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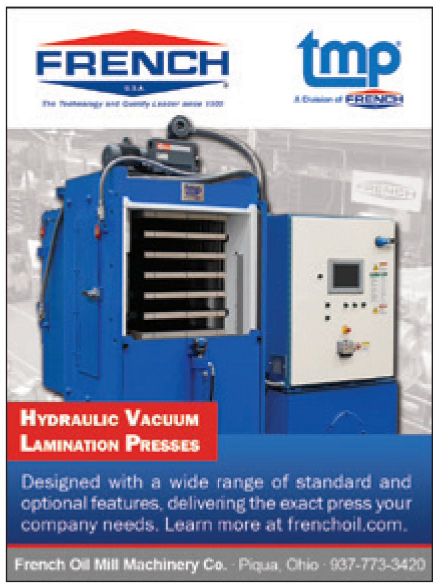
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In Case You Missed It

This column provides abstracts from recent industry conferences and company white papers. Our goal is to provide an added opportunity for readers to keep abreast of technology and business trends.

Reliability

"Electrochemical Failures as a Function of Flux Volume under Bottom Terminated Components"

Authors: Mark McMeen

Abstract: The activity of flux residue changes when trapped under a low-profile leadless or bottom-terminated component. There are three factors to consider: 1) Standoff gap: lower-standoff gaps block outgassing channels. Low-standoff gaps change the nature of the flux residue by leaving behind flux activators, solvents, and functional additives that normally would be outgassed from the residue; 2) Narrow pitch: miniaturized components have a decreased distance between conductors of opposite polarity. There is a higher potential to bridge conductors with flux residue; 3) Cubic volume of flux: increased I/O in combination with thermal lugs creates a higher cubic volume of flux left under the bottom termination. High flux volumes can block outgassing channels and bridge conductors.

A QFN test board was designed to study the research hypothesis that electrochemical failure phenomena are related to the volume of flux residues present under bottom-terminated components. The designed test board (QFN-11) has four quadrants with varying mounting pad dimensions and component standoffs, resulting in varying amounts of flux volume. The test boards were evaluated using surface insulation resistance (SIR) methodologies, followed by component cross-sectioning and visual analysis of the areas under the BTC components. An understanding of the relationship between flux volume and BTC pattern design is expected to aid assemblers in mounting pad design to reduce the risk of electrochemical failures. (SMTA International, September 2020; smta.org/page/knowledge-search#search/entry-details/5ff5024a954f42067b3f61a4/)

"An Investigation on Function of Current Type on Solder Joint Degradation in Electronic Packages"

Author: Wenhui Cai, Fei Huang, Kai Liu and Mohammed Alaazim

Abstract: As in real applications, several alternating currents (ACs) may be injected into electronic devices. This study aims to analyze their effects on the lifetime of solder joints and, consequently, shed light on these effects at the design phase. The authors investigated the effects of current waveform shapes on performance and reliability of solder joints. Three common and extensively used current shapes in several simulations and experiments were selected to study their effects on solder joint performance. In the case of a triangle current type, the results demonstrate a severe thermal swing and stress fluctuation in the solder joint, because the critical states lack any relaxation time. In fact, the stress intensification in the solder under application of the triangle current type has been shown to contribute to increasingly brittle intermetallic compounds. An accelerated increase of on-state voltage of power semiconductor was also observed in under application of the triangle current type. (*Soldering & Surface Mount Technology,* March 2021, emerald.com/insight/content/doi/10.1108/SSMT-06-2020-0025/full/html)

Transient Electronics

"Printable and Recyclable Carbon Electronics Using Crystalline Nanocellulose Dielectrics"

Authors: Nicholas X. Williams, *et al.*

Abstract: Electronics waste can lead to the accumulation of environmentally and biologically toxic materials and is a growing global concern. Developments in transient electronics – in which devices are designed to disintegrate after use – have focused on increasing the biocompatibility, whereas efforts to develop methods to recapture and reuse materials have focused on conducting materials, while neglecting other electronic materials.

Here, the authors report all-carbon thin-film transistors made using crystalline nanocellulose as a dielectric, carbon nanotubes as a semiconductor, graphene as a conductor and paper as a substrate. A crystalline nanocellulose ink is developed that is compatible with nanotube and graphene inks and can be written onto a paper substrate using room-temperature aerosol jet printing. The addition of mobile sodium ions to the dielectric improves the thin-film transistor on-current ($87\mu A\,mm^{-1}$) and subthreshold swing ($132\,mV\,dec^{-1}$), and leads to a faster voltage sweep rate (by around 20 times) than without ions. The devices also exhibit stable performance over six months in ambient conditions and can be controllably decomposed, with the graphene and carbon nanotube inks recaptured for recycling (>95% recapture efficiency) and reprinting of new transistors. The authors demonstrate the utility of the thin-film transistors by creating a fully printed, paper-based biosensor for lactate sensing. (*Nature Electronics,* April 2021, nature.com/articles/s41928-021-00574-0)


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