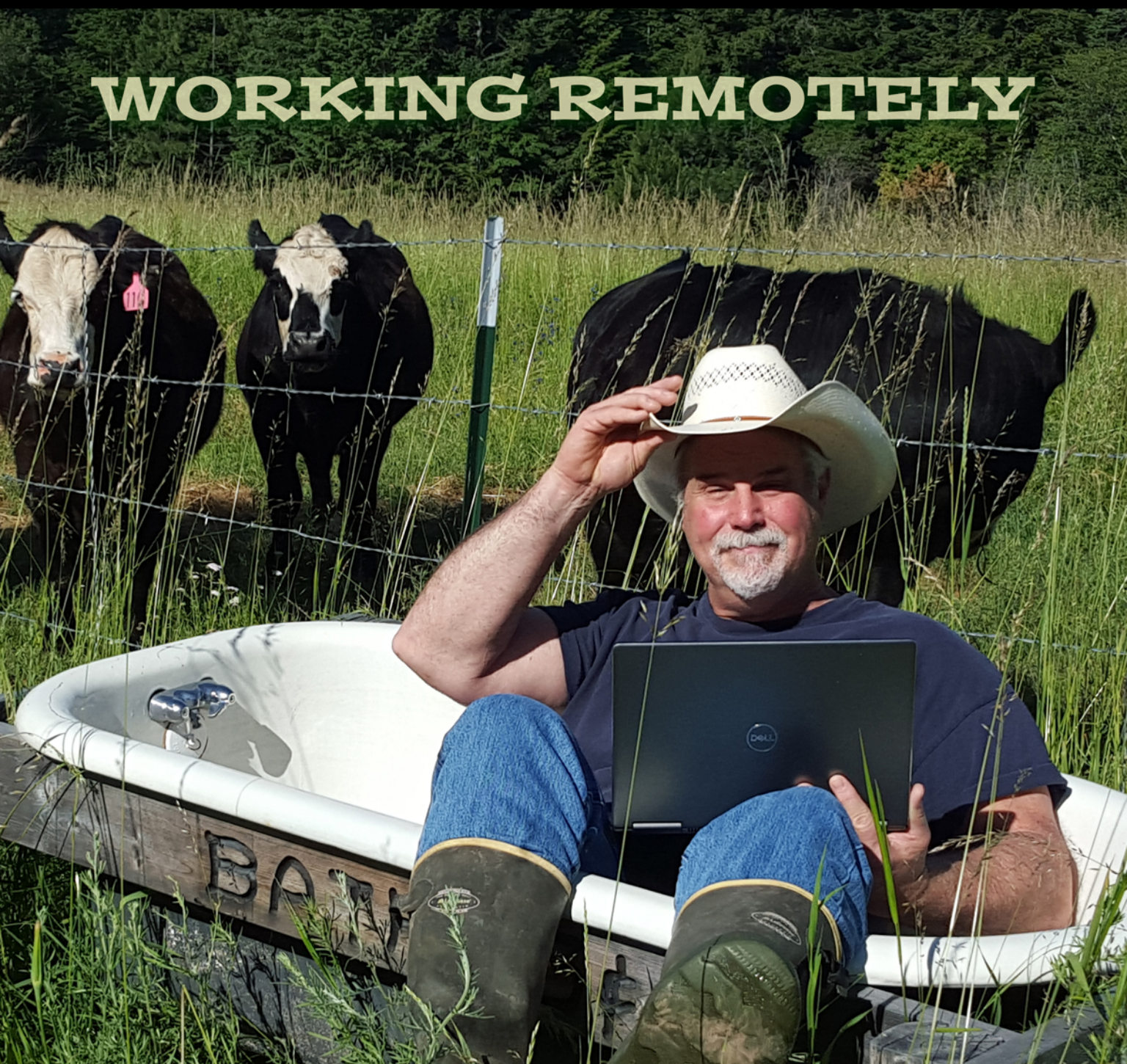
JULY 2020

I-Connect007

DESIGN007 MAGAZINE



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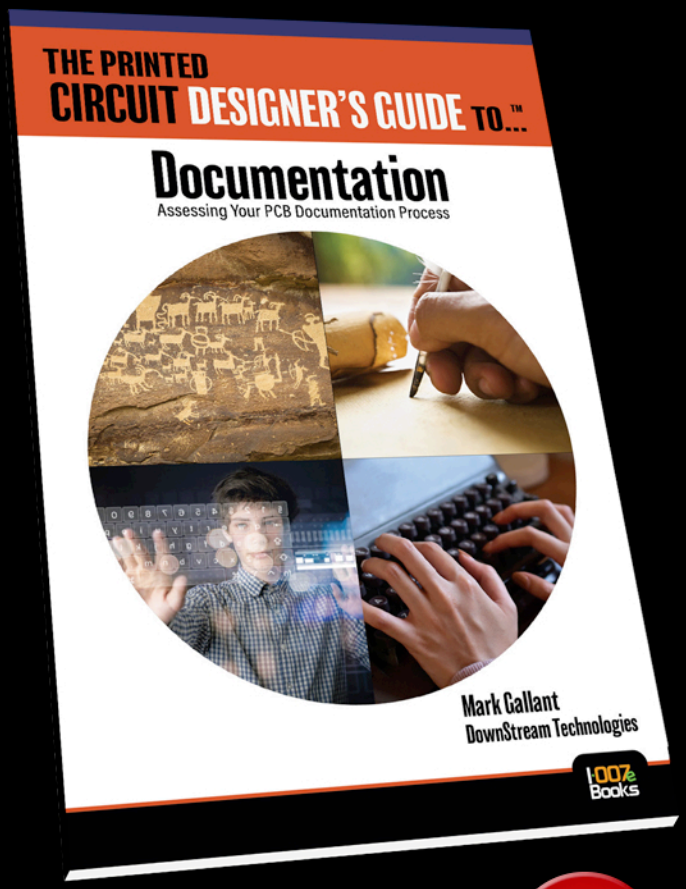

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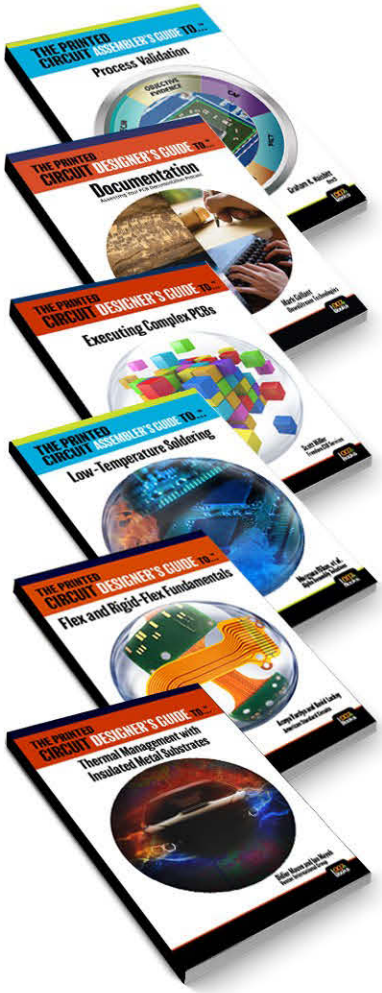
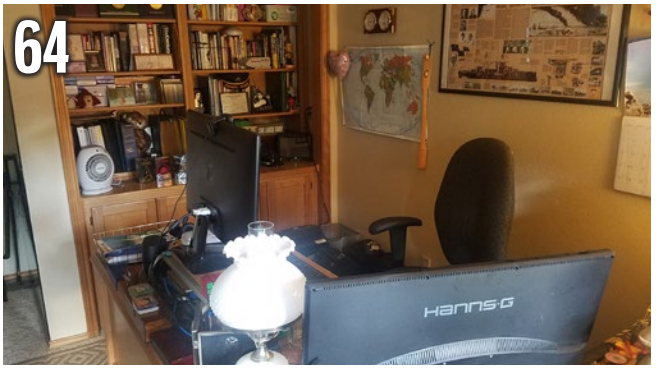


DESIGN007 MAGAZINE

Working Remotely

Since the COVID-19 outbreak, we've seen many PCB designers and design engineers moving out of their company offices and into their home offices. As we've discovered, not everyone likes working from home; some designers miss the interaction of face-to-face meetings or being able to leave their problems in the office each day. And many designers now find themselves working on sensitive ITAR projects from home, making cybersecurity more critical than ever.



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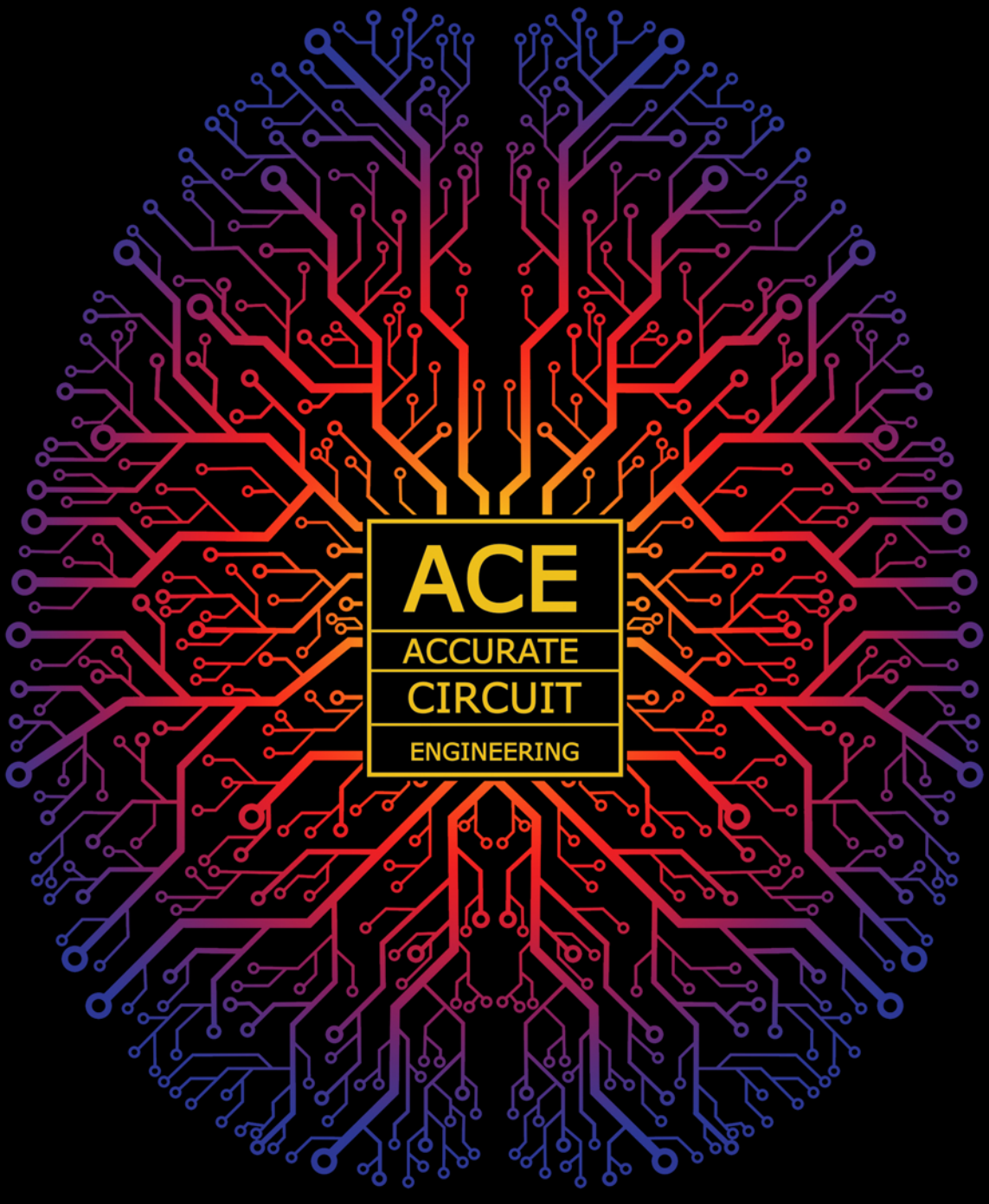

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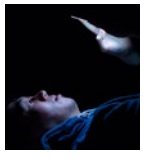

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Autonomous "self-driving" vehicles are heading our way guided by a variety of sensors, such as short and long range radar, LIDAR, ultrasound and camera. Vehicles will be connected by vehicle-to-everything (V2X) technology. The electronic systems in autonomous vehicles will have high-performance RF antennas. Both radar and RF communication antennas will depend on performance possible with circuit materials from Rogers Corporation.

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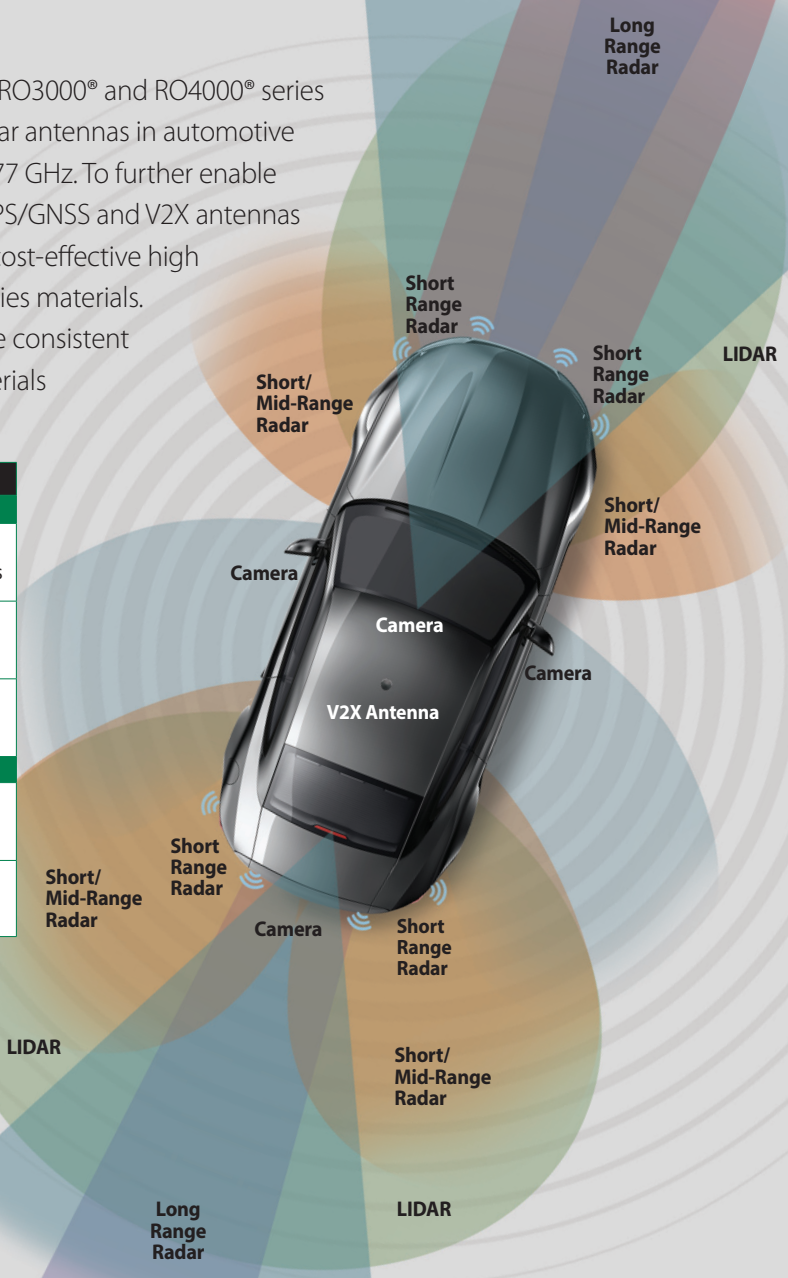

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FLEX007

This Month in Flex

Flexible circuit designers are at the tip of the spear, in many ways. Once considered a specialty technology, flex is now found in many of our handheld devices. And flex technologists are constantly seeking new applications—from autonomous vehicles to 5G—for these handy 3D circuits. But flex designers often have more questions than answers.

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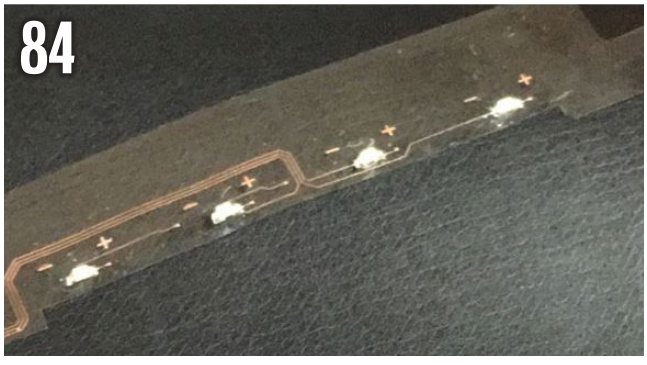

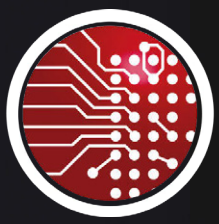

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Designing a New Work Environment

The Shaughnessy Report

by Andy Shaughnessy, I-CONNECT007

In another life, I was a newspaper reporter. I worked in a newsroom, bathed in the bright green light from my trusty Fellowes CRT. Newsrooms are noisy. This was before cellphones, so if I had to make an important call to a judge or police chief, I'd hunt for an unoccupied editor's office.

When I first got into the world of PCBs and EDA tools, I worked in a cubicle. Eventually, I wound up in my own office, and I thought that was about as good as it could get. Then, I started working remotely, and I'm addicted to it. Now that I've been working from home for 13 years, I can't imagine ever working in an office again.

But not everyone likes to work from home, as some of you told us in a recent survey. Some who have been forced to work from home by COVID-19 can't wait to get back into the office. They like the feeling of leaving their problems in the office each day. They miss the casual conversations in the break room or being able to read a colleague's expression in a face-to-face meeting instead of a quirky video conference.

I was surprised that so few of you were working remotely before the COVID-19 outbreak. As you can see in Table 1, nearly two-thirds of PCB designers and design engineers who responded said they had just recently begun working from home.

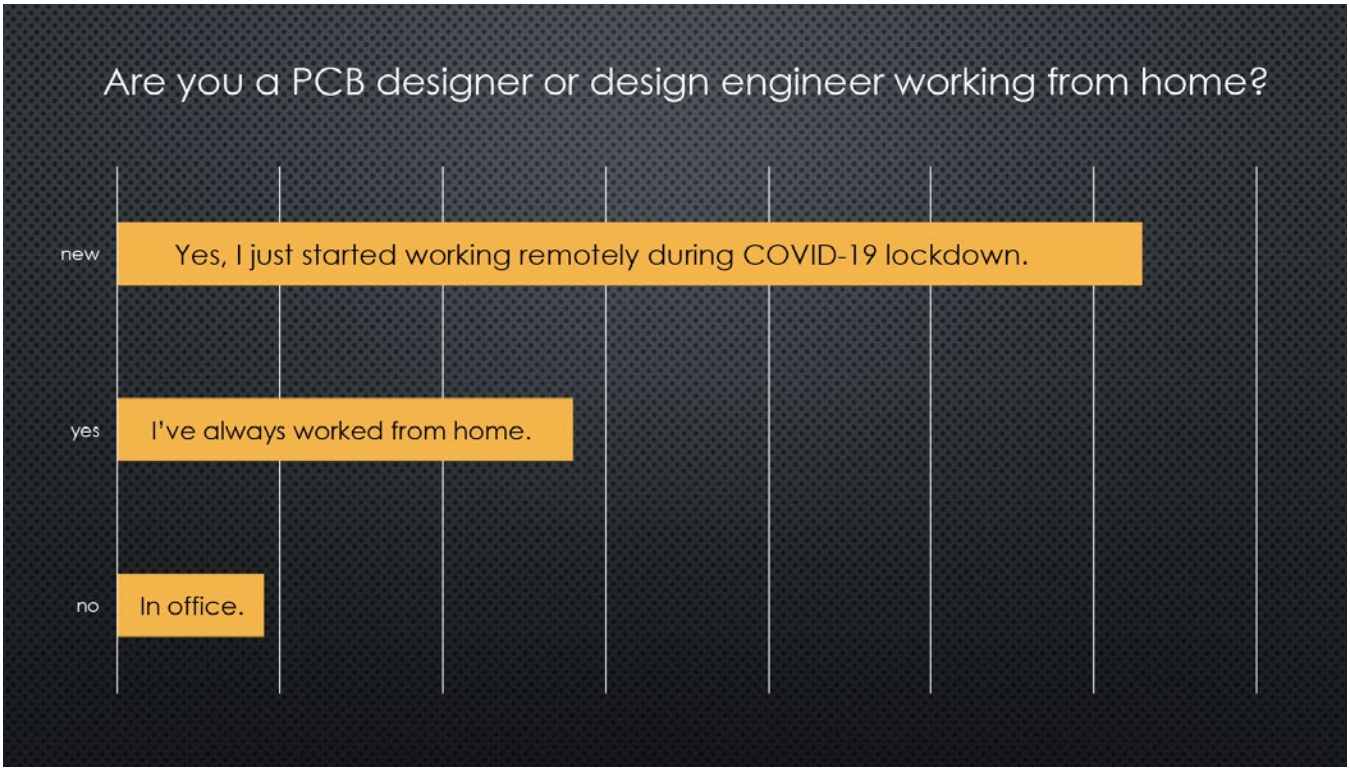

Table 1: Less than one-third of survey respondents were working remotely before COVID-19 hit.

Many respondents said that they had a difficult time dealing with family dynamics, such as noisy children and pets. Here are a few of the comments from respondents describing their work environment at home:

1. The cafeteria is not very good.
2. The social aspects of face-to-face, chance meetings, such as at the coffee station, don't happen as dynamically as they would in an office.
3. It's a better environment than in the office.
4. I'm more productive with less wasted time and better design review communication with Zoom than with staff present.
5. The main problem seems to be the personality of the clients' engineers. They are also working from home, and some are not great with remote working or with coping on their own.

Then, there's another wrinkle. On top of having to get accustomed to working from your dining room table, many of you are designing boards for military and aerospace customers. We wondered, "How can designers perform sensitive ITAR work from a typical house in a subdivision?"

For this issue, we asked a variety of experts to discuss their companies' approach to working remotely, as well as some of the cybersecurity challenges related to having employees working from home. First, Bob Murphy of Connected Enterprise Consulting at Rockwell Automation discusses the importance of considering the human element when creating new processes. Next, Steph Chavez of Collins Aerospace discusses why cybersecurity is a "necessary evil" for employees working from home on ITAR designs. Dave Ryder and Eric Cormier of Prototron Circuits address the company's ransomware attack and how other companies can protect themselves from a similar fate. Patrick Crawford shares a collection of stories by IPC technical staff regarding their experiences with working remotely. And Tim Haag provides a follow-up to an earlier column on working remotely, with some of the lessons he's learned during the quarantine.

We also bring you columns from Barry Olney, Patrick Crawford, Alistair Little, Kelly Dack, Dominique Numakura, Joe Fjelstad, and Bob Tise and Matt Stevenson. Further, we have an article by Emily McGrath of NextFlex, and interviews with Joe Fjelstad, who discusses his flex workshop, and Schmartboard founders Neal Greenberg and Andrew Yaung, who detail their new solder joint technology. Lastly, Happy Holden answers your questions about flexible circuits.

We're getting through the COVID-19 pandemic, slowly but surely. See you next month.
DESIGN007

Andy Shaughnessy is managing editor of *Design007 Magazine*. He has been covering PCB design for 20 years. He can be reached by clicking here.

About the Cover

Like many of you, columnist Kelly Dack has recently begun working from home—in this case, at a ranch named Cattleana Graziers. In our cover photo, Kelly is seen in his home office with his team, laying out "chips" to help "beef" up a power distribution network.

Human Factors in Automation

Feature Interview by Nolan Johnson and Barry Matties
I-CONNECT007

Bob Murphy, SVP of Connected Enterprise Consulting at Rockwell Automation, talks about the importance of combining people, processes, and technology solutions to achieve improvement—something that his team specializes in.

Nolan Johnson: Bob, could you start with a bit of background on you and the work you've been doing? Also, how are you communicating on this message around human factors?

Bob Murphy: I've been with what was originally Allen-Bradley and now Rockwell Automation for 41 years. I started as a production technician in manufacturing, troubleshooting earlier renditions of our products, and moved up through engineering, quality, and operations ranks to eventually hold the position of COO for our company, leading our entire supply chain for several years. I still report to our CEO Blake Moret, but I now preside over the Connected Enterprise Consulting function.

I latched onto the topic of how the people and organizational change dynamic element fits into transformation efforts several years ago. For the first time in the century-plus history of our company, we aligned all of our manufacturing operations. At the time, we merged 26 plants into one global operations organization called Operations and Engineering Services (OES). It includes all our manufacturing assets. It's all of our sourcing, material planning, and logistics functions, plus the engineering arm for our operations, but it's also all of the common engineering functions for the company where our product segment business units share similar design capabilities.

What precipitated the work from a transformation standpoint is that as we aligned all of these plants for the first time into one entity, not surprisingly, we highlighted a wealth of siloed solutions and applications employed across those manufacturing plants governing how work gets done on the shop floor. It can be really hard to leverage technologies and processes in conjunction with the people who engage with them consistently across an enterprise, and the fact was we didn't do that well across our plants. And where we actually

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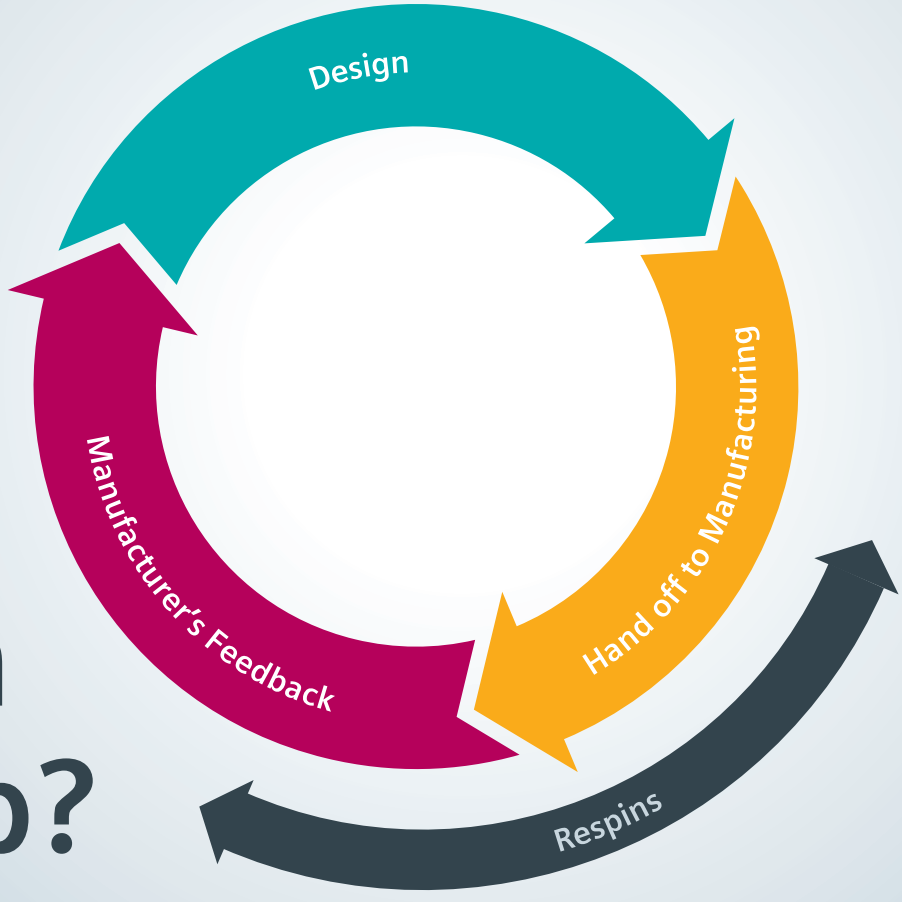

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had some processes deployed across multiple plants, the manner in which we designed them was, largely, not globally extensible. They honestly lacked the ability to truly scale out to the broader enterprise.

The founding COO, whose footsteps I followed, tasked me with the re-footprinting of our manufacturing supply chain. That involved critically assessing where we were with manufacturing. Did we need to be there, and if we needed to be there, were we doing the right things in that particular plant from a product and service perspective? Equally, we weren't presently manufacturing where we probably needed to be for a variety of reasons. I gathered a group of program managers, engineers, and practitioners to assess the current lay of the land, and we spent about two and a half years re-footprinting the supply chain. When the dust settled, we had transitioned from 26 plants across all regions to a total of 20 plants; of those 20, six were built as greenfields in that 2.5–year timeframe.

Bob Murphy

You can imagine an incredible amount of change transpiring within our manufacturing entity, and as we began to stand up the new manufacturing plants—which, in many instances, were some of our largest plants in the company—we had to decide what systems we were going to deploy. How were we going to create a more uniformed, standardized, capable, and contemporary global footprint to leverage our people, process, and technology assets? We couldn't continue to sanction all the local variations that existed across our plants for how work was getting done across what were generally very similar processes. That turned into the formulation of what has become a key market message for our company as we work with customers. We essentially "connected our enterprise" digitally in a far more contemporary and globally scaled uniform fashion. We did all of that internally, and we'll talk more later about the business results it created for us from a safety, quality, service, and productivity perspective.

As we were going through this, we found that it was very easy to focus on the technological aspects of what we were contemplating. Even the process definition and guidance aspects came naturally to a company that's founded on engineering and design principles. As we deployed these new capabilities, we found that the human and change management ingredients became front and center, so we needed to shift our priorities. There were some slips, trips, and falls along the way, but we figured it out after enough of them to recognize we had to lean a lot harder into the people element of our digital transformation work.

We started spending a lot more time talking across our enterprise about why we were doing what we were doing, not just the what and the how. There was a real end in mind that was designed expressly to create a far more competent, capable, and content manufacturing associate. It was easy for me to want to avail all of that for our associates because I was an associate way back and I knew what it was like to deal with less than capable or complete information or have to migrate during the day from one to three to five different systems to get essentially the same type of work done.

Thankfully, the things we wanted to do resonated well, and we started spending more time communicating the whys and wherefores, and the buy-in, support, and anxiety—in a good

way—started to grow. That led to very significant improvements in the core metrics of our company from a customer and an internal performance perspective.

Three years ago, when it became apparent that our journey internally was something very meaningful for others in the industry to explore, we wanted to do something to inspire the same results within their manufacturing halls. We began to share our lessons learned with many of our customers—how we got there, and what we did to pivot in terms of early mistakes. They were very intrigued because it was just practical insights being afforded, and we weren't selling anything. As a function, we were operations, talking about how we do manufacturing differently, why, and what it took to get there. The popularity of those customer interactions led to an incredible amount of time spent by me as the COO and members of our staff engaging with these customers. Our CEO and I agreed it was time to create a capability within our company where we no longer went about sharing those experiences with industry part-time. There were simply too many people in search of the same things from an outcome perspective, which was making it difficult for us to do that well, along with our day jobs.

That's when we created the Connected Enterprise Consulting function. I have a team of about 20 folks who were some of those deployment experts from a subject-matter perspective, and we brought in people from other realms of the industry who have had equally intriguing experiences. Now, we talk to current and prospective customers all over the world about what they're in search of from an improved business outcome or aspiration perspective and the transformation challenges they're trying to overcome. We often discuss how easy it is to get over-enamored with shiny technological objects, and if that's not coupled with high respect for the people element of transformation—as well as how processes and technologies come together—a firm is going to land well short of where they want to go. And if they finally do get there in spite of that respect, it's going to be an arduous trek with legitimate concerns for sustainability.

Our job is to help them find the considerations they have to entertain, and many times, engage in the development, partnering with them on their transformation roadmaps—the actual stages that they can go through to get improved performance as a company.

Johnson: You touched on three major factors: people, processes, and technologies. When you're doing your consulting work and talking to your customers and prospects, where do you start with those three?

Murphy: It has changed. When we started internally, because it was so natural, the focus was on technologies and processes. But we learned that you only go so far, and in some elements, you don't get anywhere without considering the human factors, change management, and the organizational dynamics at work. We have veered ourselves, and, with our clients, supported the notion that if you don't lean into the realities of how much change is going to be introduced—and how your people are going to embrace and adopt that in a willing and a knowing fashion versus a dictatorial one—just getting there is not the way to do business these days.

When we started internally, because it was so natural, the focus was on technologies and processes.

When we're thinking of digital transformation, there's an IT component and an OT component. And the Connected Enterprise—in terms of the enabling technologies, processes, and services that we afford, as well as how we define that as being the convergence of IT and Operational Technology (OT)—those aren't just technologies; those are people. IT and OT are functions in corporations that everyone knows didn't grow up close together in the industry.

They grew up very much apart with different charters, and in some instances, those charters were 180 degrees out of phase.

Now, we have conversations with our clients around, "If your IT folks haven't met your OT folks, I wouldn't spend dollar number one on a digital transformation deployment plan. I'd try and get them together over lunch first so that you can have dialogue around the criticality of their close alignment moving forward." There are organizational implications. It's about how you deploy people beyond getting them involved in the process and comfortable with where and why you're going to go somewhere different. You have to look at how you're structured and contemplate if that is going to work in the long term. We talk about organizational alignment dynamics and how to create global process owners where you used to have local process owners; unfortunately, this continues to perpetuate the silos of ingenuity and creativity, which aren't bad. But in our company many years ago, when they weren't globally deployable or extensible, they weren't going to solve our corporation's problems.

You have to look at how you're structured and contemplate if that is going to work in the long term.

Barry Matties: One of the things you're talking about is a cultural shift because, in many cases, you've been with the company for decades, and in a lot of cases, employees see management fads come and go. Call it what you will, but you're describing a lot of TQM principles. How do you get the employees to buy-in in a meaningful way? That must be a challenging aspect.

Murphy: It is, and there have to be proof points. You have to get to some phase of change that involves the people, processes, and technologies. It has to be the evidence that demands a verdict that that was worth the trip. The best and most effective way to engender people wanting to get on the train versus not wanting to think about buying a ticket is to start small with a proof point of how people, processes, and technologies can transform a process, plant, or enterprise if they work well together. If you start small and create those proof points, they're hard to argue.

Let me give you an example. I mentioned that we stood up six new plants across the globe. Logic would dictate that if one of those new plants—and this wasn't an if because they all eventually did—started a process with brand-new people wearing a Rockwell Automation badge, in three months, the people, processes, and capabilities outperformed a plant which had been doing that function for 20 years. People recognized that, and their responses were, "That's phenomenal. I want that. How do I get that? What shelf do I buy it on?" Others perceived that they were being lapped, wondered if it was good for them, and asked, "How did that new entity outshine me?" Still, others said, "Show me again. It worked for you once, but maybe you got lucky. Let's see two or three other similarly difficult processes performed well with new people in a new area."

That's all fair, but we try to be respectful of all of those different responses to new processes being launched. We ensured that as one process began to outperform its legacy somewhere else, the last thing we were going to do was call somebody green and somebody else red from a performance standpoint. Rather, we created a role for the first time called the global process owner. One of the processes that Rockwell deploys across many of our plants is making PCB assemblies. It's hundreds of very fine-precision parts mounted on a PCB, and together, they make a circuit(s) to perform a function.

In the past, within Rockwell, every plant that conducted that function had its own process engineering and edge applications that bolted onto the assembly equipment. The chip shooters, reflow ovens, optical inspection devices,

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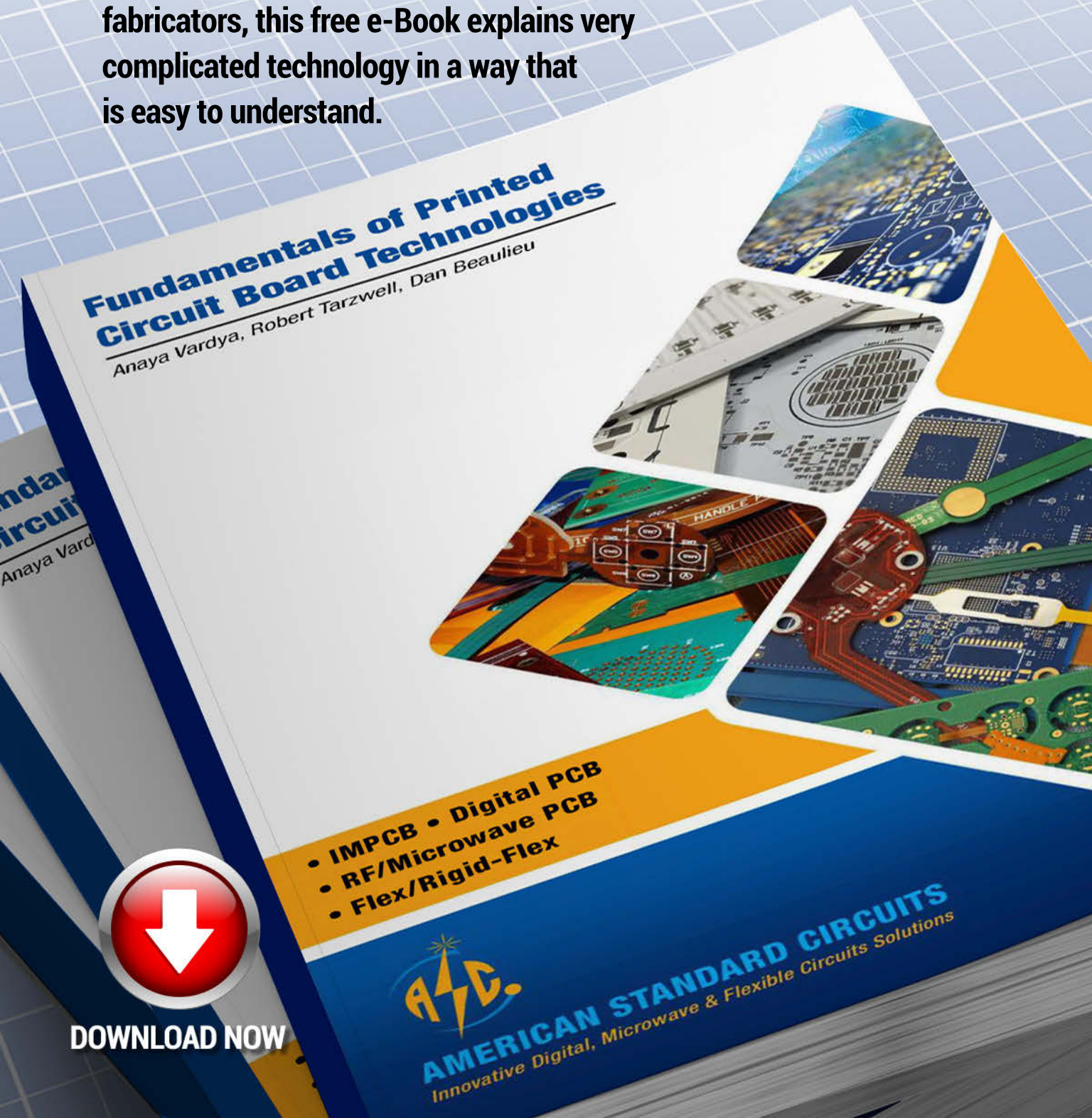

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Rockwell Automation's global headquarters in Milwaukee, WI.

etc., did as many things as they could locally to optimize those processes. But there was no one person who was looking over how all of those manufacturing cells were performing in contrast to one another and trying to figure out if there was a better recipe for processes, people, and technologies to be deployed that every cell could benefit from.

We set up a global process engineering function where we took who we believed were the subject-matter experts from wherever they were around the globe. This is truly how it worked; on Friday, Juan in Monterrey, Mexico, was responsible for that location's PCB assembly capability. Coming into this organization as a global process owner on Monday, he was suddenly responsible for improving the capability of six PCB assembly locations around the globe. Here again, we had to guard against the possible reactions of, "Is somebody else's good news bad news for me?" So, we began to deploy these resources in a fashion that was anything but judgmental or punitive; they were sincerely helpful and incremental to advancing all those sites' process capabilities.

Quickly, the reservations dropped. We created a transparent view of data across the globe. Everybody could see how everybody else was performing. There were no walls anymore, and all the meaningful performance data was transformed to be consistent. It was digitally enabled, so it was accurate and available in real-time, and we had analytics that were irrefutable, professing, "If you do this, that will be the result." It wasn't just descriptive analytics we were leveraging anymore; it became much more about predictive and prescriptive insights being gleaned. That allowed one process after another to be deployed globally with more capabilities, and the level of performance rose for everybody over time. That created confidence in the people who were watching this happen that these changes were truly a good thing.

At Rockwell, our job is to expand human possibility. When people begin to feel that in

a measurable way, they feel pretty good about it. They're more capable. They're more confident in their jobs and roles. There's a tangible difference between the kind of work they used to do that might have been mundane and repetitive, if not error-prone, to predictable, confident, and more contemporarily enabled from a technology standpoint. That expands their capability, which expands the company's performance. As a company, our mission is to espouse those very same principles with our customers.

Matties: It sounds like what you transformed into is a company that's in an endless pursuit of process improvement rather than reactionary process engineering. When you look at the endless pursuit of process improvement or continuous improvement, what drives the engineering? Is it market-driven in terms of markets that you pursue, or how do you set your technology roadmap for your process?

Murphy: It is increasingly an outside-in driven roadmap, meaning we want our customers and their needs to drive what we should do internally to satisfy those new outcomes for which they're searching. For example, if our historical lead-time expectation for a given product or service is suddenly met with what used to be affection but is now disdain, something has to change. The increasingly short lead times for information, products, and services that we all enjoy as private consumers has established a new bar for what's expected by all industrial customers.

That filters down to our supply chain, so as we embark on what we have to do differently from a performance standpoint, our customers demand something to be done in three hours that used to be done in three days. The next question is, "How are we going to do that?" That sets in place the people, process, and technology solutions that should be brought to bear to achieve that order of magnitude improvement. It ranges from something as significant as that to the kaizen of "a little better every day in every facet of what we do" type of improvement activities.

What's different now is how that happens across our company, and many of our customers are not deploying resources toward continuous improvement on hunches or saying, "I have this gut feeling that we're not doing well enough in this given process capability." We let the data speak for itself, and we respond to that with whatever corrections, changes, revolutions, or evolutions we need to make in the process to respond to it. There's a respect for that information because we gather it similarly in every plant across the globe. Our operators engage with our equipment in an entirely similar construct now. They use a single pane of glass to conduct whatever affairs they're doing from a production, quality, and traceability perspective.

We leverage that technology to the benefit of the users, and for us, there's no more important user than our manufacturing associate. It's important that they have the right information, make the right calls, and add value versus conducting mundane transactions that, in the past, weren't adding a lot to our company or customers. Our focus on continuous improvement really hasn't changed in terms of its criticality to us, but how we do it, and what it has enabled in the way of markedly better outcomes has indeed changed.

Matties: When you do continuous improvement, you have to look to your suppliers to buy in as well so that they're delivering your raw materials when you need it and communicating with your systems in the right way. What was the challenge there?

Murphy: Supply chain is required to improve. You can't just look for step-function improvements in performance within the four walls of your manufacturing plants, whether there are 20 or 200. You have to look at the entirety of the supply chain, including the upfront sourcing, forecasting, and planning for that material, as well as the backend logistics and optimization of that network of getting products through distribution and to customers. We quickly began to take our continuous improvement and extend it beyond the four walls of our plant into that broader supply chain. We

knew there were some suppliers that were going to be fully onboard and capable of driving these improvements, allowing us into the digital construct of their information, so we could deploy the same optimal techniques of planning and delivering on that supply chain. Many suppliers were all-in and ready to deploy with us in that regard.

Others weren't nearly as ready and willing for a couple of reasons. First, they might have lacked the enabling technology and infrastructure and weren't at that level of being able to provide it so that we could integrate more seamlessly from a digital standpoint. Secondly, some suppliers believe that information is a part of their secret recipe or intellectual property, and this still persists in our industry. It very well can be a form of intellectual property, and to expose those parameters and information to the downstream supply chain could be viewed as a threat to them.

In response, we have to recognize that their hesitation is sincere. They're not just being difficult; they're genuinely concerned about what could go wrong if some of that information were used in an untoward fashion for them as a supplier. We make sure that we only ask for things that are not IP or recipe-oriented.

We make sure that we only ask for things that are not IP or recipe-oriented.

But we also talk to them about their reservations. We say, "Let's think back. How comfortable were you when EDI came on board initially? How comfortable were you with the types of information that were used or exchanged for personal purchases on your smartphone?" Early on, all of us had hesitancy about what could go wrong, and things have gone wrong. We have to respect that it has created some of this hesitancy by suppliers to engage in the transparency of information, but we also have to share with them that when you open up the right information to the right partners, everybody can benefit.

Some of that is education and encouragement, but in many instances, I think it's just going to take time. The industry will become more comfortable with sharing pertinent information that is not IP, but is enabling from a supplier or a consumer standpoint, and will recognize that all parties have a chance to benefit from it. So far, we've had mixed results; some are well in our camp of thinking and supporting that full end-to-end digital construct of information exchange, and others are still hesitant.

Matties: We hear that there's some reluctance from fabricators about sharing their capabilities to designers to produce appropriate fab notes.

Murphy: When I hear that, I think, "How could reasonable people not understand that availing the most pertinent information to all parties is going to be good for all parties?" But when you think about where they maybe have been informed to be hesitant, you understand that human element of confidence versus hesitation. I believe that this journey will take a while for everybody to respect and understand that there's so much more to gain by sharing that pertinent information than there ever is to lose. Through cybersecurity and otherwise, there are ways to secure anything that could go wrong. When you're allowed to have that conversation and show them architecturally how they are protected, most people are going to come around, but that's a perfect example you cited of why wouldn't you want to do that. They're not ready.

Matties: The only answer I can come up with is that it's a fear-based response.

Murphy: Correct.

This interview originally appeared in the July issue of *SMT007 Magazine*. To continue reading the remainder of it, click here.

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Alternative Series Termination Techniques

Beyond Design

by Barry Olney, IN-CIRCUIT DESIGN PTY LTD / AUSTRALIA

In a previous column on "Transmission Line Terminations," I discussed the three most common termination strategies: series, end, and differential. These techniques are used to eliminate impedance mismatch and hence reflections to avoid crosstalk and electromagnetic radiation. As a general rule, transmission line (trace) termination is necessary when the round trip propagation time of the signal is equal to or greater than the transition (rise or fall) time of the driver; otherwise, there will be data errors caused by signal degradation. In this month's column, I will elaborate on two particular cases of series termination that every PCB designer will come across.

1. Distributing a Clock to Multiple Loads

The objective of the clock is to provide circuit timing and thereby coordinate the activity within the system. With memory circuits, the clock pulse will trigger the input and output of data, and therefore, must be timed such that each bit of data arrives and stabilizes before the next clock cycle. To do this means that both the clock and data lines must be routed to exact delays within the specified setup and hold times. Since digital signals cannot be sped up, the only option is to add length to the line to delay the signal arrival to match the arrival speed of the longest lines in the bus. However, the clock signal should always be the longest delay of all so that the data signals have time to settle before they are clocked.

Routing clock signals to multiple loads can be done in many ways. A buffer could be used for each individual receiver, or the use of a dedicated clock driver incorporating a phase-locked loop (PPL) to synchronize the timing is also a common solution. However, this adds to the cost and consumes precious real estate.

Star routing is ideal for distributing a clock to multiple loads in low- to medium-speed

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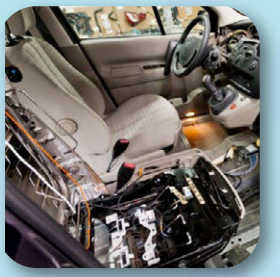

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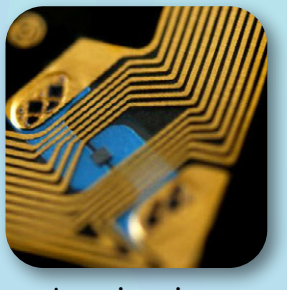

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designs. The routing fans out from the driver through a series resistor for each load. This reduces reflections. The delay for each leg is then matched for each load. For clock lines with multiple receivers, it is best to route to the receiver that is the farthest from the driver first, and then match that delay when routing to the other receivers.

Clock signals generally have a fast rise time and hence are noisy due to high harmonic content; as a result, they must be isolated from the rest of the circuitry. To reduce the impact of a noisy clock circuit, it is good practice to locate the clock circuitry in the center of the PCB and star route out to the loads in precise patterns and at a specific delay.

The electromagnetic fields surrounding a microstrip (outer layer) trace exist partially within the dielectric material(s) and partially within the surrounding air. Since air has a dielectric constant of one, which is always lower than that of FR-4 and solder mask (typically 4.3 and 3.3, respectively), mixing a little air into the equation will lower the effective dielectric constant and speed up the signal propagation. Even if the trace widths are adjusted on each layer, as the impedance is identical, the propagation speed of microstrip is always faster than stripline—typically by 13–17%.

The speed of propagation of digital signals is independent of trace geometry and impedance but reliant on the dielectric constant of the materials. Therefore, if a signal changes layers in the stackup, then the delay will also vary. If you are aware of this issue, then the trace delays (Figure 1) can be matched to compensate for the varying flight time so that at the nominal temperature, all signals running on either microstrip or stripline will arrive at the receiver simultaneously. PCB designers should always match delays—not length.

Before starting placement and routing, detailed interconnect routing constraints should be established. These constraints—based on pre-layout simulation, manufacturing restrictions, and IC manufacturer's recommendations and guidelines—will control the place-

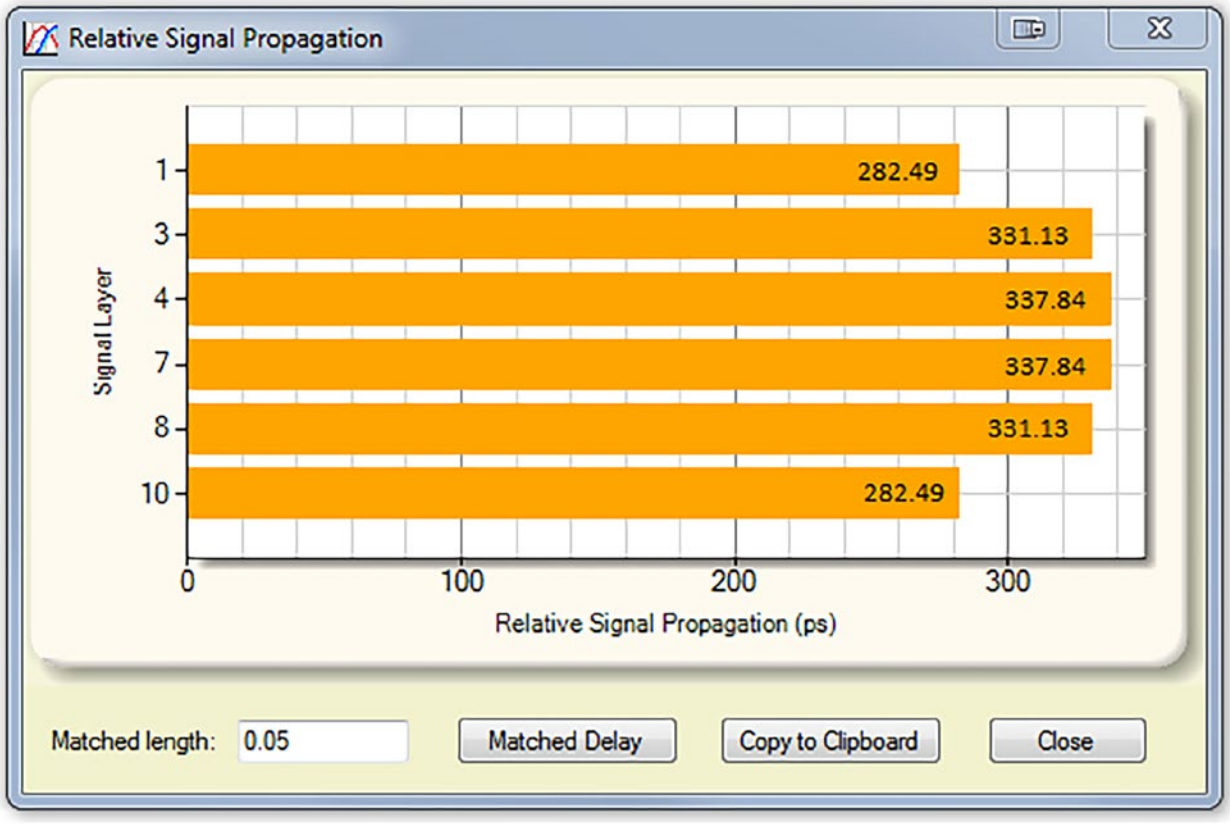


Figure 1: Relative signal propagation of microstrip and stripline (simulated in iCD Design Integrity).

ment and routing processes. Online design rule checks (DRCs) will warn the designer when a constraint is violated.

On a multilayer PCB, clock signals should be routed on a stripline (inner layer) sandwiched between two solid reference planes to reduce radiation. The spacing between the signal trace and the return planes should be as small as possible to increase coupling and reduce the loop area.

The three constraints to keep in mind include:

1. Route clock signals between the planes, fanout out close to the driver (200 mils) dropping to an inner layer, and route back up to the load again with a short fanout. A series terminator is required for each load.
2. Use the same reference plane (GND if possible) for the return signal, as this reduces the loop area and hence radiation.
3. Minimize crosstalk to other signals by keeping a distance of at least three times the trace width to sensitive signals.

2. Bi-Directional Data Termination

With series termination, the resistor needs to be close to the source (Figure 2). This ensures that the reflected pulse sees the internal driver source impedance and the resistor in series (usually totaling 50 ohms). Since this matches the transmission line, it completely absorbs the reflected energy. However, data flows in both directions from the CPU to the memory, when writing to memory, then back from the memory to the CPU for reading the memory data. Where do we place the series terminator in a point-to-point configuration—at one end of the data-trace, or maybe in the center?

Out of habit—or perhaps for fear of doing the wrong thing—one would usually put the termination close to the CPU rather than the load. The simulated waveforms of the impact of having a termination resistor close to the driver, close to the load, and also in the middle of the transmission line show little distinction. However, there is a better unconventional solution: placing a termination resistor at each end of the transmission line (Figure 3). Figure 4 presents an improved eye diagram using this solution for both the read/write cycles. The blue waveform is the termination at both ends—the red and green waveforms are at either end of the transmission line.

Having a resistor at both ends of the transmission line, close to the driver and load, is an elegant solution as the resistor and input

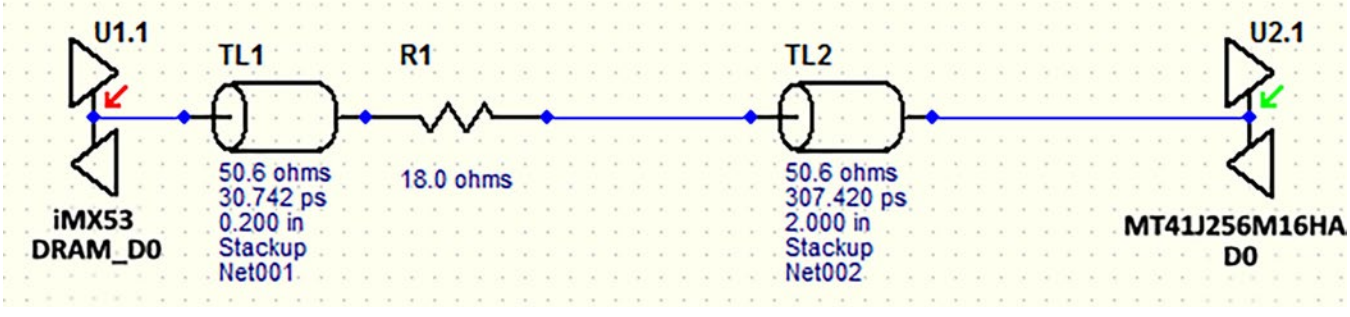


Figure 2: Typical series termination with a resistor close to the driver.

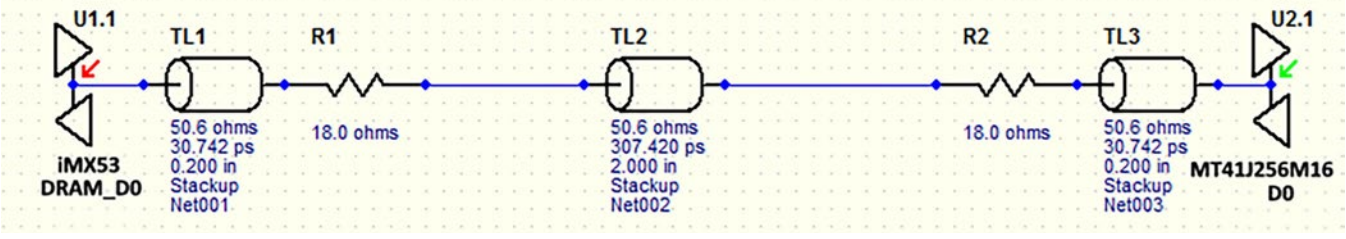


Figure 3: Series terminations at both ends (simulated in HyperLynx).

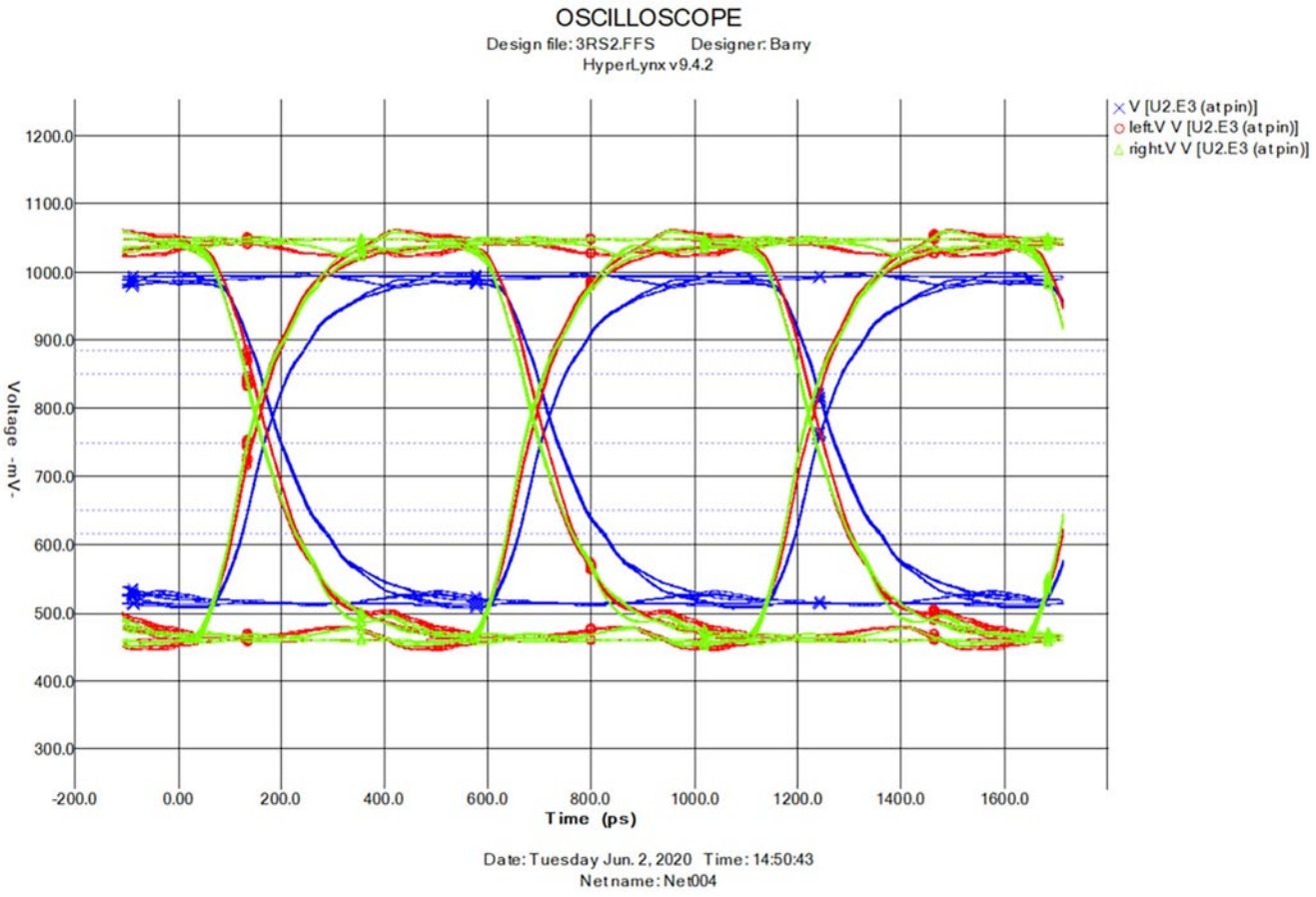


Figure 4: Comparison of the termination of both ends (blue) vs. the termination at either end.

capacitance of the tri-state load basically form an AC termination reducing reflections.

On-die termination (ODT) is implemented with several combinations of resistors on the later versions of DDR memory. Designers can use a combination of transistors which have different values of turn-on resistance. In the case of DDR2, there are three kinds of internal resistors: 150-ohm, 75-ohm, and 50-ohm. The internal on-die termination values in DDR3 are 120 ohms, 60 ohms, 40 ohms, and so forth. But for devices that do not incorporate ODT, dual-series terminations suffice.

Key Points

- The three most common termination strategies are series, end, and differential.
- Transmission line termination is necessary when the round trip propagation time of the signal is equal to or greater than the transition (rise or fall) time of the driver.
- The objective of the clock is to provide circuit timing and thereby coordinate the activity within the system.
- For clock lines with multiple receivers, it is best to route to the receiver that is the farthest away from the driver first, and then match that delay when routing to the other receivers.
- The clock signal should have the longest delay of all so that the data signals have time to settle before they are clocked.
- Star routing is ideal for distributing a clock to multiple loads in low- to medium-speed designs.
- Clock signals generally have a fast rise time and hence are noisy due to high harmonic content; as a result, they must be isolated from the rest of the circuitry.
- The propagation speed of microstrip is always faster than stripline.

- The speed of propagation of digital signals is independent of trace geometry and impedance.
- PCB designers should always match delays—not length.
- Clock signals should be routed on a stripline (inner layer) sandwiched between two solid reference planes to reduce radiation.
- Placing a resistor at both ends of the transmission line, close to the driver and load, is an elegant solution to terminate a bi-directional signal. **DESIGN007**

Further Reading

• B. Olney, "Beyond Design: Transmission Line Termination," *Design007 Magazine,* March 2020.

• B. Olney, "Beyond Design: The 10 Fundamental Rules of HSD Part 4," *Design007 Magazine,* December 2018.

• B. Olney, "Beyond Design: Signal Flight Time Variance in Multilayer PCBs," *The PCB Design Magazine,* December 2017.

• B. Olney, "Beyond Design: Effective Routing of Multiple Loads," *The PCB Design Magazine,* February 2014.

• Cadence Design Systems, "Contamination Delay in Clock Circuits: Best PCB Routing Techniques," February 24, 2020.

• H. W. Johnson & M. Graham, *High-Speed Digital Design: A Handbook of Black Magic,* Prentice-Hall, 1993.

Barry Olney is managing director of In-Circuit Design Pty Ltd (iCD), Australia, a PCB design service bureau that specializes in board-level simulation. The company developed the iCD Design Integrity software incorporating the iCD Stackup, PDN, and CPW Planner. The software can be downloaded at icd.com.au. To read past columns or contact Olney, click here.

Samsung-Accelerated Startup Luple Launches Devices to Balance Circadian Rhythms

Olly, a light technology device from Samsung's startup incubator, launched on Kickstarter and reached its funding goal in just 3 hours. The product is dedicated to helping users find balance in their everyday routines and comes in two versions–Olly Day, which helps users stay awake during the day, and Olly Night, which encourages deeper and more holistic sleep at night.

Olly Day's wavelengths mimic sunlight to keep users feeling energized and to provide a natural energy boost without the side effects commonly associated with caffeine. The device boosts focus in just 20 minutes and can work more effectively and quickly than a cup of espresso.

Unlike LED lights that suppress the natural production of melatonin in the body, Olly Night's wavelengths encourage melatonin production to prepare users for a night's rest. The device emits a warm light and automatically turns off in 30 minutes.

"We've heard many stories from people who rely on sleeping pills or excessive amounts of caffeine, and we wanted to provide something that would help people stabilize their biological rhythms in a more natural way," said Ardor, the founder and CEO of Luple.

Each device is compact, portable and can be used simply by placing it on its magnetic lid and angling the light at a tilt. Olly takes two hours to fully charge with a USB-C cable, and a single charge can run for six hours.

(Source: PRWEB)

When Working Remotely, Cybersecurity Is a Necessity

Feature Interview by the I-Connect007 Editorial Team

When we started planning this issue on working remotely, we knew we'd have to speak with Stephen V. Chavez, chairman of the Printed Circuit Engineering Association (PCEA). He is a staff engineer and senior PCB designer at Collins Aerospace and a frequent contributor to *Design007 Magazine*. Steph's company does a lot of ITAR work, which demands some of the tightest cybersecurity available. We recently asked Steph to discuss some of the security measures that his company employs and what his experience has been like since he began working out of his home office full-time several months ago.

Andy Shaughnessy: Welcome, Steph. You told me that your company employs a lot of cybersecurity measures. Tell us about that.

Steph Chavez: Yes, we do. For example, to log into this call, it took three different types of security measures to access it. One of them is an initial handshaking stage that takes place between my cellphone and computer to log in. Once I get past that certain coded handshake, then my regular log-in security kicks in. Next comes the final security stage. I'm now logging into a corporate VPN, which is another encryption in itself. There are so many barriers to cross just to get logged in and up and running these days. These little bits of time—two to five minutes here and there—add up; at the end of the day, you've spent about an hour waiting for the system to get past that encryption if you had to reboot more than once. Not only do these bits of time add up, but these security measures tend to slow down our software tools as well, due to all that is going on behind the scenes during your daily activities.

Shaughnessy: You already had this before the COVID-19. Have you had to add any new measures because of working at home?

Chavez: No. We are just more diligent. For example, we're getting more protected emails, reminding us that we're remote. For example, I've been working from home 100% of the time since May 11. I don't have access to my personal printer at home due to the security measures in place. If I want to get access to my personal printer here at my home, I have to go to a certain install from my IT department. And if I choose to do that, the only way I can print is to be hard-wired in. It can't be on the wireless network.

All our laptop USB drives are disabled for the most part. The USB readers are disabled. If you stick anything in there, it will reformat it. You can't read anything. These measures were already in place before COVID-19, but it has forced us to sharpen our cybersecurity template that was always there.

Barry Matties: What about your internet connection? At home, are you on a VPN?

Chavez: That's correct. I'm on a VPN. We've always had our VPN when working remotely. That was never an issue. Now, with COVID-19, everyone is working remotely all the time. For those of us on the West Coast, by the time we would log in, it would be either late morning or afternoon for the East Coast. It was difficult due to network overload. We were lucky to get in at all and on time. But the company quickly established another option for VPN. We adapted and created another VPN network, so now we have multiple options to get on. Now, it's a non-issue.

Matties: What advice about cybersecurity would you have for designers who have just started working remotely?

Chavez: Like anything else, when you're working from your home network, you need to make sure your home network is secure. Whoever your network provider is, and whatever hardware you have at home, you need to make sure that it's rock-solid so that you can perform at your maximum. I use my local provider, which is Cox Cable in Arizona. I have my personal network set up as a private network. It's encrypted so that I don't have it wide open, which prevents any exposure of my data to the world. That's one thing that I would highly recommend. Also, be mindful of the emails you come across. If it's something you don't recognize, or you don't recognize the individual sending it to you, don't open it. There's a big issue with phishing. Getting a lot of phishing emails is a constant issue.

Dan Feinberg: You're running a VPN on Cox, and I am as well. I've also been teaching cybersecurity for the Cyber Café in San Clemente for 10 years. What do you notice with your VPN? When you're running your own personal computer stuff, do you run a different device or use the company device for both?

Chavez: I use my own personal computer for my own personal use, and then I use my Collins laptop for Collins business, all on the same Cox VPN to access the internet. The difference is that my work laptop has so many additional cybersecurity measures on top of my personal security measures with my Cox VPN. There are times when it's blended. If I'm off on a lunch break, or I do something quickly—such as answer a personal email sent to my Collins email address—then I'll respond on my company laptop.

Right now, I'm on my Collins laptop VPN because I was doing work earlier before this meeting. I'm on this laptop most of the time while working from home, but typically, I have my own personal laptop along with my other family members with their own laptops in the house. My work laptop is always running through a VPN on the Collins network, while its connection to the internet is compounded with my private VPN network through Cox. It's basically a VPN on top of a VPN with whatever additional security Cox provides.

The biggest hurdle that comes at me every now and then regarding network activity would be the amount of data that I'm upload-

ing and downloading; depending on the rates of speed for these activities comes multi-tiered expense levels. Before COVID-19 and all this isolation, I wouldn't have even given it a second thought. I'd say, "It's not necessary to purchase the highest-tier level, unless you are a heavy streamer, a high-end gamer, or running an e-commerce business out of your home. The mid-tier is fine."

Now, I've been at home for a few months, and I don't see myself ever going back to the office full-time again. At Collins Aerospace, there are different phases of when they're allowing employees back to the office. Those who can work remotely right now are being asked to stay remote. I don't see this changing any time soon. Thus, I will re-evaluate the higher-tier level with Cox Cable.

Matties: I think it goes to a shift in thinking in that you can now hire people and not be bound by region.

Chavez: You're right. Not only that but if you allow someone in an environment where they're at their most optimum, you're going to get the best out of them. My eight hours of effort may not be from 8:00 a.m. to 4:00 p.m.; my hours may be sporadic throughout the day, but at the end of the day, I've accomplished just as much—if not more than—what I accomplished sitting in my company office for eight straight hours.

Feinberg: Not only that, but when you're working out of your home office, if something comes up late in the day, instead of saying, "I'll wait until tomorrow," you just run into your office and do it.

Chavez: Exactly! Here's one thing that my wife brought to my attention: My daily work efforts have almost doubled. Instead of working eight to 10 hours, I now work 12 to 20 hours. I just don't realize it because I'm not in my office all day long; I'm going back and forth, coming in and out of my office while doing stuff. Before I realize it, it's 9:00 p.m., 10:00 p.m., or 2:00 a.m. the next day. Then, work-life balance can become an issue. Everyone is different, as is everyone's situation, so riding that fine line of work-life balance is the challenge.

Matties: Have you noticed any tangible increases in productivity?

Chavez: Overall, I would say yes—no daily commutes to the office and less water cooler chatter. Here is a scenario: While you're in the office, you get a cup of coffee, see a colleague, or walk by someone's cube, and without notice, you stop and chat. That five minutes that you think it's going to take to say a few things turns into 20 minutes, and you haven't even gotten the cup of coffee yet. While working from home, more than likely you have fewer interruptions and walk-ups to your cube. Keep in mind, though, that working from home has its own challenges these days with COVID-19. If you're working from home and with small children, you're on a whole new level of challenges. God bless you, and good luck with that!

Matties: Saving on commute time also saves on gas and mental fatigue.

Chavez: Definitely. It takes me an hour to get from my home in Surprise, down to my office in Phoenix. I instantly gained two hours a day of optimization from being at home. That's huge. For many of us, we have eliminated that dreadful daily commute to and from the office. In my case, I regained about two hours back in my day! This directly and positively impacts my work tremendously! I am now able to give an extra two hours per day times five days a week. That's 10 extra hours gained into my weekly schedule that helps me be that much more successful at work. With that in mind, I'm just one employee; multiply this by a several thousand employees, and I'd say that's a silver lining in this dark cloud.

Feinberg: And you're not even in California. With us, it could take 20 minutes to get to the office or two hours. We don't measure in miles here; we measure in time.

Chavez: Exactly. I live about maybe 27 miles from the office, but it just depends on the time of the day like when I used to live and work in Orange County, California.

Feinberg: But there is a different side of it, too, and that's when you do have that coffee with a fellow member of your team and talk for 15–20 minutes, ideas come up. Two and two equals five. There is that factor that you don't have working remotely. There are a lot of pluses to working at home, but there are some negatives as well.

Chavez: You lose that "Aha!" moment when you're talking to a colleague at work. When you hear two people talking about a problem, walk by, and stand there while you're waiting for your coffee, you may chime in your two cents, and now they have a solution. The negative side of working remotely is losing those old-fashioned, face-to-face co-worker interactions.

Matties: Good point. When you start talking about young engineers, now they're sitting in their homes doing this. How do you go about mentoring while working remotely?

Chavez: The only way to do it is how we're doing it now. You must have teleconferences to go over designs and check things. You just have to go the extra mile, but if a young engineer is hungry and has a good mentor, they will feed off each other's energy, and it can still work. You don't have to be in the office to get that. It's just a culture shift and "buy-in" for remote collaboration by everyone on the team and within the company. In my opinion, it's the key to global integration success.

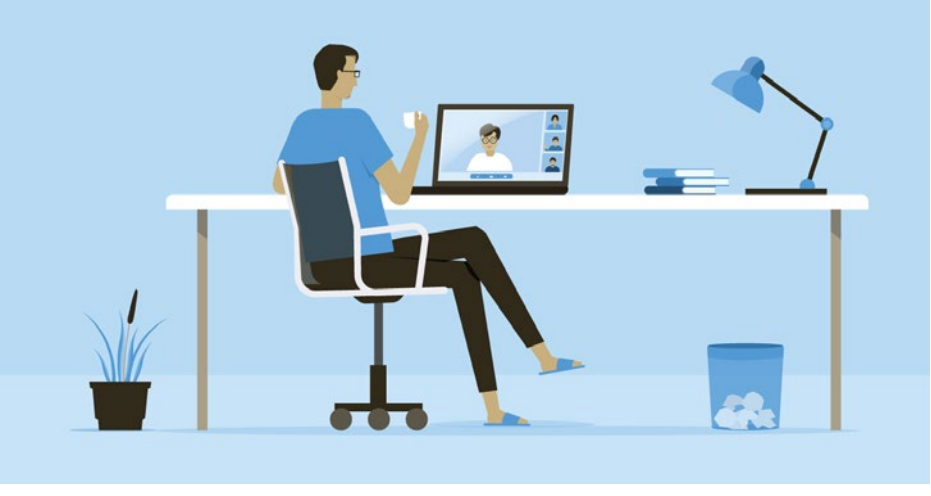
Matties: It sounds like—aside from your good housekeeping, staying on the VPN, and keeping your files in order—the security issue is driven by your IT department.

Shaughnessy: Do you have design teams around the world?

Chavez: We do. We have multiple business units strategically placed throughout the globe. For example, we have a division in Bengaluru, India, that is another engineering center. There are times where we'll work on a project and hand them data to work on overnight. But before the project even starts, there's so much internal structure that's set up. You must buy-in to global collaboration and commit to making sure that you're transporting technical data appropriately, it's approved, and that the data is non-ITAR. Who's accessing what data? At what access point are they accessing it? It's a lot of control.

Shaughnessy: Can you tell us about your design data transfer process?

Chavez: I use Xpedition as my primary PCB design tool in my daily tasks. If I am collaborating on a design with global team members, then at the end of my day, I zip up the design database and put it in our PLM system called Team Center. Then, I'll inform my colleague in Bengaluru, India, for example, that the design is there. I'll give them instructions about what I want them to work on overnight. I hand it off to them, and then I'll establish a hand-off teleconference. The time difference is 12.5 hours, so I'll set up a call at 8:00 p.m. for me in Arizona, which is 8:30 a.m. in their time zone.



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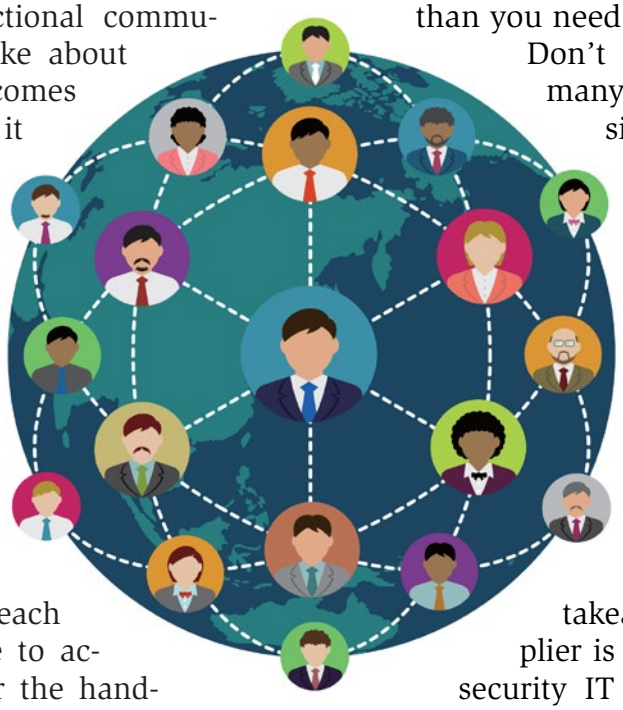
When they get in their office, and they get settled in, they'll access Team Center—which is our PLM system—download the zipped database, and open the data. Then, we'll walk through my instructions to make sure that we're all on the same page. This process is not unique to us. Everyone in the industry, no matter what part of the industry you're in, basically does this. If you're working on a global team and are located in different time zones, you are—more than likely—doing this same basic process in one form or another, especially if you work for a global service bureau.

At the end of their shift, they'll repeat the process, but it's bi-directional communication; make no mistake about that! The database then comes back to me. They'll put it back in Team Center, and we'll have another call early in the morning, which may be 5:00 a.m. for me. Then, we'll have another handshake, and I'll take the database and go from there.



The downside is when you have network problems. At that point, even though we can call each other, I may not be able to access the updated data or the handoff data I initially gave them. It screws me big time regarding project schedule because if I lose time in my scheduling and my anticipated amount of effort that I expected to get completed overnight, it's not there when I wake up the next morning, and I was not initially notified, that means I lost an entire day's effort. Network problems pose their own challenge.

Matties: How closely do a tool supplier and your cybersecurity team work together? What's the expectation of cybersecurity from an EDA tool company?

Chavez: We have a dedicated person whose main role is engineering tools. I want to say they are blended with IT and tools administrator for engineering tools. They handle all the Mentor tools in our integration and work extremely close with Mentor and the IT department to make sure we're all in sync. If we're not, you can very easily grind a company to a halt, and we'll be dead in the water. No company can ever afford that. And Mentor is very eager to jump for us and is "Johnny-on-the-spot" when it comes to providing support. In my 15+ years using this tool, in my opinion, they're the best—second to none! They're going to flood you with support so that you can be successful way more than you need.

Don't get me wrong; we have many other tools we use besides Mentor's Xpedition that are successful—Cadence Allegro, Altium, and OrCAD are other tools we use as well. I would say that most of our tool providers are doing their part to make sure they're not adding any potential weakness that I know of.

Matties: The important takeaway is that the tool supplier is working with your cybersecurity IT team to make sure that whatever the challenges are, they are being addressed and handled.

Chavez: Absolutely. We constantly get emails that are spot-checks for us. We'll get random emails that we can't tell if they're real or fake. Typically, we'll get an email testing us, and if we don't recognize who it is, we have a quick "report phishing" button so that you can quickly report it. Then, all of a sudden, you'll see a little message that says, "Good eye. Good check. There's a reason why this was a bad email." Our cybersecurity department is constantly testing us to keep us on our toes. Especially now working remotely, cybersecurity is a huge issue because it's easy to get infiltrated

if you're not on a VPN network. We stopped using Zoom initially because some companies don't allow their computer systems to get into Zoom, but that had since changed. We have transitioned to ZoomGov.

Matties: What are the accountabilities? When you're working in a shop or an office, everybody can see what you're doing and see your productivity. Is there a metric, such as what your output had been in the facility, and then your output working remotely is either higher or lower?

Chavez: From what I can see at my business unit within Collins Aerospace and the other business units that I collaborate with, we have become more fine-tuned. We have more WebEx meetings than we normally would because we usually have a stand-up meeting in our office war room. You'd go in for five minutes, report your status, and go back to your desk. Now, we have meetings that we call scrums or sprints to get a status of where we are in our tasks. Let's just look at the positives. We have performed on a sharper scale, so to speak, and we've performed more highly, even though we're remote and not face to face. We're just as effective, if not more. This has proved that working remotely does work, and it can work effectively. We're actually more connected now.

Matties: You're more connected, or in our case, more "I-Connected."

Chavez: That's right. You're definitely more in sync and locked in. Just because you're remote doesn't mean you can't pick up a phone to be more direct than an email. I don't mind sending emails, but emails can get lost very easily. Each of us receives 50–100 emails daily. God forbid if you're management, then you probably get more than that. For some, working remotely has forced people to pick up the phone and call about issues. Embrace working remotely and take advantage of Zoom, WebEx, and GoToMeeting to handle business.

Shaughnessy: Do you have any final thoughts on cybersecurity and working remotely?

Chavez: My final thought is that cybersecurity is a dreadful necessity, and I say dreadful because it slows us down in our day-to-day activities, but it is still necessary. We complain, "I have to change my password every so often. Why does my password have to be so long?" All it takes is one time for you to be personally hacked, and your world will be turned upside down—especially if your personal financial accounts are hacked. I guarantee that you'll be using the whole alphabet to make sure your passwords are all locked and tightly secured. Don't let it slow you down.

Matties: This has been great, Steph. We appreciate all of your help.

Chavez: It's my pleasure, and I'm glad to help. Thank you. **DESIGN007**

There Is No Knowledge That Is Not Power

Design Circuit

by Patrick Crawford, IPC—ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES

I'm starting this month's column with an exercise in guided association. Let's clear your thoughts and tie you to the moment: Listen to the sound of the wind, the whirring of your desk fan, or the hum of the fluorescent lighting. Do you feel grounded? Are you ready? If so, speak these three letters: IPC.

Now, reflect on the other words that came into your head.

I bet you conjured up words like standards, specifications, committee meetings, CID, or something similar. And of course, this makes perfect sense—for decades, IPC and its committees have worked to become the premier standards body for global electronics manufacturing. However, if you're like the many board designers I've spoken to since I arrived at IPC, the key phrase that probably did not come to your mind was continuing education.

This month, I want to tell you why you absolutely should associate IPC with opportunities for continuing education. I will detail how IPC Education's newest programs can empower you to grow as a printed board design professional and become more competitive in both your current job and the job market at large.

First, I think it's important to discuss why IPC cares so much about your professional growth. Put very simply, we exist for your success. Our mission statement declares, "IPC is dedicated to furthering the competitive excellence and financial success of the electronics industry." A key part of achieving that goal is ensuring that employees have the knowledge

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and skills to compete in an ever-changing global marketplace.

IPC Education exists to identify skill gaps in our industry and develop training materials to close those gaps. These materials start as a question posed to electronics engineers, tool operators, managers, designers, and other industry professionals around the world: where does a lack of knowledge and skills hamper you or your company's ability to perform at a level that ensures your continued competitiveness and profitability? IPC Education, its learning specialists, and a team of industry experts work to answer this question by developing effective and engaging educational programs to meet its challenges. The end-users of these materials get the best of both worlds: industry experts who define and ensure the accuracy of the required knowledge and skills, and instructional experts who create meaningful learning experiences.

Over the past few years, IPC EDGE's online learning platform has pushed the boundaries of what can be delivered to the electronics industry.

Many of you already benefit from these educational programs. If you are CID or CID+ certified, it means the study materials you received before the examination were developed by IPC Education in conjunction with IPC Certification. But these materials extend past the CID and CID+ certifications. Over the past few years, IPC EDGE's online learning platform has pushed the boundaries of what can be delivered to the electronics industry. IPC EDGE is an online learning management system that incorporates live video instruction, on-demand lectures, a central forum for all course materials, and built-in quiz and testing features that provide a robust virtual learning experience.

The online training courses are targeted at a wide variety of sectors and supply chains within the electronics manufacturing industry. Popular courses include topics on ESD control, assembly courses for novice operators, and program management and process troubleshooting courses for managers and engineers. More germane to this publication, IPC EDGE now offers two very popular courses focused on printed board design engineering: "PCB Design Fundamentals I: Schematics" and "PCB Design Fundamentals II: Fabrication."

This past winter and spring, I took both courses on the fundamentals of PCB design. As someone with a background in materials physics for semiconductors, I went into these courses with more understanding of chip-level design than board-level design. And while I already had learned quite a bit about printed board design (specifically layout) by managing design-focused IPC standards development committees, I considered myself to be a novice.

By the end of the course, I was pleasantly surprised at how quickly and by how much I came to understand the processes of board design—materials selection and stackup; strategic component placement; designing for manufacturing, cost, and testability; multiple signal integrity topics; design tool operation; the general fabrication workflow, and much more. It helped that the instructor, Kris Moyer, has decades of experience in board design and was more than willing to put in extra hours to help his students understand the concepts discussed in class.

Both courses are undergirded by a hands-on design project that spans PCB Design Fundamentals I and II. This project tasks students with designing a data acquisition unit replete with FPGA and sensor bundles. The assignment is no small task, and both the project and course were genuinely challenging. But the payoff was well worth the effort, and the hours I put into the design tool while perfecting my layout—checking design rules, applying new concepts learned in class, racking my brain to

intelligently re-pin and fan-out the FPGA—created a firm understanding of design that I now use when communicating with members of my standards development committees (or dazzling my non-engineering friends who still think that printed boards are little wafers of magic).

The classes I took consisted not only of novices like me but a dozen other individuals from across the industry who brought a wide range of educational backgrounds and industry experience. For example, there were electronics manufacturing veterans who had been designing boards for decades and wanted a refresher on more advanced topics like signal integrity and design tool usage. On the manufacturing side, there were fabricators who wanted to gain insight into the design process of the boards they were minting. I also noted there were individuals from across the organizational hierarchy—managers like myself, as well as individuals working in entry-level positions who wanted to gain a leg up on their competition. The diversity of the class made for interesting discussions, and Kris was quick to defer to individuals who possessed skill sets relevant to the lesson.

Considering the diversity of the professional demographic who enroll, it is worth noting there are generally no hard prerequisites for IPC EDGE courses. For example, the only requirements for the PCB Design Fundamentals I course is a general understanding of electronic components (capacitors, resistors, inductors, etc.) and a basic familiarity with board-design ECAD tools. However, I will say that while I was much more comfortable with mechanical CAD software upon starting the course, I was hot-keying my way around the design tool in no time. This is probably because the tool is so user-friendly, due in no small part to the course instructor's expertise.

Rather than bask in the success of these courses, the IPC Education team, and its ensemble of industry savants and educational experts, are just getting started. The PCB Design Fundamentals I course is starting up its summer term, and, later this year, IPC Education will debut courses that are a bit more specialized than this one. The syllabi of these courses generally build off the topics covered in the PCB Design Fundamentals courses and include design for military/aerospace applications, rigid-flex design, design for extreme environments, and advanced packaging concepts.

Students will learn about compressing circuit topology to suit next-generation, high-density form factors, all while maintaining signal integrity.

I actually have my hands on the syllabus for the advanced packaging course—the perks of being IPC staff—and I'm excited for what's in store. Students will learn about compressing circuit topology to suit next-generation, high-density form factors, all while maintaining signal integrity. There are lessons devoted to the use of microvias and sequential lamination to build HDI designs, as well as how to synthesize these advanced techniques into building high-component-density circular or non-standard geometry boards. It sounds like this course is going to be a lot of fun! More importantly, this advanced packaging course—and all the current and upcoming printed board design-focused IPC EDGE courses—will be a worthwhile and valuable addition to any printed board designer's toolkit. More than that, they are valuable to any member of the electronics engineering manufacturing supply chain who wants to improve through continuing education.

Again, there's that magical phrase—continuing education.

While I doubt you will undergo forced word-associations anytime soon, I hope I've planted a new synonym to IPC—continuing education—in your head and that you will explore the options for professional development avail-

able through IPC. At the very least, I hope you will embrace the philosophy that guides Carlos Plaza, IPC Education's director of education development, as you go about your daily life. When I talked with him for this article, he said, "The rapidly changing world of work makes lifelong learning essential to our personal and professional success. That is what drives me to action. Every day, I look forward to applying empirically-tested insights into how people actually learn to create training programs that truly meet the needs of our constituents." Be like Carlos: wake up every day excited for what you can learn and the value it will add to your own life, your company, and the industry as a whole.

Now, take another moment and listen to the breeze, your fan, or the hum of your overhead lights. Ask yourself, "What can I learn today?" If the answer involves brushing up on your layout skills or learning something new about via-in-pad construction or some other printed board design topic, then IPC can help you.

Regardless of where you go or who helps you on your journey of continuing education, heed the words of Ralph Waldo Emerson: "Skill to do comes of doing; knowledge comes by eyes always open, and working hands; and there is no knowledge that is not power." **DESIGN007**

Patrick Crawford is the manager of design programs and related industry programs at IPC. To read past columns or contact him, click here or email PatrickCrawford@ipc.org.

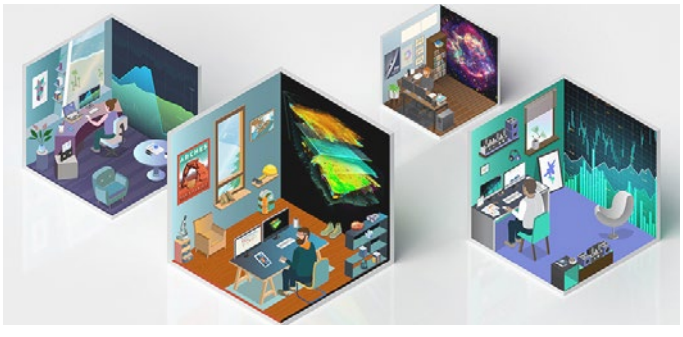
NVIDIA Provides More Tools for Working Remotely

For many organizations, the COVID-19 pandemic has created a permanent shift in how their employees work. From now on, they'll have the option to collaborate at home or in the office.

NVIDIA is giving these millions of professionals around the world a boost with a new version of our virtual GPU software, vGPU July 2020. The software adds support for more workloads and is loaded with features that improve operational efficiencies for IT administrators.

GPU virtualization is key to offering everyone from designers to data scientists a flexible way to collaborate on projects that require advanced graphics and computing power, wherever they are.

Employee productivity was the primary concern among organizations addressing remote work due to the COVID-19 pandemic, according to recent research by IDC. When the market intelligence firm interviewed NVIDIA customers using GPU-accelerated virtual desktops, it found organizations with 500-1,000 users experienced a 13 percent increase in productivity, resulting in approximately more than $1 million in annual savings.



NVIDIA has expanded hypervisor support by partnering with SUSE on its Linux Enterprise Server, providing vGPU support on its kernel-based virtual machine platform.

The latest release of vGPU enables a better user experience and manageability needed for demanding workloads like the recently debuted Omniverse AEC Experience, which combines Omniverse, a real-time collaboration platform, with RTX Server and NVIDIA Quadro Virtual Workstation software for the data center. The reference design supports up to two virtual workstations on an NVIDIA Quadro RTX GPU, running multiple workloads such as collaborative, computer-aided design while also providing real-time photorealistic rendering of the model.

With Quadro vWS, an Omniverse-enabled virtual workstation can be provisioned in minutes to new users, anywhere in the world. Users don't need specialized client hardware, just an internet-connected device, laptop or tablet, and data remains highly secured in the data center.

New features in vGPU July 2020 help enterprise IT admins and cloud service providers streamline management, boosting their operational efficiency. (Source: NVIDIA)

PCB007 Highlights

Ventec High-CTI Substrate Drives Increased Vehicle Electrification ▶

Ventec International Group Co. Ltd. (6672 TT) has developed a high-CTI substrate (VT-441C) that offers an environmentally friendly, high-performance copper-clad laminate that creates a stable and reliable platform on which to build ECU circuitry.

Elmatica's Didrik Bech Accepts Role as IPC Cybersecurity Task Group Vice-Chair ▶

On June 18, Nolan Johnson spoke with Didrik Bech, Elmatica CEO and I-Connect007 columnist, who was recently selected as vice-chair for IPC's Cybersecurity Task Group. During their conversation, Didrik outlined the task group's mission statement and the target audience for its work. He also shared specific examples where cybersecurity is increasingly important to the electronics manufacturing industry globally.

Isola Opens Expanded R&D and Analytical Laboratory in Arizona ▶

Isola, designer and developer of copper-clad laminates and fabrication materials for multilayer PCBs, officially opened an expansive R&D and analytical services laboratory at the company's new global headquarters in Chandler, Arizona.

CML Acquires Jiangyou Starteam Electronics Technology Co. Ltd. ▶

CML made a strategic decision to acquire Starteam, a manufacturer for PCBs in China, Sichuan province. Since 2018, Starteam has been under CML management and is pleased to announce that the transition was successfully completed in May 2020. During this period, Starteam became a German PCB manufacturer in China.

Walt Custer's EIPC Business Outlook Webinar: 'You Can't Sugarcoat This Stuff!' ▶

In normal circumstances, it would have been the time of year for the EIPC Summer Conference, and Walt Custer would have opened the proceedings with his business outlook for the global electronics industry. However, circumstances were far from normal. Pete Starkey discusses some of the takeaways from Custer's global business outlook webinar, organized by EIPC.

Digi-Key Electronics Launches PCB Builder to Streamline Ordering Experience ▶

Digi-Key Electronics, a global electronic components distributor, announced that it now offers a PCB builder tool to streamline customers' ordering experience of PCBs and to more broadly support their rapid prototyping needs.

Eagle Electronics Reduces Cycle Time for IPC-4761 Type VII Via Fill Process ▶

Mike Kalaria, president and CEO of Eagle Electronics of Schaumburg, Illinois, announced that his company had made significant cycle time improvements in the via fill process.

Dan Beaulieu, Part 1: Lead Generation ▶

Dan Beaulieu, president of D.B. Management and an I-Connect007 columnist, spoke with Nolan Johnson on the importance of continuing to generate leads and new customers. Beaulieu addressed concerns about market uncertainty, shared some real-world examples of mistakes, and made a strong case that sales and marketing is a process that must be constantly ongoing to keep a full funnel of customers and business.

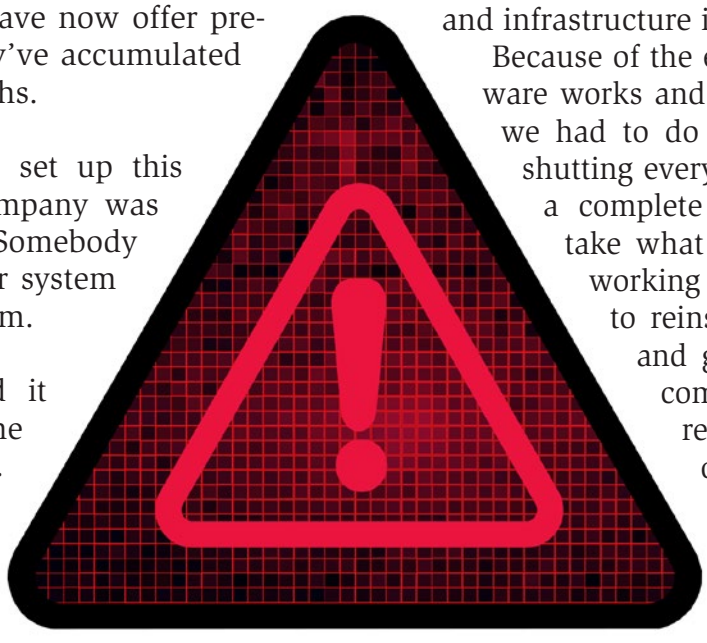
CYBERATTACK!

THINK IT COULDN'T HAPPEN TO YOU? THINK AGAIN!

Feature Interview by Barry Matties
I-CONNECT007

Cybersecurity is a necessity in every business, and this interview is a must-read for helping you and your company to understand vulnerabilities and protect yourself from attacks. Remember, until an attack hits you, you have no idea how devastating it can be.

Eric Cormier and Dave Ryder of Prototron address the ransomware attack that locked them out of their system last December, bringing business to a screeching halt and forcing them into the arduous process of a full rebuild. With things finally starting to normalize, Eric and Dave now offer precautionary advice they've accumulated over the past six months.



Barry Matties: Eric, to set up this conversation, your company was hit with ransomware. Somebody locked you out of your system and demanded a ransom.

Eric Cormier: Yes, and it was actually Friday the 13th in December 2019. It was not a good day. From what we've been able to trace, it came from a piece of equipment that we utilize for certain processes in the shop. It looks like somebody got onto the internet and accidentally clicked on some links.

With ransomware, what's insane about it—especially what we were hit with—is that it was built to not only infiltrate our network, but also determine the types of PCs we had in the shop in order to do the most damage. It ran from one PC, hit a couple of devices that weren't secure, and turned them into what they call "zombies," which wreaked havoc across our facility. It originated in Redmond, and because our facilities are connected in Redmond and Tucson, it branched out and hit multiple PCs and infrastructure in our Tucson facility.

Because of the extent of how this software works and how advanced it was, we had to do a 50,000-foot view of shutting everything down and doing a complete rebuild. We couldn't take what we had that was still working and reuse it. We had to reinstall operating systems and go the full length of a complete infrastructure rebuild. It did some serious damage. And it's not necessarily something that can be controlled from a security perspective once

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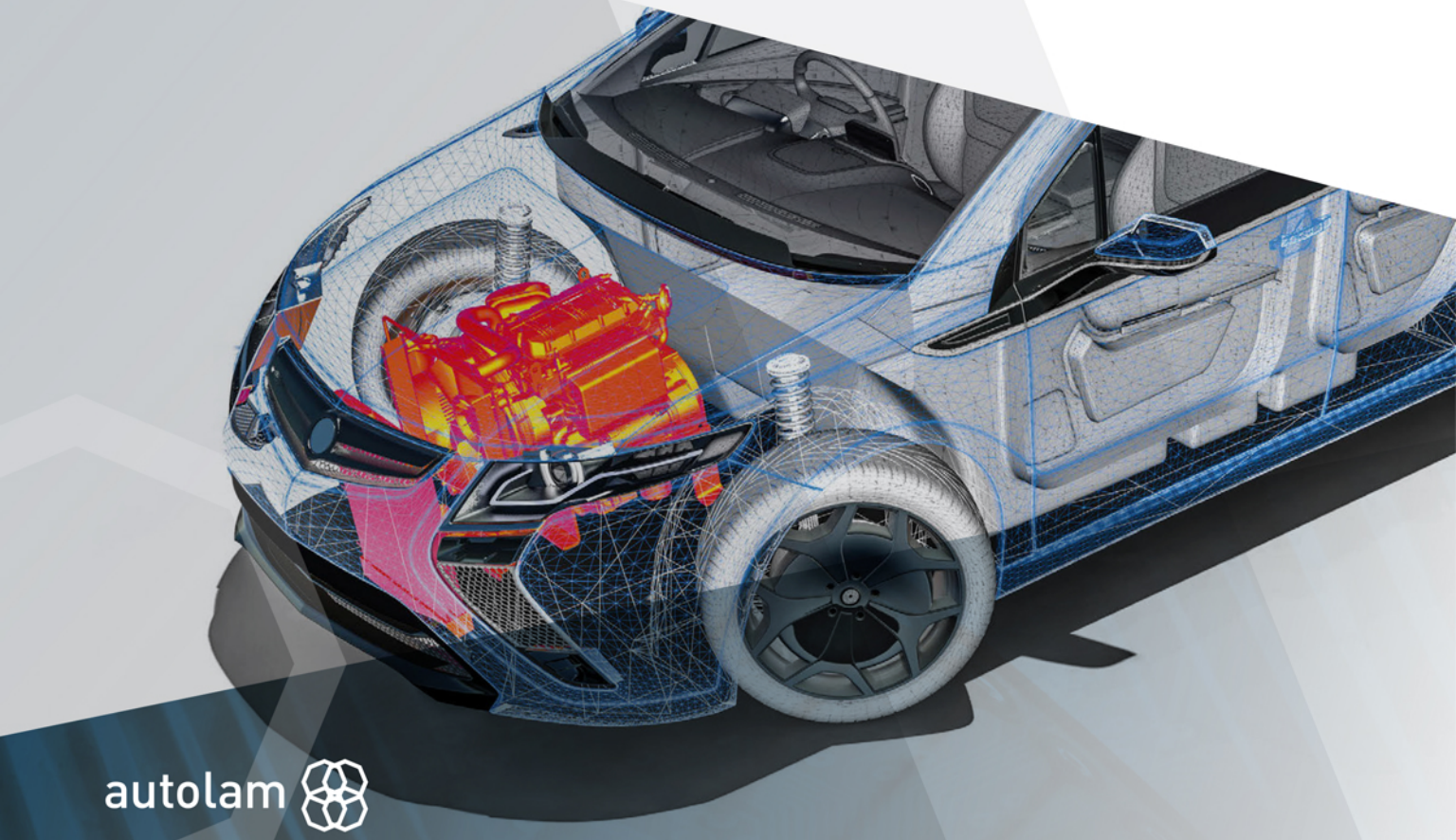

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it's been let in-house; it was very difficult to root out where it came from.

With the nature of cybersecurity today, we had tools in place that allowed us to determine—from an intrusion detection perspective and traceability of what went outbound—that our data was compromised internally. We were able to even have a third party look at it, and they verified that as well. We had a third party review everything and found that nothing was compromised externally, which meant that while our data was affected, it wasn't transferred out of our networks.

Eric Cormier

Matties: And they were able to access it through a piece of equipment that somebody had clicked the link on, or was it an open port that they found through this equipment?

Cormier: It required user intervention. Again, the best security is only as good as how far you can train your people on looking for and spotting things because 90% of all this kind of stuff comes down to a user error. When a certain user does trigger something, the ransomware gains the rights within the company network, and then it spawns beyond that. It's what started the whole process.

Matties: From that point of view, these ransomware people and hackers are pretty clever, and they disguise their emails to look like normal business emails and trick people into clicking.

Cormier: A lot of times, it could be an attachment that has a link in it that says, "You have to click this link to unlock the document," and it looks like it comes from a valid customer source. Sometimes, we see things come from a fake shipping company that looks like UPS and FedEx. They say, "Here's your invoice on your account or from your last shipment." People click it without realizing what it is. And that's where the "fun" begins.

Matties: Once they got in, they were able to go from system to system. However, they weren't there to access and steal information; they were there to lock you out of your data.

Cormier: Correct. It didn't affect servers, shared documents, or things that we had on our network. It encrypted those, but then it also spawned itself and hit local machines, like your mailbox store on your local PC. It encrypted it, and the ransomware had the key. With the level of encryption that they used, it was almost impossible to decrypt without having some piece of the puzzle, like what passphrase or what key they used.

Matties: You were locked out of the system, and your business screeched to a halt. At that point, you had to make a decision: Do you pay ransom or not? That can be a tough choice one way or the other. Regardless of whether you pay, you were faced with having to reboot your entire system. You were vulnerable.

Cormier: And that's where the threat comes in: how far did it go and what was compromised? After a great deal of time spent analyzing that question, we looked at the amount of time that it would take to either patch all the holes or do a complete rebuild. We decided we didn't want to invest the time—especially with the number of resources that we had available to us. The numbers didn't line up for us to patch the holes and find out how far it went. It was to our benefit to get things back up and running as fast as possible by starting from scratch and restoring what data we had from backups.

Matties: Even if you took the patch approach, in the back of your mind there would always be

some level of doubt or concern as to whether you found everything.

Cormier: Right. You ask yourself, "Did we miss something?" Because all it takes is one thing missing and any amount of time you spent fixing it could be wiped out. If you spend hundreds of hours in a week to fix something and you missed one thing, you're back to square one again, and you lost 100 hours. That's where you weigh the risk. Is it best to start from square one? For some larger companies, that task would be too incredible to even think about. But again, most of those companies have the resources available to make that happen in the agile environment.

Matties: This caused business interruption and a new level of awareness that changed your security protocols. What have you done to keep this from happening again, since it came from somebody clicking on an email?

Cormier: Because we were doing the full rebuild, we went through and reassessed. And I hate saying this, but it was perfect timing because we were going through a process of becoming completely compliant with a few standards, like NIST, DFARS, and ISO 27001 and 27002. A lot of the planning and security required for that helped us. There were things that we needed to implement, push the envelope, and it required us to make those changes. Reviewing the security processes and what we have in place that has been required will help us in the long term.

Matties: We hear about these things, but we never think it could be us. Then, all of a sudden, it is us. And you're not the only one who has been hit by this in the industry.

Cormier: Yes. There's a substantial infrastructure that's been affected by this very kind of situation.

Matties: And other fabricators, I understand, have been hit directly as well. Moreover, what advice do you give to somebody to protect themselves? And specifically, are you keeping all email isolated from your network now?

Cormier: That's one thing that we decided to go toward because a lot of solutions are cost-prohibitive, but there are options now for cloud compute and cloud email systems. It makes sense to make that change because it requires managing less in-house that could possibly be affected if an event like this occurs. Businesses that build this kind of cloud infrastructure put in place a lot more security to provide multiple levels of security. We found that it's much more cost-effective to go with that approach than having things in-house nowadays.

As a recommendation, I would say to look at that kind of transition, even if it's a hybrid cloud environment, to where you're reducing your surface area of attack, the number of areas that could be affected, and services that could be affected if you do get hit with something. We're living in a world where that's not necessarily a requirement, but to do business, it is a good idea.

Matties: Is your email now isolated from your internal networks?

Cormier: Yes, and some of our file sharing and backup systems are now being compartmentalized.

Matties: On your internal systems, as we move into digital factors, a lot of equipment is connected to the internet for firmware updates and such. How have you changed the infrastructure, or do you have any concern about that connection point?

Cormier: I followed a model called "zero trust," where you don't trust anything inbound or outbound. Instead you have to manually approve certain things, including with the network. Now, I compartmentalize. I have a completely separate network where all proprietary equipment requires the internet be placed onto and it uses cloud solutions to share files back and forth. That way, if something hits one of our local machines, we're not going to be affected

by a lot of our proprietary systems like we were before. So, that would be a recommendation I would make: use the cloud-based file systems and file-sharing sources to make that work.

Matties: Because of ITAR and other regulations, how does that cloud-based or hybrid cloud-based service fit into those situations?

Cormier: As of right now, there are only two mainstream providers that can meet the standards: Amazon Web Service's GovCloud (which is its full suite of AWS products, from S3 bucket storage and cloud compute to anything that you're looking for on the compute side), and Microsoft Azure. The GovCloud allows you to be pinpointed as a government entity, and you can tell it what boundaries you require your data to stay within. Then, you still meet those ITAR requirements and some of the defense requirements as well.

Matties: Third-party solutions are providing your security, but it probably provides you some relief in IT concerns or workload.

Cormier: Exactly, because there are services that we're able to turn on to monitor and alert us that are better than most security systems that we could try to bring in-house and pay a lot more money for. Again, the cost-benefit made too much sense not to move in that direction.

Matties: You have some new mechanisms. What other advice do you have for fabricators to consider?

Cormier: I recommend performing a risk analysis quite often to pinpoint your vulnerabilities, know how to drive yourself forward to fix certain points of weakness. Review and confirm on a regular basis that you're reviewing your disaster recovery plans. Then, ensure that everybody's on the same page as you add new services, etc. You have to constantly review those to make sure that you're not going to miss anything in case of an event like this.

Matties: Backup is something that's part of the strategy. You have an isolated backup that is offsite, remote, and not connected as well. Have you changed your backup strategy?

Cormier: Yes. We've gone through a different approach for utilizing more cloud. Again, we're using Amazon AWS's GovCloud services and Glacier storage for a lot of our backup systems. We were originally sharing between facilities so that they were technically offsite, but again, this exposed a weakness that required us to switch gears and change tactics.

Matties: With offsite and go-between facilities, that seems like a reasonable and sound strategy until somebody finds the vulnerability.

Cormier: There are a lot of companies and solutions, and they meet a lot of these industry requirements, such as Veeam Backup Solutions and a couple of others that allow for your backup strategy to slipstream straight into a cloud platform, which is quite nice.

Matties: And you were lucky since it wasn't a data breach. It was a lockout situation.

Cormier: It affected availability but not the integrity or confidentiality of the data.

Matties: But even with the lockout situation, this shut your business down.

Cormier: Correct.

Matties: From a leadership and administration perspective, Dave, this is a business interruption that most people don't insure against. I'm not sure what the insurance companies are doing in that regard. Do you have any advice for people on what they should look at when insuring that type of business interruption?

Dave Ryder: First, let me address the insurance side of the issue. There are certain things you can do through your insurance company to ensure that you're covered in cases like this. Unfortunately for us, we were limited on that side of the insurance coverage, and it simply

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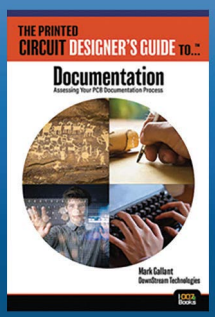

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covered hardware if there was physical damage, meaning they were rendered useless.

We also had another issue with a specific customer. We submitted the invoice onto their system, but with our profile in their system, that's where we submit and place our bank and routing information. Somebody was able to log into our account and change that bank and payment information so that the vendor started paying to that wrong account. But when we reported it, it took them almost two weeks to even stop sending payments to it and to start a process of fixing the situation.

Dave Ryder

Matties: And how did you discover that was an issue—by receivables not coming in and you were making some calls to inquire?

Cormier: Yes. That was the first stage, but we also received an email. One of our accounting people had received an email about an account change. We immediately looked and I told them to change the password on that site. We didn't think anything further because it didn't notify us of what changed. That was another thing the hackers didn't have and didn't include in their system. By not knowing what changed, I assumed it was a password situation. We reset passwords and continued business as usual, and then discovered a couple of weeks later when we weren't getting paid that the information had been changed on their system within their profile.

Matties: The advice is, when you get an account change notification, don't assume anything. You should email them and verify what's being modified, especially when it's a financial account.

Cormier: Right. In most financial accounts, whenever you make changes like that, and you put in your financial information, it generally sends you a confirmation saying, "Your financial information was changed." It gives you specifics and timestamps on when it occurred. In many cases, it will tell you what IP address the change came from. Those are certain things that you think would be a given but weren't in this case, and it has been a long process trying to get intelligence information back to make proper inquiries and resolve it.

Matties: The question that comes to mind is, "Are these two events connected, or are they isolated and coincidental in timing?"

Cormier: They were coincidental in timing. Everything occurred at least a month or two before our ransomware incident.

Matties: Good advice. Back to the insurance review, what changes or recommendations would you have people consider when looking at their insurance coverage?

Ryder: I would recommend getting a cybersecurity incident policy. That's what it has to be. And I've heard that some insurance companies are now at a point of not even writing policies like that because your hands are pretty much tied. These people can get into your stuff, and there's no preventing it.

But as Eric is pointing out, the policy has to be written specifically to that. Otherwise, your typical business interruption policy is not going to cover these kinds of things. We found out the hard way that business interruption insurance covers natural disasters, such as fire and flood. But even floods become an issue because if you don't have specific flood insurance, they may not cover that either.

Matties: This is a real out-of-pocket expense for you.

Ryder: It has been six figures several times over, but that's only in the cost of the replacement and equipment, etc.; that doesn't even begin to cover lost revenue. We were hard down for a full month in the Redmond facility, and we were limping along for the first month in the Tucson facility. We've recently gone back to a more normal sense of business, but the website had to be rebuilt because they seized and locked that up, and the repercussions are devastating. If customers try to look at your website and it's down, they move on.

Matties: There was relief for all customers when they learned that there was no data breach. What's the customer's attitude toward this?

Ryder: Sympathetic, but the first question they have is, "Did they get my files?" Fortunately, that's not the MO of these people. They're seeking Bitcoin ransom money, so it's virtually untraceable. But I don't think that they have any clue whether they're talking to a circuit board shop or an auto repair shop when they're encrypting your stuff. They don't care because they just want your money.

Cormier: There are a few cases where there have been data breaches along with these, but some of these companies had been breached previously without any knowledge of it occurring. It was preemptive in certain instances.

Ryder: Their goal is really about getting the customer's information, such as credit card and social security data. Files for a circuit board design are kind of useless unless you're building that product.

Matties: This happened in December, so it has been nearly a half-year process.

Cormier: There were a lot of odds and ends. We were technically operational within 30 days, but there are a lot of different proprietary software packages and proprietary systems that had to be brought back online individually, as well as the website. Those processes to get back to the pre-event condition have been close to a six-month window.

The attack took out operating software for a lot of the equipment. It took out scripting for the front end, the CAM side of things, and all that was stuff we had built up over years and years of experience. They were able to encrypt the backup on all that. As Eric pointed out, we had to start from scratch. It took us years to accumulate all the technology and software programs that we had, and Eric and his team have been able to fix that in a few short months—a Herculean task.

Matties: With every disaster, there tends to be a silver lining. Any silver lining here?

Cormier: We've been able to implement new technology that we didn't have before. And it's a lot more end-to-end encryption for customers' safety. And there are new processes in-house, too.

We've been able to implement new technology that we didn't have before.

Ryder: We'll be a lot more secure than we had ever been before.

Matties: And there's no doubt you're going to carry that forward. Until it happens to you, you have no idea how devastating it can be. How was the law enforcement aspect of this? Was there an investigation?

Cormier: The Department of Homeland Security was helpful in pointing us in the direction of assessing whether we'd be able to have assistance in recovering from this, but there wasn't much in the way of investigation, or contact from them or the sheriff's office and local authorities. It was fairly minimal, to be honest.

Matties: They probably realize that these people could be anywhere in the world, and it's probably pretty unlikely to find them.

Cormier: At the same time, there are so many different municipalities and infrastructures being hit with ransomware that it has to be a priority for them to be investigated.

Ryder: The city of New Orleans got hit the same time we did. I understand the infrastructure of a city is far more important to society than a circuit board shop is, so their priorities go, as Eric said, with municipalities.

Matties: It's amazing how widespread this problem is. Why aren't more people talking about it and protecting themselves? Hopefully, the point of this whole interview is to get to that level.

There's no honor amongst thieves. There's no guarantee that if we paid we would get our stuff back, and they'd leave us alone.

Ryder: You don't hear much about it in the news. The first few issues that we heard about it seemed to be buried on page 12, and then you don't hear anything more about it. Nobody is immune to this stuff. They've encrypted hospitals and things of that sort, and a lot of them have chosen to pay, but we were advised by the feds not to pay. There's no honor amongst thieves. There's no guarantee that if we paid we would get our stuff back, and they'd leave us alone. There's nothing to say they wouldn't come back a week later and do the same thing.

Cormier: We also heard from technical sources that some paid to receive what is called a decryption key tool but depending on file sizes and things of that nature, it wouldn't work 100% of the time. They had to hire in another firm to rebuild a decryption tool based off what they received to help them get data back that wasn't always 100% recoverable.

Matties: Even if you pay, you still have to go through all that diligence of what you've done to rebuild your systems for your own peace of mind.

Ryder: Yes. It may shorten the time it takes you to get fully operational again by paying, but if you're looking at it from a fiscal standpoint, at the end of the day, we're in it a lot more than we would have been for the price of the ransom, and that's through lost revenue as well as damage. Many people lost a lot of hours. We didn't have anything for them to do, so the damage was very far-reaching.

Matties: It's not just your shop; it's also about all your employees not working for a month.

Ryder: It impacted customers on the local level here. All of a sudden, for a period of a month, there were no quick turns being made in the Northwest.

Matties: In terms of customers, did they stick with you?

Cormier: It's hard to say, definitively, that all of them stuck with us. They were all sympathetic, and they were supportive when it made sense, but some of them have moved on. At the same time, COVID-19 showed up before we were through with the ransomware problem. It's hard to say what the issue with the customers is in a lot of cases.

Matties: Are things picking up for you now? I hear it's quite busy out there.

Ryder: We see a bit of an up and down on a daily basis. Unfortunately, in the Seattle market, we're heavily influenced by a big airplane manufacturer, and they're kind of slow right

now. That has impacted our business, so we don't see the same numbers that I hear about in other areas of the country.

Matties: If you were doing ventilators, you would be full up.

Ryder: And there's not a lot of medical manufacturing in the Northwest here. It's a lot of aviation, aerospace, and software, which doesn't have anything to do with us.

Matties: I'm glad you were able to come back out of this stronger and better. Do you have any final thoughts or advice you'd like to share with the industry?

Cormier: Again, make sure disaster recovery plans are in place, and you're doing business risk assessments to verify where your pain points are. This is key, from an IT perspective.

Ryder: I would recommend that you have an outside party come in and review your level of security, as well as your insurance, for any problems. There's nothing to say that you will be hit with it, but if you are and don't have coverage, you're going to wish you did.

Matties: You were in a great spot because my understanding is the financials of your organization are quite strong, and you have low or no debt, but most companies aren't in such a great position.

Ryder: If we had debt, it would have wiped us out. As I said, we were hit with a one-two punch because the virus problem showed up before we were out of the woods on the ransomware issue. Effectively, in the Seattle market, King County, we're not even in phase one of being back and open for business. It's still a ghost town around here.

Cormier: I'd also note that if you don't have anything at all in place and you're looking, there are some fairly inexpensive online solutions. Some options are within the $200-a-month range to help you put together plans for security awareness training, etc. One that I utilized in the past is securityprogram.io. It's pretty inexpensive to get yourself started on awareness, training, and implementation for the right kind of security that your business needs.

Matties: You have been talking about a stress test on your systems. If you wanted to bring somebody in, is this a company that you would look to? Are there other resources that you would have come into your organization and work with you?

Cormier: Other resources I've utilized include IT firms that do penetration testing and internal security penetration testing. They give you an overview of deficits and where you need to be.

Ryder: Probably the easiest thing that businesses can do is make sure that they've trained and informed their employees who have access to email, the internet, etc., to be suspicious if you don't know who an email is from or if it looks weird. Make sure your IT team checks it out before you click on any attachments or links. Once you've clicked, you're going down a one-way street from which there's no return.

Matties: As you said, isolating your mail service from your internal infrastructure is a backup to that vulnerability of an employee clicking on a link, whether they intended to. Sometimes, these things get clicked. I'm glad you're back on your feet. Eric, I know it's a monumental task you went through, so I'm sure there were a lot of IT lessons learned on your part, too.

Cormier: Exactly. It gave me a lot to take with me to school because I'm going back for my master's.

Matties: Thank you both for sharing your story and advice for others. It's greatly appreciated.

Ryder: You're welcome. **DESIGN007**

Resins: Are They All About Chemistry?

Sensible Design

by Alistair Little, ELECTROLUBE

In my previous columns, I have looked at many different aspects of resin systems by going right back to basics, questioning the key reasons for potting and encapsulation, examining how different resins systems vary from one another, and exploring how their individual properties can be exploited to maximise performance under a wide range of environmental conditions. I hope this has proven useful.

When it comes to resin selection and application, there are a plethora of factors to consider. Resins come in many forms and have lists of properties that would challenge even a graduate chemist. For this month's column, I'm going to take a closer look at thermally conductive resins, flexible resins, elevated cure temperatures, resin types for different applications, and resin systems that enable wider operating temperatures. Without further ado, let's look at these topics in our signature five-point format.

1. What are the benefits of a thermally conductive encapsulation resin?

As electronics have become smaller and more powerful over the years, the amount of heat generated per unit area on a PCB has increased as well; however, it is well known that electronics will perform much better at low temperatures. Thermally conductive resins are designed to allow heat to be dissipated away from sensitive components. The typical thermal conductivity of an unfilled resin is 0.20-0.35 W/m.K. For a resin to be classified as being thermally conductive, it must have a thermal conductivity of >0.8 W/m.K.

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This is usually accomplished by using selected ceramic fillers, which offer a combination of thermal conductivity and chemical stability.

2. Which resin chemistry types typically allow the widest operating temperature ranges, and why?

Providing exceptional performance at high temperatures, silicone resins have the broadest temperature range (-50 to +250°C), but these are generally soft resins and are not as chemically resistant as some of the other resins. Some polyurethanes can go down to temperatures lower than silicones (-60°C) but have a maximum operating temperature of +150°C, while epoxies are designed more for higher temperature applications (-40 to +200°C) but have excellent adhesion to a wide range of substrates and excellent chemical resistance.

3. Why are some resins suited to different applications?

It's all in the chemical bonds! Epoxies are tough yet can be brittle due to the high crosslink density that is possible. But this high crosslink density also means that the resins are very resistant to chemicals and have excellent adhesion to a wide range of substrates. Polyurethanes are generally made up of long flexible polyols linked together by reactive isocyanates, giving rise to the classic hard and soft segment polymer, which means the resins are normally tough yet flexible. The reactivity of the isocyanates also means the resins have good adhesion. Silicones are soft yet very flexible resins due to the presence of silicon in their chemical structure. This makes them very temperature stable and capable of withstanding a wide temperature range, particularly high temperatures.

4. Is it a good idea to use elevated temperatures to accelerate the curing process?

Elevated cure temperatures are used to speed up the production process and reduce the cycle time. However, there are a few points that need to be considered. It is best to wait until the material has reached its gel time before subjecting the resin to a high temperature; if this is not possible or desirable, then the use of a temperature ramp is advised.

In the case of epoxy resins, care must be taken due to the exothermic nature of the epoxy curing reaction, particularly with fast-curing unfilled resin systems. Also, the amount of resin being cast at one time in a unit is critical. A large amount of resin has the potential to generate a lot of heat, which speeds up the curing reaction.

For silicones, care must be taken when curing as the catalysts used are very susceptible to being poisoned. It is recommended that silicone resins be cured in a separate oven from other resin types. If they are to be cured in the same oven as other resins, then the oven should be well ventilated before putting the silicone resin inside—no other resin types should be present.

5. Why would I potentially require a flexible encapsulation resin for my application, and what types of applications would typically suit this type of encapsulation resin?

Flexible resins find a wide range of applications as they can accept and absorb physical and thermal stresses well. If a unit will be subjected to thermal cycling, either continuously or infrequently, then a flexible resin is designed to withstand the stresses induced under such conditions. Similarly, in the case of physical shock, where the electronics need to be protected against vibrations, then a flexible resin will absorb the stresses far more effectively than, perhaps, a more rigid resin.

Conclusion

Every customer and customer project is different; while we can advise a customer as to which products are best suited to their needs based on our years of experience, it all boils down to the unit, dispensing method/equipment to be used, curing times, and temperature limitations that may be imposed during

the production process. The more information that the customer can provide regarding the resin's ultimate operating conditions—temperature range, likely chemical exposures, and so on—the better.

Certainly, technical datasheets can be a great help when you embark on a new production schedule with new components and resins, but if you foresee any problems with matching resin types to your production procedures that are not easily resolved by studying the literature, be sure to contact your supplier's technical support team for further advice.

Next time, I will take an in-depth look at some of the most frequently asked questions we get as resin experts and explore various options in response to these enquiries. **DESIGN007**

Alistair Little is the global business technical director of the resins division for Electrolube. To read past columns from Electrolube, click here. Download your free copy of Electrolube's book, *The Printed Circuit Assembler's Guide to... Conformal Coatings for Harsh Environments*, and watch the micro webinar series "Coatings Uncoated!"

Toyota Launches Stamping-Type Plating Machine that Significantly Reduces Environmental Impact

Toyota Motor Corporation announced that it has developed a world's first stamping-type plating technology that uses a polymer membrane (solid electrolyte membrane), through which metal ions can pass, to apply plating, like a stamp, only to areas requiring plating. The technology is used in the plating process for forming copper, nickel, and other metal coatings on substrates in the process of manufacturing electronic parts. The machines will be launched on July 1.

This new stamping-type plating machine eliminates the need of a dipping process where parts to be plated are completely immersed in multiple baths of plating solution, which is required in the most common plating process at present. As a result, waste solution can be dramatically reduced to about one-thirtieth and CO_2 emissions to about one-third, which contributes to a significant reduction in environmental impact. The technology also reduces plating time and process footprint.

Over the next two to three years, Toyota hopes to sell the stamping-type plating machine for use by a number of companies as a test machine for verification and evaluation purposes. Then, from 2023 or 2024, with the aim of achieving widespread use, it will expand sales more broadly for use by general users as a full production machine.

The newly developed stamping-type plating machine has a head, with the upper part filled with solution, and a solid electrolyte membrane, through which metal ions pass, mounted to the tip of the head that is pressed against the area to be plated. This structure enables the solid electrolyte membrane, which is mounted to the tip of the head, to be pressed against only that part of the substrate that requires plating. When the electric current flows, a metal film (plating) is applied, like a stamp, only to the area in contact with the membrane.

(Source: ACN Newswire)

Reassessing the Risk of Offshore PCB Manufacturing

Connect the Dots

by Bob Tise and Matt Stevenson, SUNSTONE CIRCUITS

Offshore board production has long been considered an effective way to reduce the cost of producing electronic devices here at home, but those savings often demand a higher tolerance for delivery issues and come with lowered expectations for quality. In addition, the risks associated with global supply chain logistics have increased in the wake of COVID-19, and the component costs of offshoring already were increasing due to rising wages abroad, persistent high overseas transportation costs, and uncertainty surrounding global trade policies.

These macro-factors are not unique to our industry. Their impacts can vary as market conditions evolve. Problems with quality assurance (QA) are a more persistent issue when it comes to PCBs, accelerating the reshoring trend. When quality issues occur, they are usually accompanied by an absence of transparency. Collaboration with offshore manufacturers is inherently limited by time zones, distance, and, sometimes, language. These impersonal relationships foster a "take what you get" transactional paradigm that device manufacturers should not and cannot tolerate.

Offshoring Production Can Onboard Problems

Along with the highly visible risks, there are some less apparent complications that will tangle up a manufacturer. If you plan to offshore PCB manufacturing, carefully examine the impact on your domestic operations in several key areas.

Offshore manufacturing does not automatically equal savings and can disrupt cash flow. If you need the boards fast, expedited shipping might end up offsetting much of your potential cost savings. Most Chinese manufacturers require full payment for prototypes or small-volume orders before they begin production. If offshore PCBs fail to meet design specifications and you've already paid for them, you have limited leverage with the supplier—meaning the resources required to re-tool the boards yourself or adapt the product to accommodate them further masks the real cost of low yield.

Increased Risk Can Unleash Additional Costs

Risk mitigation isn't free, and the resource burden required to manage it falls on your domestic production team. This creates additional hidden costs

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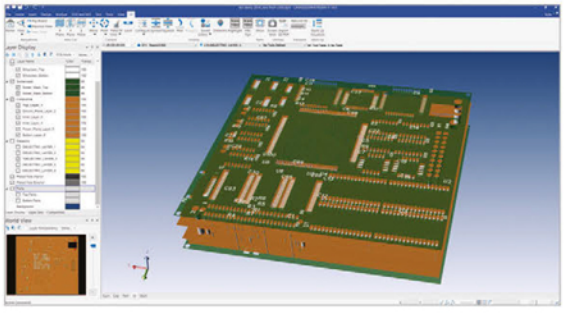

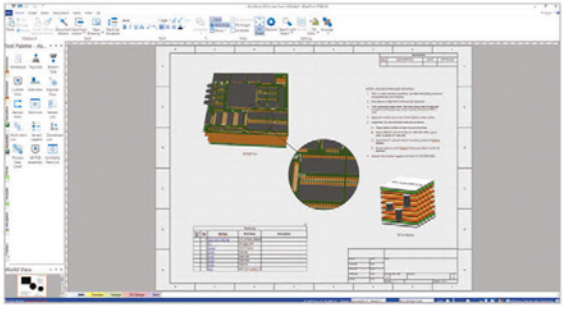

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Figure 1: Differences in time zones can lead to difficulties.

that can quickly add up to offshore manufacturing actually being more expensive than domestic.

An overseas manufacturer in a time zone 10–14 hours different from yours builds your board while you sleep. Unfortunately, if you need to speak directly with someone on the offshore team, one of you will be getting up in the middle of the night to do so. Disruptions to routines like this can lead to miscommunications, misunderstandings, and expensive mistakes (Figure 1).

Your IP Won't Protect Itself While It's Away

The threats to your IP are complex, vary from country to country, and require a substantial financial commitment to combat. Laws surrounding domestic patents, trade secrets, and mask work are antiquated and provide minimal protection. Little or no motivation exists in places like China to protect U.S. corporate IP. Their laws, aimed at protecting foreign IP, are mostly toothless and carry limited enforcement effort with them.

Your Production Volume May Not Justify the Journey

Volume is one critical factor in determining whether to use a domestic or offshore manufacturer. Offshoring favors simple or established PCB designs that require high-volume runs with long lead times. The larger, potential aggregate savings better insulate your bottom line against less apparent offshore manufacturing costs.

The return on offshore manufacturing investment diminishes quickly when dealing with a lower volume or prototyping production. This QA risk alone should give pause to lower volume producers. A domestic resource offers more transparency to the manufacturing process, and collaboration happens faster and with less effort. Issues resolve quickly, which minimizes risk to yield and PCB quality.

Excellence Is Not Relative

During the transition from design to manufacturing, you need effective communication and coordinated effort to succeed. Transition plans, phase-ins and phase-outs, and revision control demand immediate attention that is sometimes unavailable because of time zone differences. Respected PCB fabricators in the U.S. build their businesses by excelling in these areas, while offshore vendors simply aren't structured to provide the responsive support often required in such situations.

For an overseas provider, it is hard for your small-run project to be a priority. Even if you have an established PCB design to manufacturing flow, larger production runs will take precedence over smaller ones. Unless you are prepared to overstock to accommodate your offshore vendor, this widely accepted practice impacts scheduling and can ripple through your supply chain—adding up to significant delays in getting the finished product out the door.

Domestic manufacturers are structured for better flexibility, can provide real-time support, and are more likely to better meet the needs of low-volume production. They are also more likely to adopt green manufacturing practices and provide a safe working environment for their employees—qualities increasingly important to members of our industry. And if you operate on a JIT basis, fabricators located in your hemisphere pose less of a scheduling risk.

Did You Get What You Paid For?

Once your boards arrive from the offshore fabricator, yields become your next concern. Again, we encourage multi-dimensional analysis of the production. Instead of targeting a percentage yield and checking a box, consider the consistency of yields over time, along with the boards' functional reliability in the end product.

Long-term reliability is a key measure. Counterfeit components routinely find their way into PCBs manufactured offshore (Figure 2). Some substandard parts are easy to spot, but not so much with others. Counterfeit components in your offshore PCB may stand up to initial testing, and then fail after your product is in use. This can impact product performance, reduce customer satisfaction, and, eventually, tarnish your reputation in the marketplace.

Conclusion

Making the right decision about domestic versus offshore PCB manufacturing depends on a thorough cost-benefit analysis. Your results will vary depending on volume and design requirements. We encourage our customers to look for the hidden costs in offshoring and seriously consider its less quantifiable pain points. **DESIGN007**

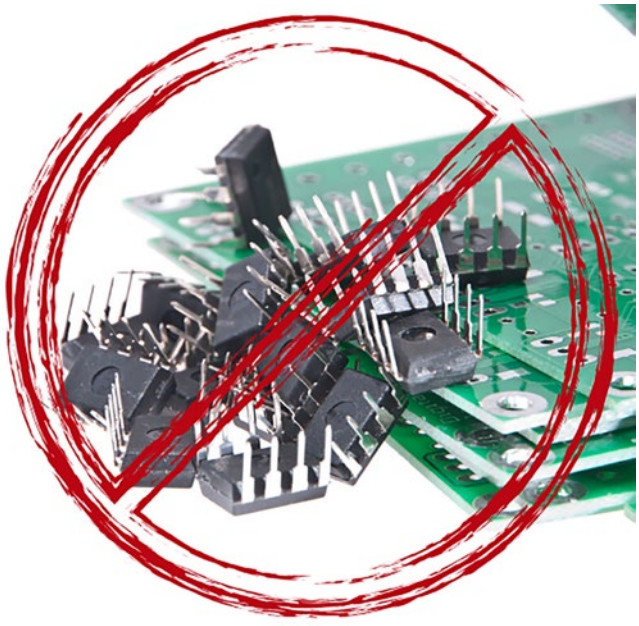


Figure 2: Counterfeit components.

Bob Tise is an engineer at Sunstone Circuits, and **Matt Stevenson** is the VP of sales and marketing at Sunstone Circuits. To read past columns or contact Tise and Stevenson, click here.

Bob Tise

Matt Stevenson

Würth Elektronik Sets Up Virtual Exhibition Stand

As Würth Elektronik is not able to present new products to customers and interested parties in personal contact at trade fairs due to the COVID-19 pandemic, the manufacturer of electronic and electromechanical components has now set up a virtual exhibition stand. Instead of visiting a trade fair, visitors will find an attractive online presentation of product innovations and the ability to have direct conversation in the chat.

The Würth Elektronik team offers a creative answer to the current situation with its virtual trade fair stand. Interested developers and manufacturers can use this platform to stay in close, personal contact with the manufacturer. Products are visualized with their technical data and can be discussed with Würth Elektronik specialists in the chat.

Component samples and developer support can be requested directly from the virtual booth.

Focus Topic Single Pair Ethernet

As lectures are held at exhibition stands, webinars can be found at the virtual exhibition stand. The current topic here is single pair ethernet. Würth Elektronik offers solutions and standard-compliant reference designs that make this copper-saving cabling, which originates from the automotive sector, usable for industrial applications. (Source: Wurth Elektronik)

The Pros and Cons of Working Remotely

Feature by Patrick Crawford
IPC—ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES

For this issue of *Design007 Magazine,* Managing Editor Andy Shaughnessy asked me if IPC had any insight into how the "new normal" of working from home has impacted their members. Here is what the IPC technical staff had to say about the advantages and disadvantages of working remotely, as well as working with IPC volunteers who are new to working from the dining room table.

Mike Milostan
Marketing Director

This is a new experience for many in the electronics industry who have never worked from home or have had limited experience working from home. The most common experience has been plugging in at the hotel room after putting in a full day at a customer site and sending the day's notes back to the boss, as well as plans for the next day.

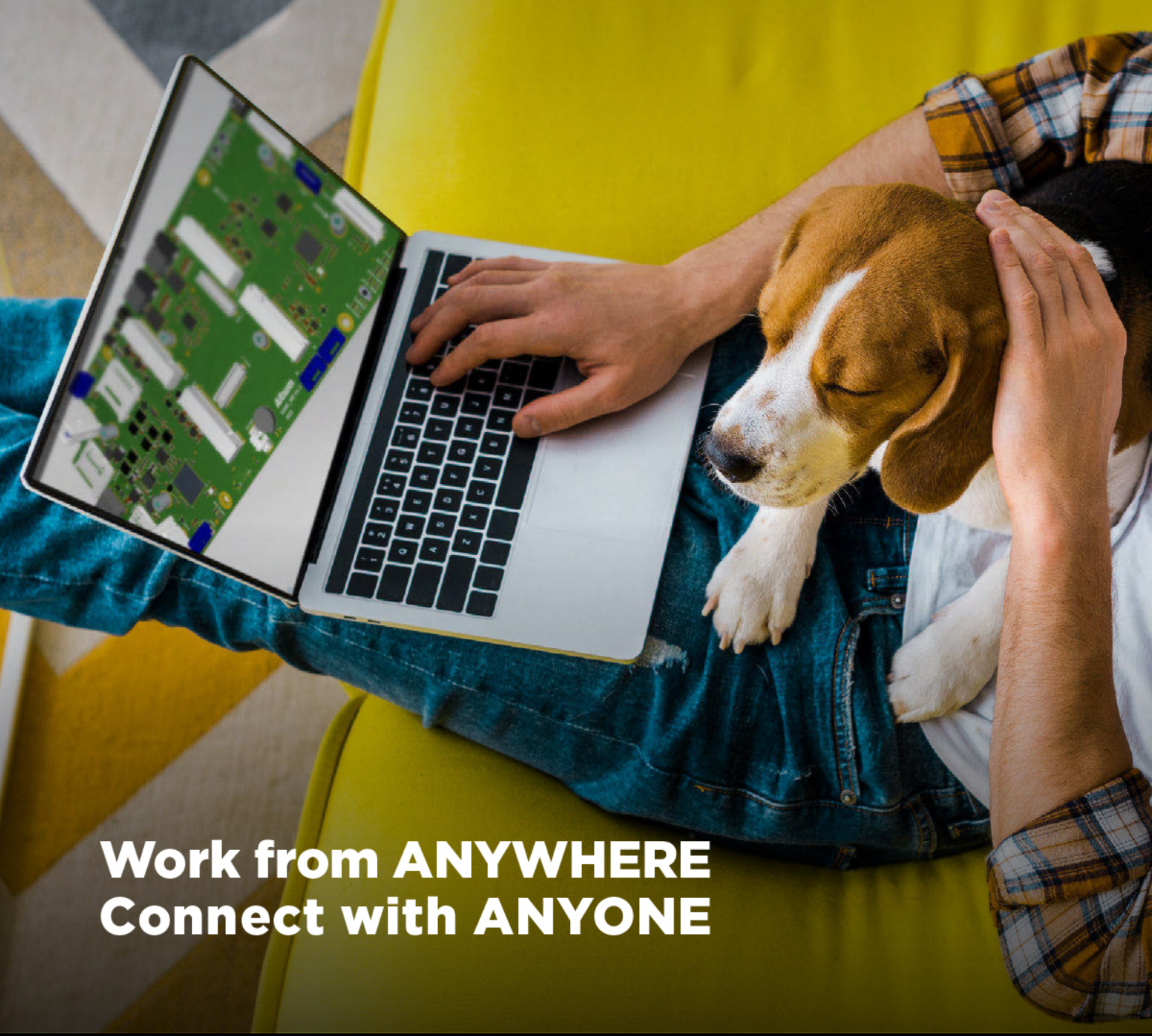
Having two college students at home, as well as myself, needing working space was a struggle at first. "Who gets the desk vs. the dining room table vs. the spare bedroom desk?" Making sure we had a solid internet connection was also a concern for three users, and we had to work around video calls to ensure there was a solid connection for the Zoom user. We had to make sure there was no noise when someone was on a call, in addition to no one yelling, "Hey, get the phone."

The only struggle we still experience is, "What do we do with our spare time?" There are only so many times you can ask. "Did you work out today?" "Did you find any part-time work?" "What is your schedule for the fall?"

Finally, since working from home is mandatory, I see more meetings scheduled during my lunchtime. I have now experienced eating during a meeting, which I had not done when working from home was only an option.

Teresa Rowe
Senior Director, Standards

There is a difference between working remotely on a full-time basis and being thrust into it because of a virus that we can't see, feel, taste, hear, or smell. One of the biggest differences is the location. Most IPC staff have an office area, even if it is only a desk and a lamp. Sure, we can move around, but there is a place to go to



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work. The task group members I speak to on a regular basis tell me that isn't true for them. They are working from dining room tables, kitchen islands, coffee tables in living rooms, etc. This is disruptive because they then try to have fun or relax in the same spot later in the day. This alone can cause them stress.

Early on, some people hated the very idea of working from home. I heard the typical questions, such as, "How do you do this every day? Don't you get lonely? Is it Friday yet?" The last question occurs even when people are in the office, but it took on a different connotation this time. They couldn't wait until Friday so that they could put the computer down and do something else at home. Unlike IPC staff, our task group members didn't know to take their laptops to a different location in their residence, such as going on the patio or even walking away for 10 minutes to regroup. We are social creatures by nature, and working from home put that in a different light and added a new definition of how we can be social creatures and still isolate.

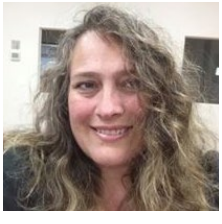
We are social creatures by nature, and working from home put that in a different light and added a new definition of how we can be social creatures and still isolate.

I have had more teleconferences in the past two months with my task groups than anyone can imagine. I fondly termed this "crazy busy," and I wasn't afraid to tell my task group members that. If a day goes by without a call, note, meeting, or message by carrier pigeon (okay, exaggeration there), I think something has happened to my internet service. I had one task group member beg the task group during a meeting to give him any action items for the topics they were discussing, and when they did, I received the input within a few hours. This not only highlights our volunteers' commitment but a fundamental desire for all of us to stay busy and serve, even while struggling with isolation and fear.

Even more than two months later, I see our volunteers staying on task and working toward common goals. We know from science that something becomes a habit after 21 days, and sure enough, many of those who initially hated working from home are starting to see the benefits. Sure, they miss seeing their co-workers, but they have adapted. They can see them on video calls any time they want. I'm sure some have even figured out where their "office" is located.

But the best and most rewarding part for me as a staff liaison is to know that we have committed volunteers. They didn't put the industry they serve on hold, and they didn't hesitate to share their expertise while they were trying to figure out when they could get their next grocery delivery. They can even laugh harder now with a new appreciation of what I mean when I tell them that they have no idea how many times I have had a call with them while wearing my PJs and my hair in a knot on the top of my head.

Debora Obitz
Manager, Technical Programs



I have seen and heard various members make statements regarding working from home:

- Many are attending the interim meetings as they are trying to keep their days busy and have stated that they now have the time to support their volunteer efforts.
- I have seen more members attending the meetings lately. I have one technical group that usually has 6–10 members during face-to-face meetings at IPC APEX EXPO, but on recent calls, we've had over 15 attendees.
- I have some committees that have not requested meetings other than at IPC APEX EXPO and SummerCom to review/revise their documents; they are now doing meetings every two weeks.

- I have seen a quick response to email requests and action items. I get an almost immediate response vs. the usual week to no response (had to send reminders).
- Some are worried that they will get accustomed to working from home and dread the "drive back to work."
- They enjoy creating their own work schedule to help with children's schoolwork (those who have them), as now most evenings are free because all of the work is done during the day.

John Perry
Director, Printed Board Standards and Technology

A majority of my committee members are in aerospace and defense, and as such, were granted exemptions that allowed (or perhaps the word is required) them to work in their office/manufacturing plant several days a week, as some of the products they build are designated for national security and defense purposes. For them, the issue was addressing adequate social distancing at work with other employees and using masks. **DESIGN007**

Patrick Crawford is manager of design standards and related industry programs at IPC and an I-Connect007 columnist. To contact him, email PatrickCrawford@ipc.org.

Fairview Microwave Introduces New SOLT Calibration

Fairview Microwave Inc., an Infinite Electronics brand and a leading provider of on-demand RF, microwave and millimeter wave components, has unveiled a new series of short-open-load-through (SOLT) calibration kits designed for use in lab, test and measurement, and RF and Microwave production test applications.

Fairview's expansion of its VNA calibration kit line consists of 12 models including short circuit, open circuit and load kits (SOL), as well as short circuit, open circuit, load and thru kits (SOLT). Interface options include 2.4mm, 2.92mm, 3.5mm, 7/16 DIN, 7mm, N-Type and BNC.

Every model in this new line of VNA calibration kits includes the required short circuit, open circuit, loads and thru (model dependent) components required for VNA calibration. These RF test and measurement kits come packaged in protective wooden boxes. They are suitable for a variety of vector network analyzers from the industry's leading providers such as Rohde & Schwarz, Agilent, Copper Mountain and Anritsu.

"The precise characterization of RF and microwave components requires a properly calibrated VNA. These new SOLT calibration kits deliver the precision components necessary to perform accurate analyzer calibrations," said Steve Ellis, Interconnect Product Line Manager.

Fairview's new SOLT calibration kits are specifically designed for the calibration and fine-tuning of sensitive test equipment in production environments, engineering labs and quality testing facilities. These kits are constructed to provide accurate RF equipment calibration for the life of the product and withstand years of rigorous use.

(Source: Fairview Microwave)

Working From Home: The Benefits and Rewards

Tim's Takeaways

Feature Column by Tim Haag, FIRST PAGE SAGE

A few months ago, when the COVID-19 outbreak first started to impact how we all live and work, I wrote a column titled "Working From Home—5 Tips for Newbies" with my recommendations for being more successful while working from home. Having worked out of my own home now for 17 years, I've discovered a few things along the way, and my hope was that my experiences might be helpful for others.

Five Tips

Now that a few months have gone by, and working from home is becoming the new norm, let's review these recommendations again and see how everyone is doing. Here's an abbreviated recap of my five tips for working successfully from home.

1. Set an Alarm

One of the biggest traps that can derail an attempt to work from home is failing to keep to a regular schedule. It becomes easier and easier to sleep in, and soon, your 9-to-5 workday has turned into 12-to-8, leaving you feeling more exhausted than before. To maximize your productivity, set your alarm, get up, get dressed, and jump into your regular workday schedule.

2. Build a Nest

If possible, set up a spot in your home that you can designate as an office area (Figure 1). Not only will it signal to everyone else in the house that you are "at work," but you will also be able to step right into your work without having to first search for a quiet corner of the house.

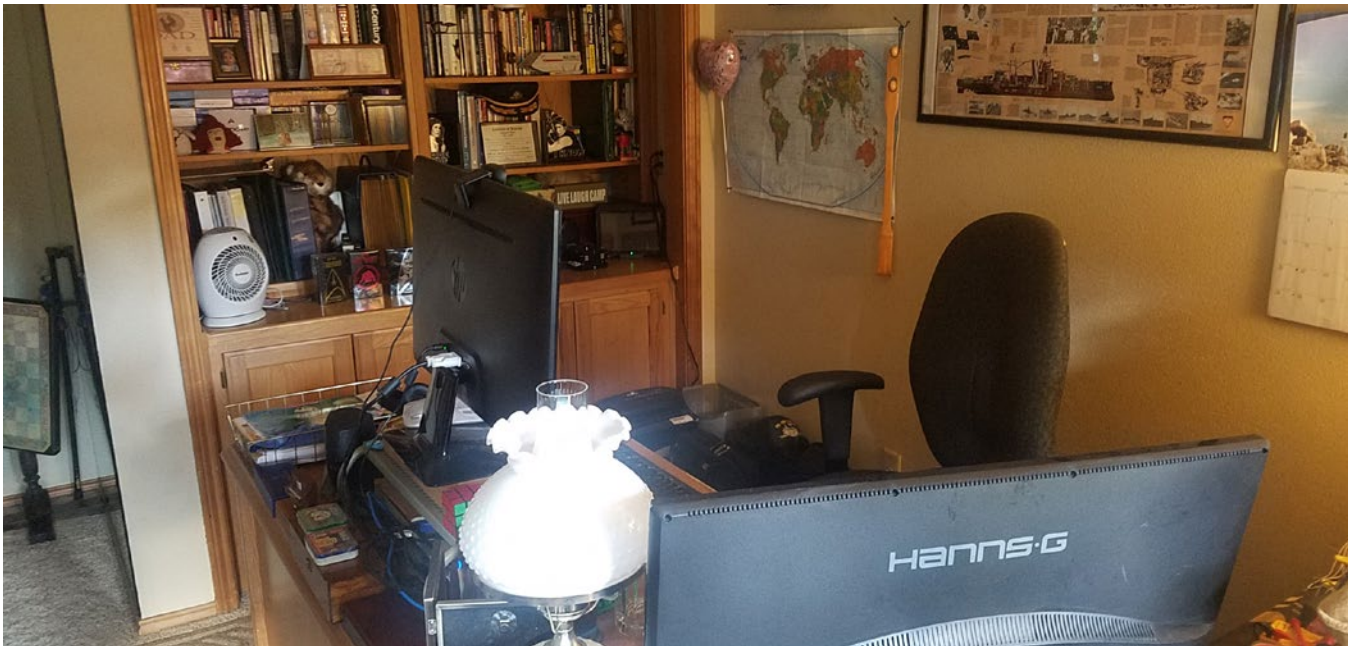


Figure 1: My office setup.

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3. Manage Interruptions

How do you tell the people that you love and share your home with to "go away and stop bugging me?" The answer is that you don't. Instead, you gently manage expectations so that everyone understands your schedule. If interruptions happen (as is bound to happen with children in the house), don't let them frustrate you. Instead, try to look for ways to include everyone in what you are doing so they don't feel disconnected from you.

4. Smile: You're on Candid Camera

If you are set up for video conferencing, use it. We humans need to see and interact with each other. You wouldn't hide behind a mask in a meeting at the office, so don't hide now at home. Even if it doesn't help you directly, it will probably help others. I know of one engineering manager who has made it his policy to leave his camera on all day long so that other people can see him and know that someone is always available for them.

5. Reach Out

There may be members of your own team who are struggling during this time, especially if they are extroverted and rely on regular contact with other people. Please seek them out and check in with them. If you can help your co-workers to succeed, then you will succeed as well.

I started with these five tips, but there are many others. I would love to hear about your methods for staying productive while working from home, so please don't be shy about sharing with me. Who knows—maybe we'll update this list to include your ideas in a future column.

The Benefits and Rewards

Now, let's talk about some of the advantages of working from home. Of course, there are the obvious ones, such as saving money on commuting. I finally put gas in my car last week for the first time in three months. You can also save money on clothing and eating out, too—although, at this point, I think I would give a week's pay just to sit down in my favorite restaurant again. But what about some of the other benefits that might not be as obvious but are still equally rewarding?

One pleasant surprise has been that, for many of us, life slowed down just a bit. Instead of the day whizzing by in a blur, I've discovered I am more focused on my work—and I was working from home to begin with. But with fewer external distractions that used to divert my attention, I've found I now have more clarity in my daily tasks.

Working from home also freed up time for some to invest in online education for both professional and personal development. For myself, I find I am doing more research into new design topics and ideas, with the byproduct of expanding my professional network.

And just for whimsy, I took the time to put together a 1,000-piece puzzle (Figure 2). Without my regular lunch appointments or errands to run, I was looking for a new way to take a break during the workday. It took me a month of lunches (along with some additional late nights), and just a tiny bit of frustration, but I got it done. I don't think that I've built a puzzle since I was a kid (not counting board layout, of course).

Our entire industry has had to learn new ways of doing things, and it has been encouraging to see how both individuals and corporations have responded. One example is the increase in design-based webinars and online training sessions over the past few months.

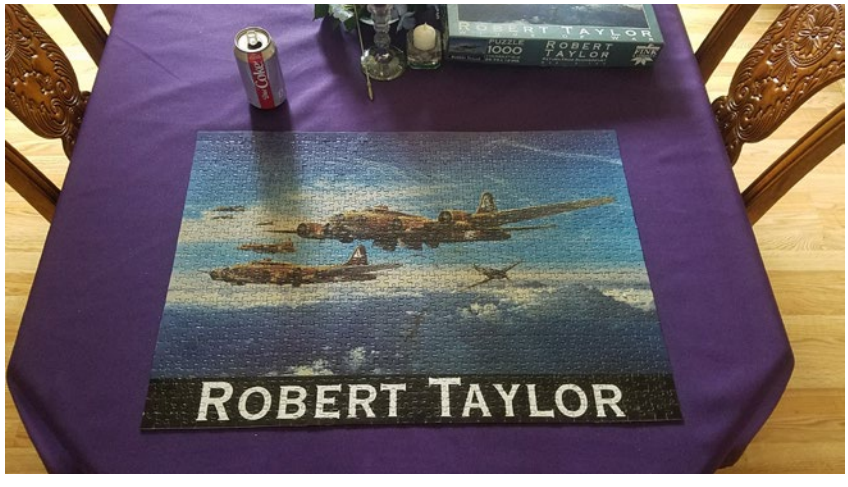


Figure 2: A completed "quarantine puzzle."

Even with the cancellation of some regular conferences and classes, the design information is still available online.

A second example is observing EDA vendors respond so quickly to those using their software to work at home without disruption to their workflow. And while engineering and other tasks are being accomplished remotely from home offices, management teams are devising new ways to support their at-home staff. There are even resources available for leaders who need help and ideas in this new world of managing teams remotely [1].

Our jobs and our industry aren't the only areas where we've seen some of the benefits of working from home; however, there are personal rewards as well. For instance, I've talked to many couples and families who are cherishing the unexpected opportunity to become reacquainted with each other. Families are spending more quality time together, neighbors spend more time talking over their fences, and personal projects are being worked on at a furious rate. My wife and I even put in a small garden this year, which is something we haven't done in a long time.

Conclusion

The problems related to COVID-19 are not something to be trivialized, and many have suffered greatly. I know that it is a long road to recovery, getting our personal and work lives back into balance. But for the moment, we can look at the silver linings and be thankful for many things. And as could be expected, the PCB design industry has become (in my humble opinion) one of the champions in this changing world in which we work. Well done, designers, you've done an exceptional job. Keep up the good work, everyone, and keep on designing. **DESIGN007**

Reference

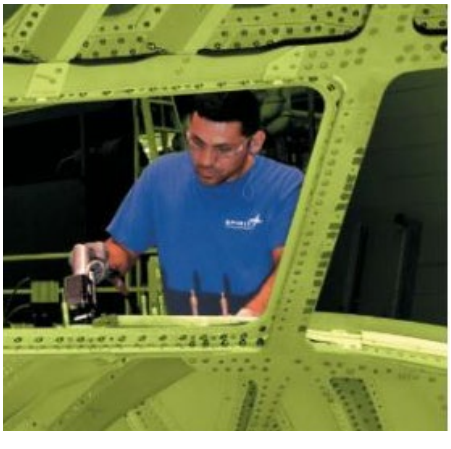
1. E. Bailyn, "How to Manage Remote Teams Successfully," First Page Sage, April 30, 2020.

Tim Haag writes technical, thought-leadership content for First Page Sage on his longtime career as a PCB designer and EDA technologist. To read past columns or contact Haag, click here.

Virgin Hyperloop, Spirit AeroSystems to Collaborate on Hyperloop

Spirit AeroSystems has joined in partnership with Virgin Hyperloop as it prepares to move towards a commercial product. The collaboration will help to solidify the hyperloop prototype utilizing Spirit Aerosystems engineers, fabricators, builders, supply chain and certification experts, and technicians.

Hyperloop is a new mode of transportation designed to eliminate the barriers of distance and time for both people and freight. It can travel at speeds approaching 700 mph, connecting cities like metro stops—and it has zero direct emissions. With hyperloop, vehicles, called pods, accelerate gradually via electric propulsion through a low-pressure tube.



"As a new form of mass transportation, hyperloop opens up a new segment of diversification for us in the transportation space. Our collaboration with Virgin Hyperloop is a prime example of our belief that this burgeoning industry is a game changer," said Keith Hamilton, Spirit Executive Director of Programs & Business Development.

This new transit mode will unlock exponential growth opportunities for cross-industry manufacturing and development jobs—across construction, aerospace, rail, automotive, aviation, electric vehicles, and autonomous control. As Virgin Hyperloop looks to create the first Hyperloop Certification Center in the United States, it will bring thousands of jobs for first movers of the technology and its partners.

(Source: Globe Newswire)

The PCEA's Grand Opening

The Digital Layout

by Kelly Dack, CIT, CID+, PCEA

Introduction

This month, I interview Rick Hartley about his presentation for the PCEA's grand opening webinar on July 14. Next, PCEA Chairman Steph Chavez shares a timely message on how our time working from home is a serious matter, and how letting our guard down could be a mistake.

Again, PCEA chapters are in transition, and due to social distancing requirements, no face-to-face meetings have taken place to date, but there's a lot of virtual activity happening. I also share our most updated list of professional development opportunities and events, which we hope you will find useful.

PCEA Updates

In this interview with Rick Hartley, we discuss an upcoming educational opportunity at the PCEA's grand opening webinar on July 14 at 11:00 a.m. PDT, where he will present a free class on PDN tips for successful power distribution. To learn more and register for the event, click here.

Kelly Dack: Today, I am speaking with renowned electronics industry educator and PCEA executive team member Rick Hartley. I'm so glad to talk with you. You have been kind enough to share your knowledge at the upcoming grand opening webinar. Tell us a bit about the event and why designers won't want to miss what you are going to share.

Rick Hartley: The power distribution network (PDN) is where everything starts. All of the transmission lines and energy moving have to come from somewhere. It comes from the power supply but the high-frequency portion that gets loaded into the drivers and onto transmission lines so that driver "A" can drive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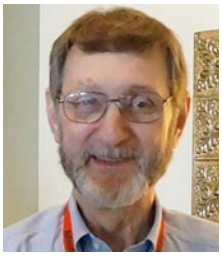


Rick Hartley

load "B" and so on comes from the PDN. Generally, the PDN consists of either power planes or power routes with ground planes, decoupling capacitors, and sometimes other devices as the main ingredients.

I have done a longer version of this class at PCB West that was 3.5 hours and took the audience through everything I consider important for power delivery. For the PCEA grand opening, I'm going to share an hour of good tips on key features that need low inductance, how to maintain that, and other things regarding PDNs that they need to understand first and foremost. For example, one of the most important elements of good PDN design is maintaining a low inductance through the PDN at a broad range of frequencies at which the energy gets delivered. One of the myths engineers believe is that the principal energy of the circuit is the clock frequency, but it isn't; it's driven by the rise and fall times of the IC outputs. They run at a much higher frequency than the clock.

One of the myths engineers believe is that the principal energy of the circuit is the clock frequency, but it isn't; it's driven by the rise and fall times of the IC outputs.

Dack: Will you tell the audience some horror stories about how this misconception can play out in design? I love the horror stories you sometimes share because they illustrate what can go wrong when improper assumptions are made at critical points in the design process. What do designers miss with regard to this topic?

Hartley: Designers need to care about inductance because high inductance at any of the frequencies of concern can cause major problems—and there is a broadband of frequencies that the PDN has to deliver. It starts at the clock and extends out to a very high-frequency level based on the rise time. All of that energy has to be delivered through the inductance of the power bus. If the inductance—or impedance—is high at any of those frequencies, you get large voltage drops that lead to switching noise, which leads to signal integrity and EMI problems, as well as others. It is important to understand how to design the PDN to ensure these things do not happen.

Dack: That sounds outstanding. This is you speaking about physics in action. It sounds like you are going to provide the audience with visual representations of stackups and show how the conductors work to distribute power.

Hartley: Yes. With everything I present, I try to bring a simple but realistic view of the physics to people so that they can understand why things happen, including a behind-the-scenes approach on how this stuff works and why people need to know it. I do not approach the subject matter like a professor in college who launches into high-level math.

Instead, we'll talk about subjects like the proper location of decoupling capacitors. For example, with a BGA part, do the caps belong under the BGA, or do they go on the same side of the board, next to the BGA? The answer to a question like this is, "It depends."

It depends on the board stackup, the BGA, the power, and a number of factors. Designers have to possess that knowledge when they deal with these elements so that they won't do it incorrectly. Without considering these elements, they will end up creating some amount of power starvation, resulting in inductive losses and switching noise that will lead to other problems. It is very important to know these tips, and I have chosen the important ones to go through during the one-hour class.

Dack: It's something for our design community and membership to look forward to. As you know, our PCEA membership is not limited to PCB engineers and designers. Tell us how PCEA membership is relevant to other electronics industry stakeholders from the manufacturing side.

Hartley: What is the PCEA going to do for manufacturing and test engineers and many of the other professionals involved in getting a PCBA to market? This whole spectrum of people needs to be involved with the PCEA because it will give them a better ability to share their knowledge with one another and make each other better at what they do. The PCEA exists to facilitate collaboration between all of these disciplines.

You may remember the story of when I first got into board design. I thought that because I had just obtained my EE that I was going to be the best board designer in the world. Nobody could tell me anything. The very first board I designed caused the board shop to show up at our company for an important meeting in the conference room with me and my boss. The DFM reps from the PCB supplier sat us down and said, "The other EEs at your company may think you are a great designer, but we think you are an idiot (laughs)! This thing you have designed is completely non-producible." And I admit that it was. While I put all of my design efforts on electrical performance, I did not know how important manufacturability or DFM was to the overall process of getting a design to market. One of the things the PCEA needs to do is focus heavily on getting manufacturing engineers involved for that reason.

Dack: Amen! The PCEA is on its way to attracting all of the cross-sections of the electronics industry. It's going to make the electronics world a better place. I look forward to hearing your presentation, and I appreciate you giving us a preview of what you are going to be share. I'll see you at the webinar!

Hartley: Thank you. It has been my pleasure.

In addition to this upcoming webinar, there are so many ways to get involved! Join the PCEA by visiting our website (pce-a.org) and registering as a member to become part of the PCEA collective, which is more than 1,000 members strong. You can always reach out to me (kelly.dack.pcea@gmail.com) or PCEA's Chairman Stephen Chavez (stephen.chavez.pcea@gmail.com) for more information.

Message From the Chairman

by Stephen Chavez, MIT, CID+

Stephen Chavez

Another month has gone by, and many of us continue to work remotely from our homes. It has been a challenge to get the foundation of the PCEA set in place. The executive board members have done an amazing job juggling their day jobs while putting in so much extra personal time to help the PCEA succeed. We are extremely excited about the release of our official website that took place on June 1. All the hard work has paid off so far with lots of activity coming from our website, including new members joining, webinar collaborations with SMTA, and our grand opening webinar. Stay tuned for more activities coming your way now that the PCEA is up and running!

Now, the "new normal" has become our new way of life. I, like many, have been working remotely for about three months, if not more. I don't see an end to this remote isolation any time in the near future as the world battles COVID-19. With the constant barrage of meetings through WebEx, Zoom, GoToMeeting, and other platforms—as well as virtual seminars—it seems to be getting a bit tiresome and overloaded when you add in isolation, constant sanitation, and wearing face masks in public.

As we have adapted, we continue to push on successfully. Work has not stopped for many of us, and in many cases, we are busier than ever. The industry had already made the jump many years ago to the ability to work remotely. For the most part, the toughest challenges today are usually network connections and remote access onto VPNs, Mobil Pass, or Duo Mobile.

Security is paramount, but, at times, it comes with its own set of issues. However, we continue to do what we do best; we do what it takes to get the job done!

Again, this new way of living is taking its toll on us. We eagerly look forward to the day we can get back to those days of old before this virus hit the world. Businesses have started slowly to re-open, even though the world is seeing spikes of the virus in certain locations. It's scary! Many people have seemed to let their guard down, though, and have relaxed social distancing requirements, as well as not wearing face masks in public. I've heard and read that some people have even felt that this virus is not real and is more of a political conspiracy attack. Everyone has their right to their own beliefs—this is America—but I can tell you from a very personal and recent experience that this virus is real; it's no joke.

It's amazing how one's perspective changes when the virus hits close to home, and someone close to you dies from COVID-19. This happened to me on June 7. My extremely close and dear friend Alvin was as healthy as anyone I knew; I grew up with him over these past 43 years, and he was like a brother to me. He lost his battle with COVID-19. From the time he contracted this virus to the time he passed, it was less than 30 days.

As we continue to work remotely in isolation, my personal belief is it's necessary for all of our safety. We need to continue doing our part, maintain social distancing, sanitize, and wear face masks when we are in public until the world gets a handle on this virus, and a vaccine is developed. I continue to wish everyone and their families to be healthy and safe.

Professional Development and Events

It has been our custom to highlight all up-and-coming industry events to watch for in 2020. We will continue to do this; however, with the challenges brought on our industry by the COVID-19 outbreak, we can only remain hopeful that these events will not be affected. If you are interested in any of these events, please search and contact the event coordinators directly for the latest event status.

- July 14, 2020 (11:00 a.m. PDT): **The PCEA's Grand Opening Webinar—*Virtual***
- August 11-13, 2020: **CadenceLIVE Americas 2020—*Virtual***
- September 7-10, 2020: **PCB West** (Santa Clara, California)—***Virtual***
- September 16-17, 2020: **Del Mar Electronics & Manufacturing Show** (San Diego, California)—***TBD***
- September 28 -October 23, 2020: **SMTA International —*Virtual***
- October 6-8, 2020: **AltiumLive 2020 Virtual Summit—*Virtual***

- January 23-28, 2021: **IPC APEX EXPO** (San Diego, California)
- January 26-28, 2021: **DesignCon** (Santa Clara, California)
- May 11-13, 2021: **IPC High-Reliability Forum 2021** (Baltimore, Maryland)
- November 10, 2021: **PCB Carolina** (Raleigh, North Carolina)

Spread the word. If you have a significant electronics industry event that you would like to announce, please send me the details at kelly.dack.pcea@gmail.com, and we will consider adding it to the list.

Conclusion

We have many choices with which to occupy our time during this COVID-19 era. From wherever you work—whether that's at home or in an office—it's a good time to gain knowledge and take it seriously. Use that knowledge to become part of the solution and avoid becoming part of the problem. **DESIGN007**

Kelly Dack, CIT, CID+, is the communication officer for the Printed Circuit Engineering Association (PCEA). To read past columns or contact Dack, click here.

MilAero007 Highlights

Defense Speak Interpreted: C4ISR ▸

Only the U.S. Defense Department would lump together seven concepts—command, control, communications, computers, intelligence, surveillance, and reconnaissance—into a single acronym: C4ISR. Denny Fritz explains how C4ISR has been called the "nervous system" of the military.

FLIR Captures $23.5M in Additional Orders for Centaur Unmanned Ground Vehicles ▸

FLIR Systems Inc. announced that the United States Army and Navy have ordered in total more than 160 of the company's Centaur™ unmanned ground vehicles (UGV), plus related spares and accessories. The two contracts, totaling $23.5 million, are being sourced through the Army's Man Transportable Robotic System Increment II (MTRS Inc II) program.

Murrietta Circuits Appoints Alliam LLC to Cover Sales in South-Central U.S. ▸

Andrew Murrietta, CEO and co-owner of Murrietta Circuits, announced that his company had appointed the sales firm Alliam LLC to handle Murrietta's sales in the South-Central United States.

From Drones to Flying Taxis: The Future of Traffic Is in the Air ▸

Get ready for takeoff: Food deliveries and work commutes might be airborne sooner than you think.

Integra Technologies Wins $3 Million Contract Award From Northrop Grumman ▸

Integra Technologies—a world leader in semiconductor packaging, assembly, test, characterization, and related services—was awarded a $3 million contract from Northrop Grumman.

Northrop Grumman Awards Contracts to Kitron ▸

Northrop Grumman Corporation has awarded Kitron a contract for the production of Integrated Communications, Navigation, and Identification (ICNI) modules for the F-35 Lightning II program. Deliveries will secure a backlog into 2021 and have a total value of more than USD 18 million.

KBR Wins $570M NASA Contract to Propel Human Space Exploration Endeavors ▸

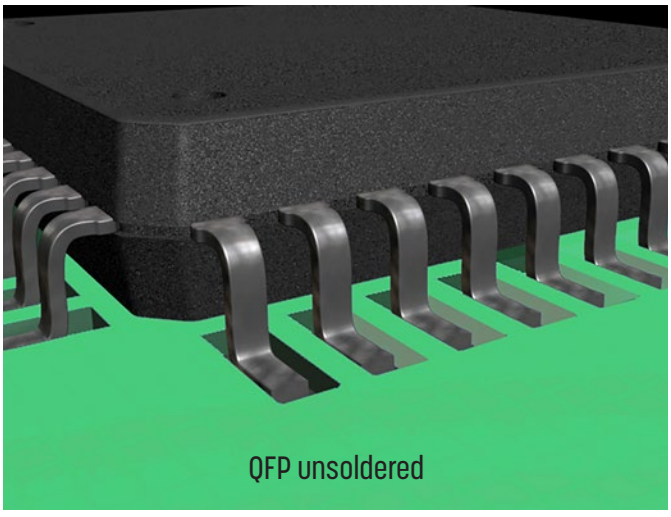
KBR announced it had been awarded a $570.3 million contract by NASA to develop and execute spaceflight operations at Marshall Space Flight Center in Huntsville, Alabama.

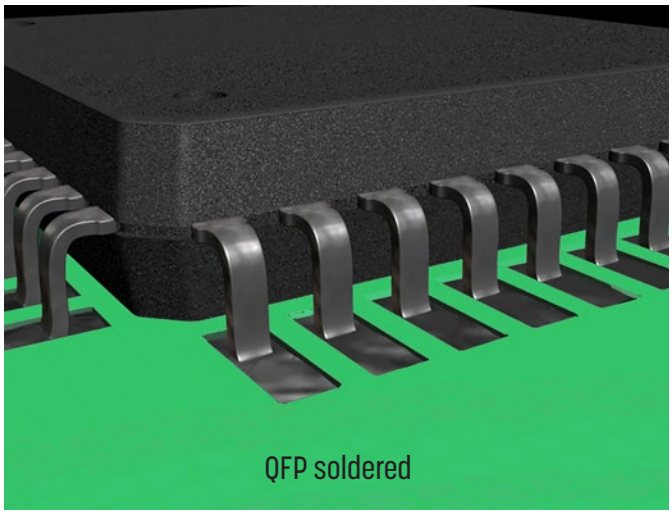
AeroVironment Receives $9.8 Million Raven and Puma 3 AE Awards From NATO Support and Procurement Agency ▸

AeroVironment Inc., a global leader in unmanned aircraft systems (UAS), announced its receipt of two firm-fixed-price orders totaling $9,804,448 from the NATO Support and Procurement Agency (NSPA). The orders—received on March 5, 2020, and April 16, 2020—encompass the procurement of Raven and Puma3 AE tactical UAS and spares. Delivery for the first order is anticipated by August 2020 and the second order by October 2020.

Cobham Advanced Electronic Solutions Names New Board of Directors ▸

Cobham Advanced Electronic Solutions (CAES)—a leading provider of differentiated RF and high-reliability space, power and computing solutions—announced a newly comprised Board of Directors.


QFP unsoldered


QFP soldered

New Solder Joint Technology From Schmartboard

Interview by the I-Connect007 Editorial Team

Schmartboard has a surprisingly simple patented process to improve solder joint reliability; founders Neal Greenberg and Andrew Yaung talk in detail about it, as well as their hopes of finding a go-to-market partner.

Dan Feinberg: We are joined by the founders of Schmartboard, who have come up with a process that appears to significantly improve reliability. I'm going to let them talk a little bit about Schmartboard first and then about this process. I have to state ahead of time that they are a client of mine, but with all the issues we've been talking about at IPC regarding improving reliability for areas such as autonomous transportation, medical devices, military, etc., this is a very interesting and timely topic. Neal, tell our readers about Schmartboard.

Neal Greenberg: We started as an engineering service company designing circuits, doing layouts for companies like Analog Devices, Intel, Texas Instruments, and a lot of smaller companies. In that process, we found a problem. These companies were going through many iterations of prototyping boards. We would start with revision A and go through the alphabet sometimes. We started thinking about how we could improve that from a prototyping standpoint. Back then, if you were going to use an IC from Analog Devices, for example, you'd get a reference board for it from them. This reference board would have the main core and all the bells and whistles—every type of I/O that you could imagine—and you would have to dissect it down to what you needed for your development.

That's what you were doing as an engineer, taking this reference board and dissecting it down. We thought that was kind of silly. Wouldn't it make more sense if you have the core functionality—what it is that you're buying—and then have a way to add different things that you need, different I/O, etc.? Our first patent was what we called circuit board building blocks, and they were two-inch by two-inch boards that you take the core technology and then physically connect it to needed I/O. Here's an SOIC chip—0.5 millimeters in

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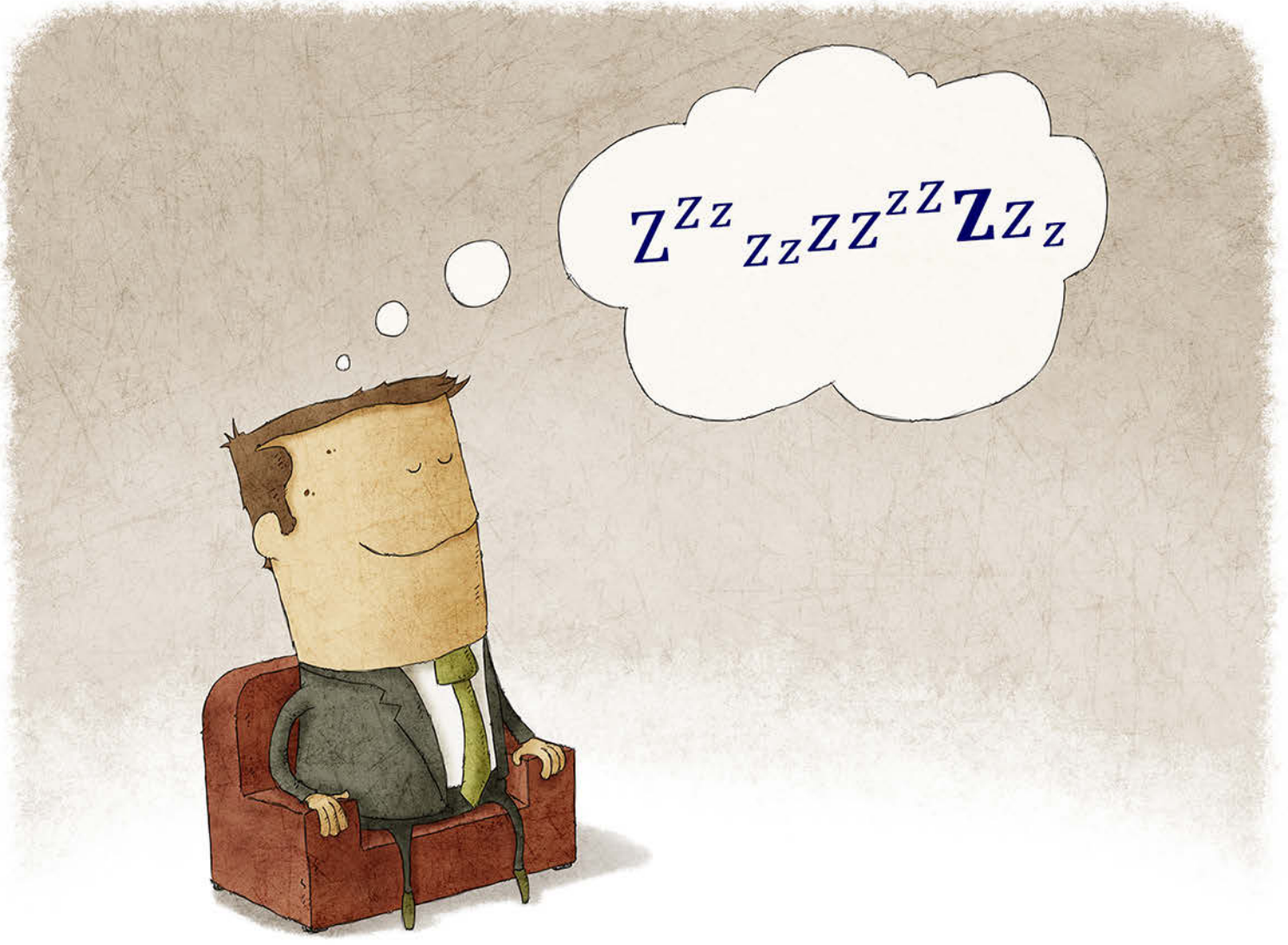

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pitch—here's some kind of an RS232 connector, and here's some memory. We invented a way to connect these little circuit board blocks together.

Generally, it was well-received. But the problem we found was that people could no longer hand solder these parts onto the boards as they could a few years ago. When the pitch was a 1.27 millimeter, they could do that, but when pitches started getting down to 0.65, 0.5, and 0.4, and they could no longer hand solder it. We asked ourselves, "Is there a way for us to make it where people could now solder these new parts the way they used to with older technology?" We worked for two years and went through many different ideas. We finally came up with the idea of significantly raising the solder mask, letting the parts fall in, and then the solder mask turns into walls in between the legs. It then became much easier to solder—even a 0.4-millimeter pitch IC—and the products quickly went into Fry's, Digi-Key, and Mouser and Arrow, for example. Today, our products are sold to a "who's who" of companies.

Neal Greenberg

Andrew Yaung: One of the hardest things for someone to do when hand soldering a surface-mount IC onto a PCB is to position the legs. We brought up the solder mask a little bit higher and ended up achieving two things during the process. One is that the chips then dropped into what we call canals, and second, the solder mask became protective barriers for shorts between each leg. If you were to look at the current product lines that do the prototyping for people with hand soldering, you would see canals—the traces are long so that they can use a soldering iron and push the solder through inside that canal. That was done on purpose so that they don't necessarily have to use outside solder, although if they use outside solder, it's better for them.

We always thought that someday, eventually, if this technology were to be polished, it could get much better usage. We started talking to folks from the aerospace industry, such as Lockheed Martin and NASA. We discovered one of the biggest problems that they have is these joints get broken in a very high-pressure and high-vibration environment. The idea for using this technology is that, if you can imagine, each of those legs sits inside a pocket or a nest. Then, the whole leg will be covered with solder during the solder reflow process. This will make the joint not only stronger but also not crackable anymore. It's almost like a through-hole technology—and perhaps even better than through-hole—because the whole leg or nest is surrounded with solder. The idea that we are taking into the next phase is to have this be used in the volume production environment for reliability purposes.

The other thing that we also discovered was that during the manufacturing process today in high-volume products—because components are becoming smaller and smaller and smaller—when they go through the reflow oven, they have to bring up the temperature as high as possible and then cool it down by blowing air into it. During that process, many tiny components get shifted. That's why, in a production assembly line, you'll see a separate station called final inspection for boards. They're inspecting by eye whether a component gets shifted and which one they have to rework. This technology will also improve that. You can imagine that the component legs will be sitting inside the pocket so that it will not come up. That's the whole idea behind this. Dr. Ephraim Suhir, a Ph.D. who worked for Bell Laboratory, mathematically proved that this would be 10 times more reliable than the current way of doing things.

Greenberg: This also works for things like QFN and BGA and any of the modern components.

Nolan Johnson: This technology has also evolved out of what you were previously doing with your earlier Schmartboard product.

Greenberg: Exactly.

Yaung: We are taking it one step further, and this is in addition to what we've been doing.

Andrew Yaung

Greenberg: Now, the truth is we are small and don't have the resources to bring this from where it is now to where it needs to be as a proven technology that could be used. One of the reasons that we're working with Dan is to help us get to the point where we find a partner or someone who wants to take this to the next level. We're looking for someone with that need, and we have an idea of who those types of customers are.

Barry Matties: Do you have companies already interested, and if so, what's their key motivation?

Greenberg: We are in the process of speaking to people. We've had a few who are interested in the need, but we are only beginning to talk about what the technology is and how they're going to need to be involved in taking this forward.

Matties: With your product, how widely accepted for use do you expect this to be?

Greenberg: Initially, it's going to be the people that have the critical need. I was watching the SpaceX launch, and that's a perfect application, as would be any military or automotive technology and critical medical supplies. But like with everything else, cost savings or significant improvements in yields have to happen—which is one of the things that we claim this will do—before it's brought into the mass market for consumer goods.

Matties: How are you validating the data, and what would the timing be for acceptance into space or automotive?

Yaung: As Neal explained earlier, we are a very small company. We have shown that with the current product line for using this technology to do hand soldering, you can count the total complaints with a couple of fingers, and it all came down to the user error. The technology has been very widely accepted in terms of how this is being used. Many people with a technology background or PCB background came back to us and said, "How come I didn't think of this?" It's so simple. For taking it to the next step to use it in volume production, one of our criteria is not to alter today's manufacturing processes because the minute you start altering them, you have to introduce new equipment.

Matties: It's a roadblock.

Yaung: Yes. As part of the invention process, that is a no-no for us. Where are the areas that need to be fine-tuned in the manufacturing process for this to be used? Number one is the PCB. When you make a PCB today, the solder mask layer is put on before finishing the PCB in the process. If you're taking a look at the board, the pads where the IC legs sit on is a little bit higher than the mask in today's technology. Because we reversed that, the way that it changes is the solder mask may have to be put on even earlier, and then the process of taking off the solder mask may have to use a laser to etch out all of the path areas, or apply multiple coats. That's one additional step that needs to be done.

The second step to be looked at is when the PCB is put in the manufacturing process for assembly use, they have to put on solder paste. How do you control the solder paste that goes inside each nest or pocket in these IC legs or joints? If you put too much, it's going to flow

out, and if you put too little, it may not be enough. That had to be a trial and error that required some experiments to perfect the process. When you start dropping the components with the SMT machine, the third phase is we may need to fine-tune the robotic head to make the precision be that much better. There is an opportunity to fine-tune the robotic heads and hardware, as well as software, to make this process a lot more precise so that when it's dropped into these nests, once the IC goes in, it will perfectly sit inside.

Those are a couple of areas that immediately come to my mind: knowing what the processes look like today, not altering today's processes, and then how do you fit into those processes? Those may be some of the areas that we have to experiment and work with, and this is where we need a partner who has the resources to make this thing a reality.

Matties: Oftentimes, we see new technologies come along—and there are some great ideas—but without the proper funding or distribution, they fail. There's a big risk in the mind of the user to even invest in experimenting with this new technology. Not yours, per se, but we've seen the history time and time again. It repeats itself.

Yaung: Every new technology or invention has its own risk. We have seen a lot of new technologies go through the process, spend billions of dollars, and never even go anywhere. In our case, the first barrier that we already removed is not to alter today's manufacturing processes. That's already a plus. Now, how do you work with the processes to make this thing a reality? A lot of it is trial and error. And to do that, you need the time and resources.

Matties: How many shops are currently using this?

Yaung: We have had five shops, and we purposely experimented in different places: one in Korea, one in the United States—because we invented it in America—two in China, and one in Taiwan, but Taiwan was short-lived. We don't produce these things in Korea anymore because the cost is high. The two shops in China are making them. Now, with the pandemic, we are thinking about bringing it back to the U.S. I'm having discussions with a couple of shops. They're very intrigued. They look at this and say, "Wow, but let us think about it. How are we going to do this thing?"

Johnson: To be clear, this is in production in those shops.

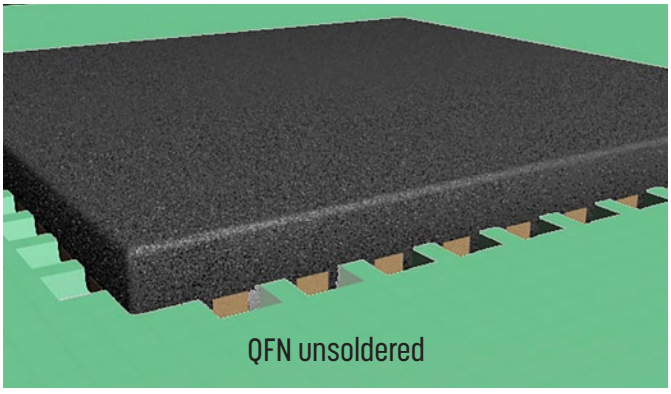
Yaung: Yes. They are volume production shops. For one reason or another, these two shops in China are able to do this thing very well. They signed the NDA with us, we tell them exactly what our criteria are, and we are not altering their processes. They go out and do it. As long as they meet our specifications, we'll be fine, and they came back with it.

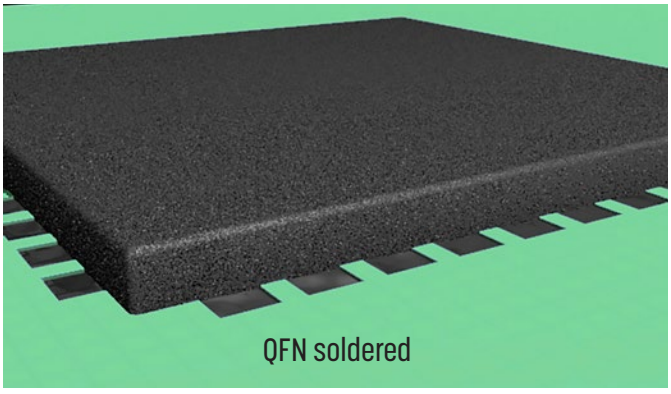
Matties: You said the shop in Taiwan stopped using it. Why did they stop?

Yaung: We stopped using them because they were having trouble making the height of the solder mask even close. We were very forgiving in terms of meeting exact spec, even though we have a specification call-out for it, our tolerances were quite generous, but they were still having a difficult time. They tried it for two or three lots, and there was a 30–40% yield loss.

Greenberg: Right now, we're talking about our current product line, which is the prototyping product line. I want to make sure that's clear. We are not talking about the mass production product at this point.

Yaung: If you look inside of our current product, you'll see canals. Where the IC leg sits, the trace is pretty long out there, and the purpose for that was for manual hand soldering with a soldering iron. You push the solder in the canal toward the legs to adhere to it, but the volume production one that we are talking about, or that we are taking it to, is not bad. It's just a pocket. The pocket is as long as the chip leg will sit.


QFN unsoldered


QFN soldered

Feinberg: At I-Connect007, we're following a lot of the advances in 3D additive manufacturing, and there have been some very significant advantages over the last three to four years. In fact, Barry and I were the initial ones to cover it about five years ago at CES. One of my thoughts is that the geometry that meets with the patent and meets with what gives the higher level of reliability depends on the solder mask, but that geometry can be created by 3D additive printing.

This is a process that may very well be applicable to 3D additive printing—especially since with 3D additive manufacturing, we're now getting to the point where we can 3D print the dielectric, conductors, solder mask, another dielectric, resistors, and capacitors, but not the chips. The chips are going to be very small. One of the issues is making sure that they have a reliable solder joint because these things are being produced not in two-dimensional circuit boards—height and width; there's some thickness, but they're creating the circuit on the outside of a pipe, etc. That's something else that is an opportunity to be discussed with some of these companies.

Greenberg: Absolutely.

Yaung: It's like any invention. You think of something, and you invent it along that line, and all of a sudden, someone else finds it useful in their applications that you never even considered.

Matties: That's how these things evolve. This looks great. I appreciate you sharing what you're doing. What are the critical next steps?

Greenberg: We want to find the right partner where this is a huge need for them, they have resources, and they're going to work with us. Then, we're going to figure out all the details and all the definitions of how this is to be done.

Matties: Is the future of this technique predicated on a partnership, or is this something that you can carry forward without a partner?

Greenberg: It's going to be predicated on finding the right partner. Our focus now is exclusively partnership and testing.

Matties: Hopefully, this will help. When it comes to rethinking manufacturing, you're definitely an example. As the industry or the world rethinks manufacturing, they have to think in terms of seeking out and examining new processes because it's so easy to get trapped in what we know.

Greenberg: We are responding to the issues created by advances in technology or things that are beyond everyone's control. This is kind of in response to RoHS never truly being resolved. Component miniaturization continues, but it's never been resolved. Everything has been a band-aid, and what we have to offer is the solution that's better than a band-aid.

Johnson: Thank you, gentlemen, and good luck to you.

Yaung: Thank you. SMT007

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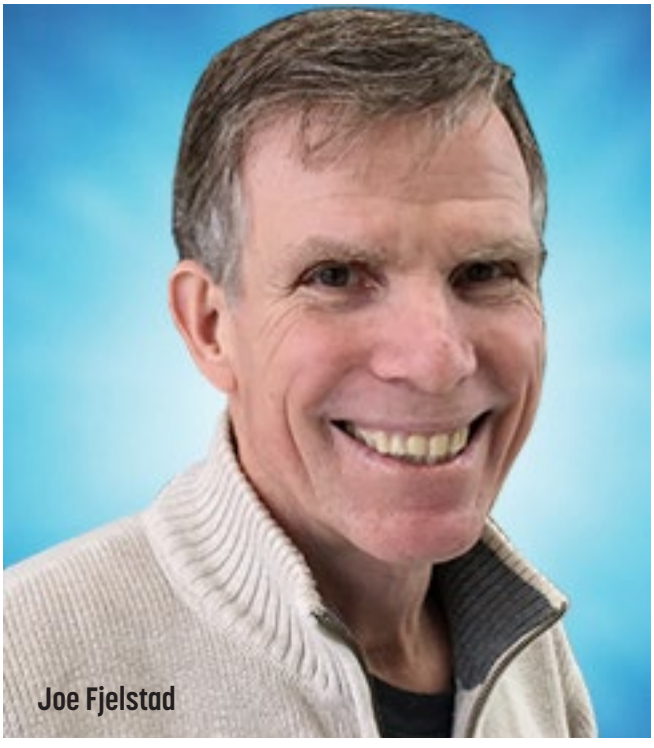
Joe Fjelstad

Joe Fjelstad Updates His Online Flex Workshop

FlexOO7 Interview by Barry Matties
I-CONNECTOO7

Joe Fjelstad has been an innovator in flexible and rigid-flex technology for four decades. About 10 years ago, I-Connect007 helped Joe produce an online workshop on flex technology based largely on his book *Flexible Circuit Technology*, which was first published in 1994 and is now heading into its fifth edition. In this online video course, Joe offers a primer on flexible circuits, covering everything from the history of this technology through the most cutting-edge technologies.

Now, Joe is updating this workshop to make it current with today's flex technologies and processes. In this interview, Joe explains what attendees will learn in the "new and improved" seminar, as well as his drive to continue sharing his wealth of knowledge with the young flex technologists of today.

Barry Matties: Joe, thanks for joining us today. Around 2010, we worked with you on your first online flex course. Please give us an overview of the course and what your intent was when you created it.

Joe Fjelstad: First of all, thanks for being so supportive of this cause for the last decade. For years, I was going out and doing live seminars on flex technology. Live seminars cause one to have to get on a plane and travel somewhere. It takes a lot of time, and much of it is not terribly productive. For me, it's really about getting information out in a very efficient way, and

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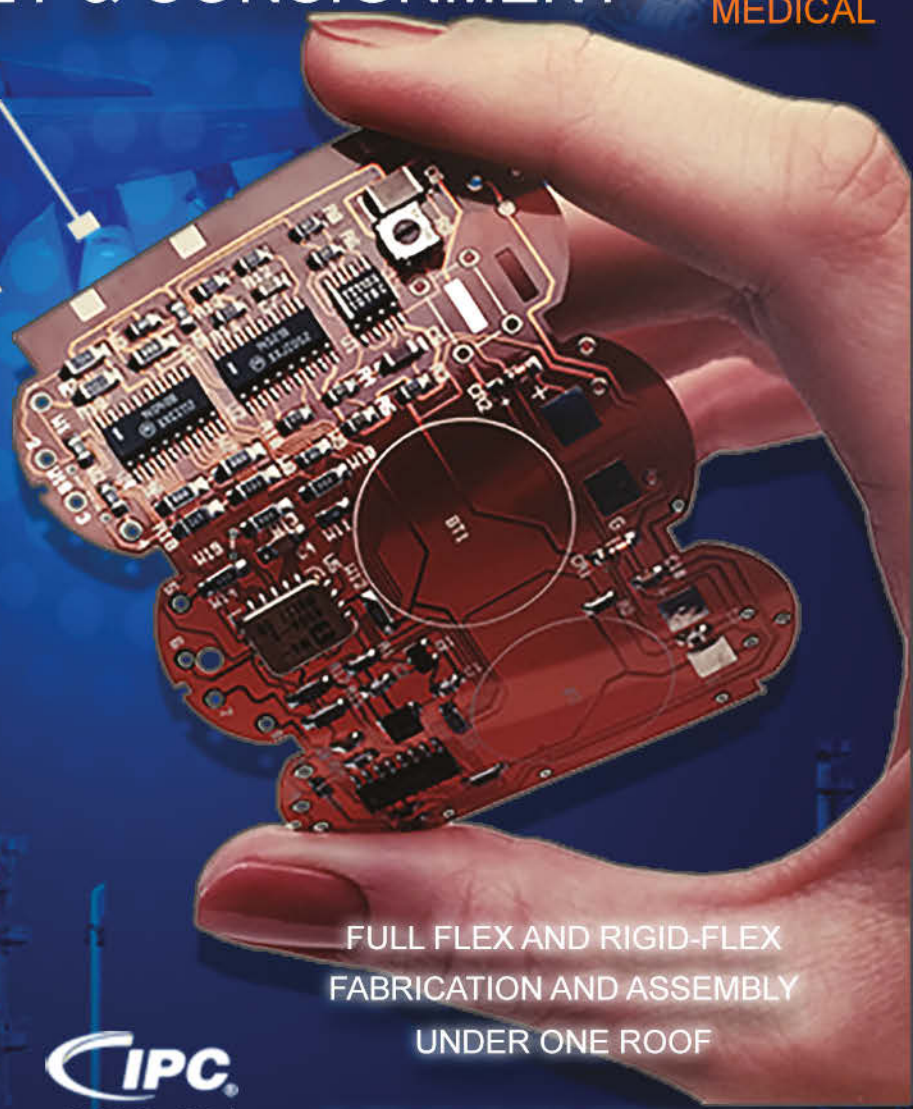

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online video training does exactly that. I trust you recall that it was actually you who suggested the idea to me. I greatly enjoyed working with you on that first run to put this information out there for flex circuit technologists.

We have friends in the industry who are still doing live seminars, and I can appreciate the importance of that—especially because it offers a potential for asking questions and interacting in real-time with the instructor. But your vision made sense to me, and I wanted to make this content available to the attendees on their own time, on their own schedule.

One of the good things that has happened with this COVID-19 pandemic is that it has taught us to think differently about how we put information out there. I have been delighted that I've been able to attend a lot of webinars over the past couple of months that I wouldn't have been able to get to ordinarily. What we did almost 10 years ago was a presage of the way things will likely increasingly need to be done into the future; let's put the content out there, and then people can absorb it in their own time.

One of the good things that has happened with this COVID-19 pandemic is that it has taught us to think differently about how we put information out there.

Webinars, in general, are in real-time, and people get to ask questions during webinars. This flex webinar won't have that same real-time aspect, but questions can be asked after the fact about anything within a session that was found of interest or if somebody had something to add. I would be delighted to be able to include that.

Matties: In the structure of the course, you have it sectioned into nine areas. How did you come up with those sections?

Fjelstad: They were based on where I saw natural breaks in terms of knowledge. The first couple of sections are not deep science or deep learning. But for someone who steps into the industry for the first time, these things are new. If they don't have this knowledge, it gives them a sense of how we got to where we are. The opening statement that flexible circuits are well over a century old is something that might catch people by surprise.

We're trying to put out the information explaining how we got to where we are. There's an old saying—"Those who do not learn history are bound to repeat it"—and unfortunately, we often find a lot of repetition in history. I liked the idea of giving people that opportunity to understand where we got it. We're all natively and fundamentally creative individuals, and then our schooling tends to drive it out of us. People can attend webinars to look at things differently and appreciate them in a new way. Maybe it gives them an opportunity to think of a missing link, and that becomes a springboard for them to be able to think about where the next stop might be. What's the next lily pad?

Matties: You start with a historical view, and then you move into some of the applications, as well as design and materials.

Fjelstad: Yes, and the steps to implementing flex. What do you need to do? What kinds of things have to be in order? When you're making the decision to use flexible circuits, what goes into that decision? That was another aspect of this—a sort of a checklist for being able to step into it. Then, it goes into the issues of design. As I get older and older, I have a greater appreciation for the importance of design. The designers are leading the parade of electronics manufacturing, and the decisions they make have a significant impact on everybody that follows. And if they don't make the right decisions because there was a lack of understanding or knowledge, then trouble can ensue.

It certainly isn't their intent; nobody goes to work in the morning and says, "I'm going to design something that can't be built." Flex

designers would like to make something perfectly the first time out. That's how I feel. I recently wrote a column about the difference between going from design for manufacturing to design with manufacturing. In a similar fashion, columnist Dana Korf had a recent interview that I thought was very insightful. He understands the designer really needs to understand manufacturing.

This flex circuit workshop will help them to understand the next pieces. How do you manufacture? What materials do you use? All of the bits and pieces, hopefully in a logical order, will allow the user to appreciate what goes into flex circuits and what needs to be accounted for if you're going to be successful on your first pass.

Matties: Let's talk a little bit about who should be viewing this course. The course is probably a four-hour time commitment. Each of the nine sections is about 20 minutes or thereabouts. Who should be watching this seminar—anybody interested in flex or incorporating flex into their products?

Fjelstad: Anybody could be a prospective audience member. If you're engaged in designing or using electronic interconnections, flex is arguably one of the most versatile interconnection technologies out there. I did some work at Boeing, building rigid-flex back in the late '70s, and we had no guidebook; we learned on the fly. Later, I was involved in the manufacturing and development of processes for flex in the mid-'80s. But even then, it was not a mainstream technology by any stretch of the imagination.

However, today, if you open the most advanced products out there, you're very likely going to find a flex circuit in one place or another. And as I say in the seminar, there are many reasons to use flex. It isn't just because it's flexible; it's also thin, lightweight, and high-performance. It allows you to do very fine-line features, which are becoming increasingly important. It has a lot of attributes that make it very attractive.

Matties: Do you touch on printed electronics as well?

Fjelstad: Yes, we cover printed electronics briefly. In my book *Flexible Circuit Technology*, which is going into its fifth edition, there is an entire section on printed electronics that I did with Happy Holden. That is going through a revision right now to make it current. There is another section in that book on stretchable circuits that I did with Jan Vanfleteren from Ghent University in Belgium. Those are two areas that are becoming of increasing interest. And of course, there's a little bit of confusion that has been injected into the idea of flexible circuits with the term that's been generated in the last several years where they talk about "flexible hybrid" electronics. To me, it's kind of a marketing thing.

On the bright side, they have generated a lot of funds to be able to continue to develop and stretch out the capacity of flexible circuit technology. I'm kind of ambivalent as to whether we really needed a new term. If the branch branding brings minds to explore the benefits of flexible circuit technology, I say, "Godspeed." Still, much of what they're talking about is covered in what we refer to as flexible circuits, and since it has a long history, I figured there's no reason to suddenly treat it like flex is a past technology. It's very current technology and will continue to be.

Matties: We appreciate you putting this course together, as well as your books and your ongoing commitment to helping the industry learn and improve.

Fjelstad: We all travel the road built by those who went before us, and if we can extend it a little bit, then we've done our job and been blessed. I've been blessed in this industry to work with so many giving people. It's just a part of our DNA to teach one another and then make everything a little bit better than it was before.

Matties: Exactly. Joe, we certainly appreciate your time today. Thank you very much.

Fjelstad: You're most welcome. FLEX007

Next-Generation Flex Circuits: Transparent

EPTE Newsletter

by Dominique K. Numakura, DKN Research LLC

DuPont, one of the largest chemical companies in the world, developed a super engineering plastic film during the 1960s and soon after introduced Kapton®, a polyimide film that remains stable across a wide range of temperatures.

DuPont also developed basic constructions of flex circuits as the major application of Kapton films. Nowadays, the flex circuit market reels in $20 billion a year. It is the primary wiring material for smartphones and smartwatches. If you remove the back cover of a mobile device, you will discover films that are orange in color. The industry term for this is "Kapton color." The color and low transparency of Kapton was never an issue for suppliers and contract manufacturers, so circuit designers did not require any particular color for heat-resistant films. It was Apple that decided it didn't like the Kapton color and required flex circuit manufacturers to paint the polyimide films black.

Circuit designers never questioned the color of Kapton either (fortunately for polyimide film manufacturers). Clear films were required for some flexible circuits in display devices or photovoltaic cells; however, polyethylene terephthalate (PET) films were used instead. Low-temperature packaging processes were developed for non-heat-resistant materials.

The ever-changing electronics market requires upgrades to components, films, and circuits. New photo modules and medical equipment

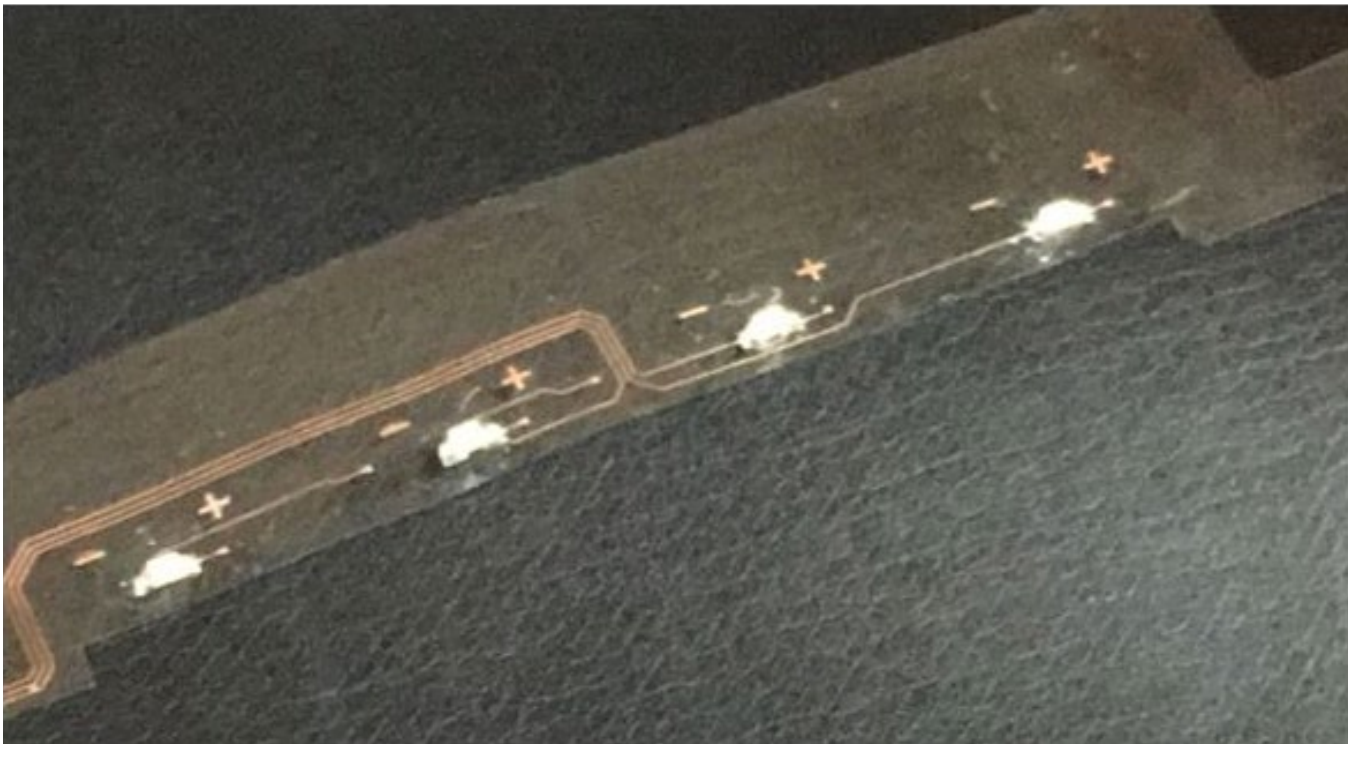
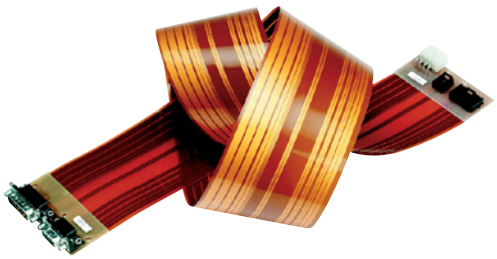


Figure 1: An example of a transparent flex circuit. Several LEDs are mounted by soldering.



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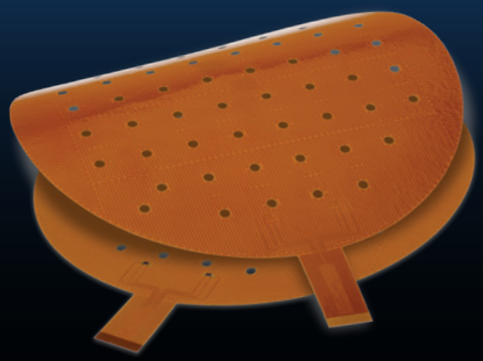

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now demand both transparency and heat resistance for high-temperature processing, such as soldering and wire bonding. Material suppliers found a way to satisfy these new requirements, but it was not easy to have both transparency and heat resistance without a trade-off. Some material suppliers were successful in creating clear polyimide films that have transparencies greater than 85% and stable mechanical properties with temperatures over 300°C. One polyethylethylketone (PEEK) film manufacturer successfully created a heat-resistant and transparent film, and a few fluorocarbon resin manufacturers successfully developed heat-resistant and transparent films.

The next hurdle is to build copper-clad laminates with transparent and heat-resistant films. A couple of laminate manufacturers—including DKN Research—already developed a universal metalizing and copper plating process to produce copper-clad laminates. The bond strength is proven, and these laminates are ready for the standard etching processes.

The coverlay is currently under development. Laminate manufacturers are not prepared to ship reliable coverlay films with transparent glue. Chemical companies are close to delivering transparent and heat-resistant ink (actually transparent polyimide ink) as a screen-printable transparent coverlay.

There is one last detail to overcome before we complete transparent and heat resistant flex circuits—transparent conductors. We are considering several candidates. ITO film is still useful because of its long history. Low performance with flex endurance is the major issue of the flex circuits. A relatively high conductor resistance stands in the way of application expansion. Organic conductive ink could be an option, but relatively low conductivity is still a problem. A lower heat resistance restricts applications. A screen-printable silver nanowire ink could be used, but its relatively high cost eliminates it as an option. Fine copper mesh generated by chemical etching has a very different concept as a transparent conductor. It has almost the same conductivity as copper foils but requires a very high etching capability for the fine-line mesh and is cost-prohibitive.

The perfect solution is within reach. Once it comes to fruition, there will be high demand for transparent flex circuits. **FLEX007**

Dominique K. Numakura is the managing director of DKN Research LLC. To read past columns or contact Numakura, click here.

SEMI FlexTech Launches Three Flexible Hybrid Projects

In collaboration with the U.S. Army Research Laboratory, FlexTech will fund half of the total $2.6 million for three projects aimed at maturing the flexible hybrid electronics technology ecosystem.

1. The University of Colorado project is focused on integrating soft actuators and flexible electronic control circuits to demonstrate a complete soft robotic system. The system will mimic muscular structures such as an octopus arm or elephant trunk and will use a human-machine interface for robotic manipulation. CU will be partnering with PARC on this 18-month project.

2. Researchers at the University of Washington will focus on an 18-month project to improve and optimize sensor design with ultra-high-resolution printed structures using the novel piezoelectric material of a TMCM MnCl3 (trimethylchloromethyl ammonium trichloromanganese). Deliverables include demonstration of large area roll-to-roll printed electronics fabrication and integration, with compact signal conditioning and wireless data transmission.

3. UCLA will develop and demonstrate a foldable, high-resolution microdisplay on PDMS substrates by developing an ultra-high yield, scalable and low-cost mass transfer process for assembly of high-quality GaN μLEDs at 100um size for a resolution of >200 pixels per inch (PPI). The prototype will be made using heterogeneous integration of mass-transferred GaN μLED with Si CMOS driver circuitry on a common flexible organic substrate using fan-out-wafer-level packaging. (Source: SEMI)

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BY TAIYO

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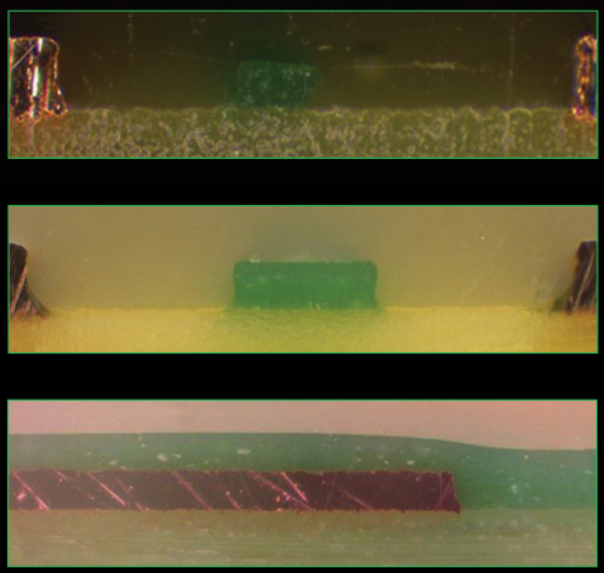

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Flex007 Highlights

The iNEMI 2019 Roadmap: Flexible Hybrid Electronics ▸

The emerging trend for "electronics on everything, everything with electronics" was the theme of iNEMI's webinar presentation of the highlights of its recently published Flexible Hybrid Electronics Roadmap Chapter, delivered by Girish Wable, senior engineering services manager with Jabil.

EPTE Newsletter–Next-Generation Flex Circuits: Elastic ▸

Wearable electronics and health care devices brought a need for elastic, flexible circuits. Dominique Numakura explores next-generation flexible circuits, starting with elastic circuits.

NextFlex Secures Seven Years of Funding in Agreement with Air Force Research Laboratory ▸

NextFlex, America's Flexible Hybrid Electronics (FHE) Manufacturing Innovation Institute, announced that it secured seven years of government funding worth up to $154M in a cost-sharing agreement with the Air Force Research Laboratory (AFRL).

EastPrint Expands Offerings for Printed Electronics to Include CNT Hybrids ▸

CHASM Advanced Materials Inc. inventor of AgeNT formed a partnership with Eastprint, a premier printed electronics provider serving clients across North America. As an affiliate of the CHASM Preferred Integration Partner (PIP) Program, Eastprint secured access to CHASM's line of transparent conductive printed electronics materials to offer their customers greater choice in high optoelectronic performance transparent conductors.

SEMI FlexTech Launches Three New Projects to Advance Flexible Hybrid Electronics ▸

SEMI FlexTech announced the launch of three projects to accelerate sensor and sensor system innovations for new applications in industries including healthcare, automotive, industrial, and defense.

Matrix Electronics Expands Flexible Circuit Materials Manufacturing ▸

Matrix Electronics has completed a new, larger flexible circuit materials conversion center at its Santa Ana, California, location. This facility will accommodate the company's growth and improve productivity with state-of-the-art automated processing equipment.

MFS Technology Opens Fourth Manufacturing Plant ▸

MFS Technology recently opened its fourth manufacturing plant. The new factory, which specializes in high-precision flexible printed circuit boards and electronics components assembly, is in Yiyang city's Economic Development Zone, Hunan, China.

ROARTIS Introduces Fast Cure Materials for Printed Electronic Applications ▸

ROARTIS has developed a range of anisotropic conductive adhesives, used in the assembly of fine pitch RFID antennas, where reliable interconnections of the RFID tab onto the RFID antenna can be realized in a matter of seconds. IQ-BOND 5976-ACE addresses the economic challenges of printed electronics, in combination with the high throughput processing requirements and long-term reliability requirements.

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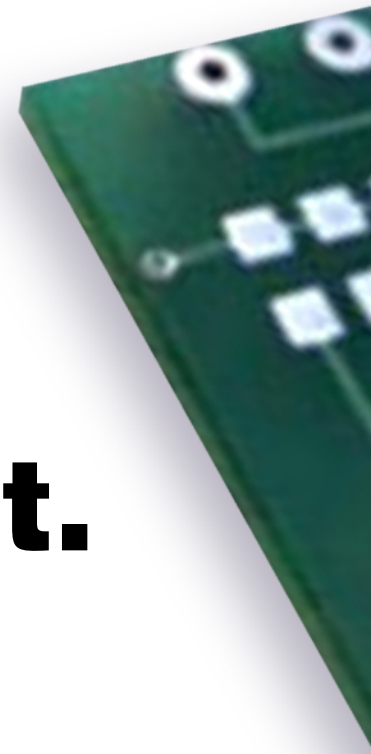

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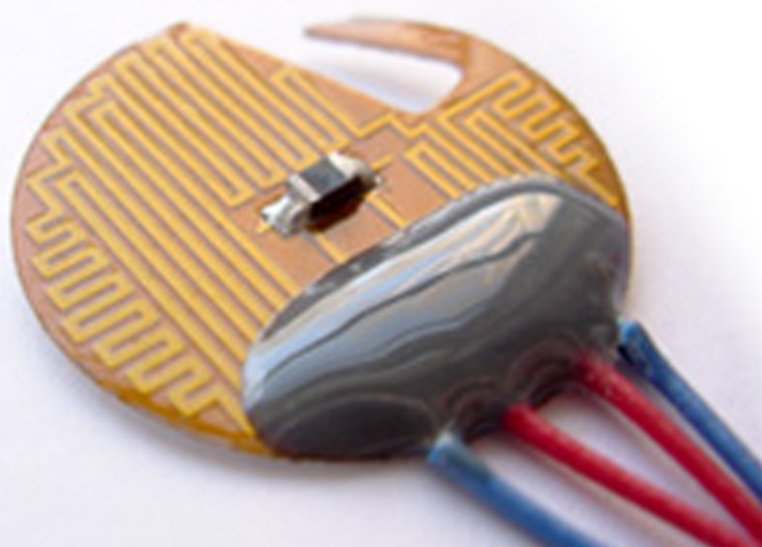

Closing the Talent Gap: Work-Based Learning for Industry 4.0 and Beyond

FlexOO7 Article by Emily McGrath
NEXTFLEX

It is hard to come across an article, a lecture, or a webinar on closing the advanced manufacturing skills gap that does not mention work-based learning—apprenticeships, internships, co-ops, and the list goes on.

The prevalence of mentions of work-based learning but lack of actual programming speaks to the difficulty of establishing and replicating these types of platforms. However, there are some notable successes in the field. The Federation for Advanced Manufacturing Education (FAME) Program is a well-known national example, and some institutions have succeeded on a local scale, such as Lorain County Community College's TRAIN OH Program. But for the most part, the education and industry sectors have failed to crack the code on impactful and scalable collaboration.

There are good reasons for this. Education and industry, while closely linked, are accustomed to operating sequentially but not in tandem: students are educated and then hired. This hands-off approach to talent creation has allowed the academic and industrial communities to develop fundamentally incompatible standard operating procedures. Now that work-based learning is enjoying a resurgence in popularity, schools and companies are trying to figure out how to work together. While collaboration is fundamental to success, the complexities of inter-organization cooperation paralyze many promising initiatives.

In recognition of the vital role that multi-sector collaboration plays in technology and workforce development, the federal government launched Manufacturing USA in 2012. This program is comprised of 14 public-private

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institutes, each focused on different emerging technologies and guided by the same parallel mandate: to develop and commercialize their technology and ensure the creation of the skilled and capable workforce needed to support the advanced manufacturing sector.

NextFlex, one of the 14 institutes, operates as a consortium of academic, industry, and government partners focused on advancing the domestic manufacturing of flexible hybrid electronics (FHE). As part of our mission to help create a deep talent pool for the advanced manufacturing sector, NextFlex has developed a portfolio of workforce development programs that leverage our position as an intermediary. Each program is designed to address a critical gap in the progression of talent through the labor market by bringing together diverse stakeholders to accomplish common goals. Figure 1 illustrates two of these programs and the gaps they bridge.

NextFlex's flagship outreach program, FlexFactor, addresses the interest and awareness gap in modern manufacturing. By showcasing the potential and vibrancy of the advanced manufacturing sector, FlexFactor engages students with the education and career pathways that lead to industry jobs. Through an immersive project-based learning experience that centers on first-hand engagement, the program introduces students to a high-technology field with exciting career prospects that typically have been disregarded for decades as dirty, dull, and dangerous.

Building on FlexFactor's success in engaging students with the advanced manufacturing sector, NextFlex decided to tackle the next challenge: educating and training the next generation of talent for the advanced manufacturing sector.

To support a competitive and innovative advanced manufacturing sector, the U.S. requires a range of talent. Ph.D.s focus on the fundamental research underlying new technology development, while individuals with master's and bachelor's degrees design and develop new products using those technologies once they are fully mature. Technicians and technologists support the spectrum of activity from research to production through testing, analysis, and assembly roles.

The development of new technologies and manufacturing processes has led to the exponential growth of technician and technologist positions. These jobs do not require the deep foundation provided by a bachelor's degree but still demand significant specialized training in the basic knowledge and skills required to prototype, test, assemble, and manufacture products.

The challenge of creating the quantity and caliber of technicians and technologists needed by the advanced manufacturing sector has largely fallen to our national community college system. These two-year institutions are perfectly positioned to address the technician/technologist talent gap with their high-impact training and affordable education but are fac-

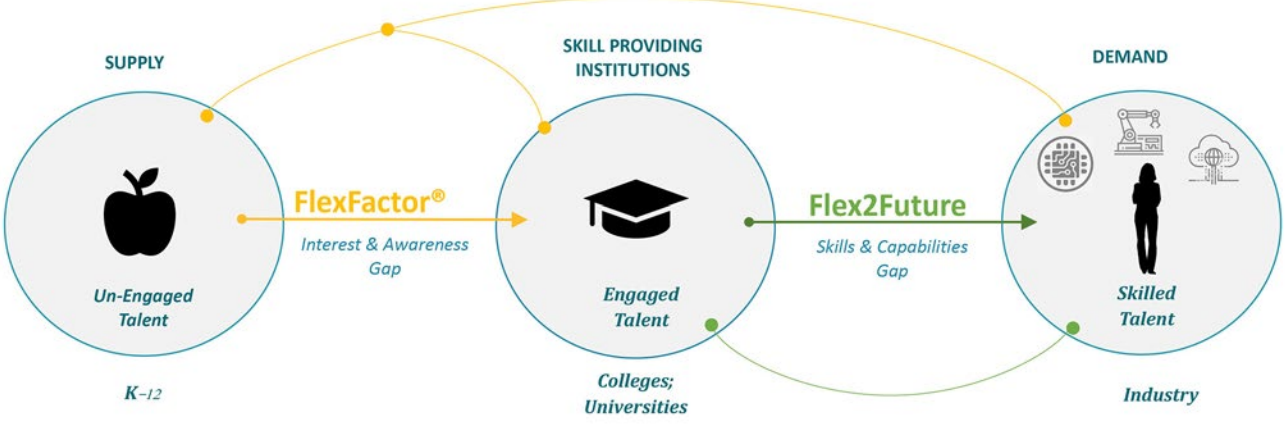

Figure 1: How two of NextFlex's programs bridge the gaps between education and industry.

ing increasing difficulty maintaining a curriculum that reflects current industry needs.

While foundational learning for STEM careers involves a fairly static body of knowledge, the applications of that fundamental knowledge changes at the pace of innovation. As technology development and commercialization cycles tighten, the corresponding demand for new knowledge, competencies, and equipment is accelerated. Increasingly tight innovation cycles make it virtually impossible for community colleges to maintain up-to-date coursework and tooling. The budget and space required to procure and house industrial-grade equipment and associated curriculum are far beyond the means of an average community college, as it is essential to student learning.

To address this seemingly impossible situation, there is only one option: colleges and industry must closely partner to provide the full range of education and training necessary for graduate success in Industry 4.0. Colleges deliver the foundational STEM learning in classrooms and labs, while practical applications are taught in an industrial manufacturing setting at local companies.

To facilitate and enable this division of labor, NextFlex developed Flex2Future, a work-based learning program designed for advanced manufacturing pathways. The program is adopted by community colleges and provides the twin pillars of successful work-based learning: partner collaboration and program management, and high-impact and transformative learning experiences for students.

Academic and industry partnership initiatives often fall between the siloes of education and industry, leaving important efforts to flounder without supervision and strategy. Joint committees are generally composed of volunteers operating not only outside their organizational hierarchy but also outside their job descriptions. Flat reporting structure and borrowed time are stumbling blocks that even the most motivated of teams will have trouble overcoming.

Even if strategy and management can be effectively established by a multisector team, there is still ample opportunity to squander programmatic potential. Once students are onboarded at companies, their experiences vary greatly and have an immense impact on which individuals develop the skills and competencies that make them competitive and attractive hires—and which ones languish without direction or support.

The most impactful work-based learning experiences are deliberately structured and carefully monitored to drive technical growth and skill development in interns. Essential components include technical training, professional development, routine feedback, and networking opportunities. To close the gap between academic learning and practical application of skills, intern managers need to scope a set of tasks that increase in complexity and couple each assignment with technical training. Students also should receive guidance on building professional presence, including written and verbal communication, public presenting, and attire; these valuable competencies are frequently overlooked in a classroom setting but are central to career mobility.

Impactful and transformative internships are only possible if the primary goal of the internship is learning and skill development. In many companies, interns are treated as a low-cost means of fulfilling a random series of tasks. To truly reap the benefits of work-based learning—future employees with initiative, deep comprehension, and analytical thinking, which are so critical to innovation and continuous improvement—assignments must be chosen with strategy and accompanied by corresponding mentorship.

Designing and implementing this type of experience takes effort and resources most companies do not put into interns. Those that do, however, generally find the investment pays off as their students develop the aptitude, knowledge, and experience to become valuable contributors. Companies that prove successful at this process transition from talent recruitment to development, redirecting their resources toward the deliberate creation of a capable and skilled employee base.

While both education and industry tend to agree about the benefits and need for work-

based learning, this recognition has not translated into action. Work-based learning partnerships require both companies and colleges to move out of their operational comfort zones and commit resources to the effort.

Colleges need to take a leadership role in this process not only by defining strategy but also by providing project management. While many colleges have a faculty member in charge of industry relationships, few have a project manager in charge of coordination legwork. Although this additional headcount may feel like an unnecessary luxury for cash-strapped departments, it is the driving force that allows a joint committee to translate high-level strategy into tactical action. Tapping into company machine shops and industry experts for the price of a program manager saves huge expenses in capital equipment and instructors. This small investment in personnel can transform lackluster advanced manufacturing programs into high-octane pathways that lead to exciting careers in cutting-edge industries (Figure 2).

In addition to the program management capacity, college departments need to be flexible about the structure of work-based learning experiences. The academic world depends on the standardization of opportunities, schedules, and experiences, while the labor market is subject to individual effort, personal luck, and fluctuating organizational requirements. Colleges will need to find a way to accommodate unpredictable and diverse opportunities within the rigid framework of educational programming. Without this management and flexibility, colleges will continue to box out their most valuable education partners.

Similarly, the industry will need to redefine its role in education. Participation in the learning process needs to be supported by

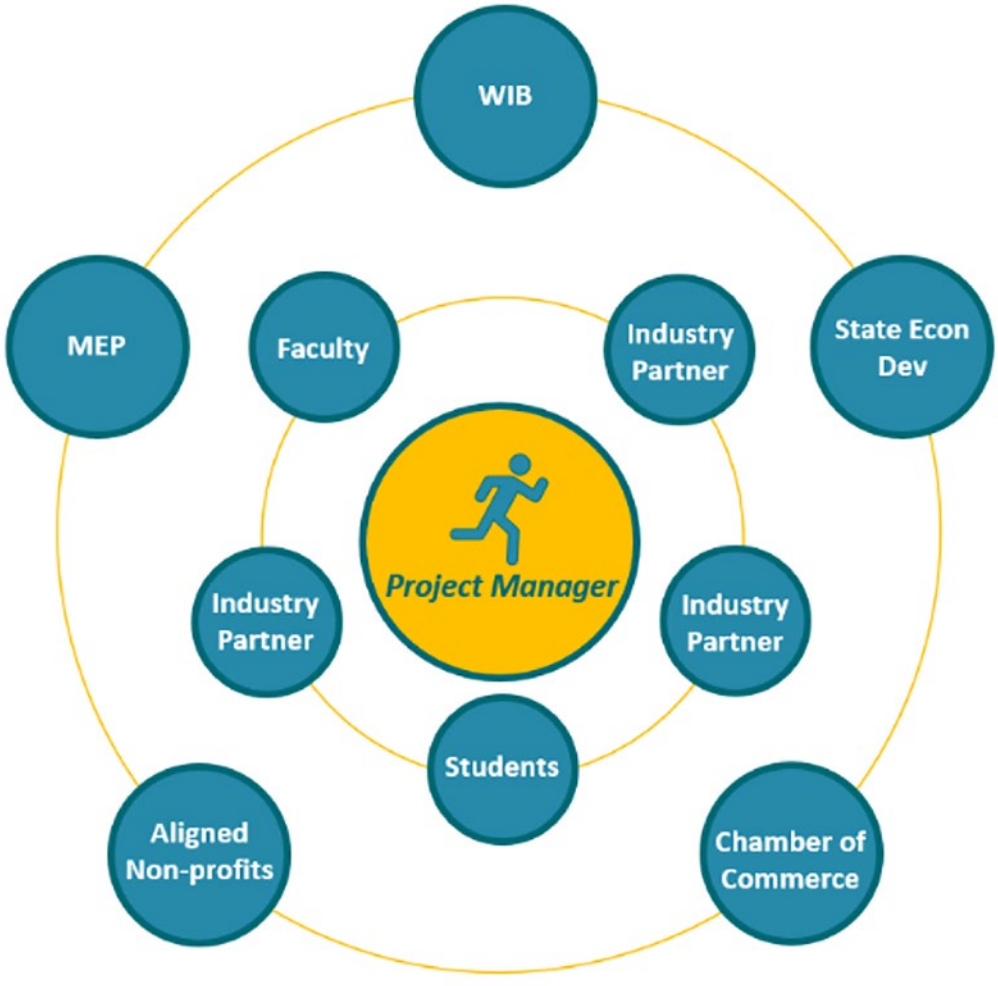

Figure 2: Flex2Future program manager orchestrating work-based learning activities.

company leadership and involve more than quarterly advisory meetings by volunteers. Intern managers should be identified based on a proven ability to foster talent, and the corresponding coordination and mentorship responsibilities should be codified within their job descriptions. Without this level of commitment and engagement from companies, work-based learning will continue to fall far short of its true potential to cultivate those characteristics that are so essential to Industry 4.0—entrepreneurial thinking and complex problem solving.

U.S. leadership in the advanced manufacturing sector—as well as the cascade of defense, economic, and social benefits that position provides—is fundamentally enabled by our educational system. To maintain the status of a world leader, the U.S. needs to ensure schools continue to generate talent driving an unparalleled rate of innovation and production. But the educational system that powered the Industrial Revolution is unlikely to meet the needs of Industry 5.0. Preparing a workforce for the 21st century will require unprecedented levels of collaboration and cooperation between education and industry. Only through robust partnerships will the U.S. pave the way to create the next generation of innovators and ensure that America remains a powerhouse of invention and entrepreneurship. **FLEX007**

Emily McGraths is the director of workforce development at NextFlex.

Happy Holden Answers Your Flexible Circuit Questions

Industry veteran Happy Holden, "Mr. HDI," has been answering readers' questions about everything from stacked microvias to the global PCB market. Here are a few of the questions he's fielded regarding flexible circuits.

Q: What are the key reliability concerns for flexible circuits moving to newer technologies, materials, and processes?

A: The reliability concerns for flex are the same as for rigid circuits, with the exception of flexing. Material performance, conductor performance, external factors, usage, cleanliness, assembly, etc., are all important. Raza Ghaffarian of the Jet Propulsion Laboratory wrote a great review of flex reliability in the 7th edition of the *Printed Circuit Handbook,* which I co-edited with Clyde F. Coombs.

Q: What do you think will be the next leading-edge technology for flexible circuits?

A: Disposable and wearable substrates, including paper.

Q: Will flexible circuits be considered an integral interconnect for 5G technology?

A: Yes. Flex circuits will evolve to fulfill the needs of 5G. What may change are the "connections" as millimeter-wave devices, and IIoT can be used to connect signals in 3D and at angles instead of using flex.

To pose your own question for Happy Holden, take the survey.

Designers at the Edge

Flexible Thinking

by Joe Fjelstad, VERDANT ELECTRONICS

"I want to stand as close to the edge as I can without going over. Out on the edge, you see all the kinds of things you can't see from the center." –Kurt Vonnegut

Kurt Vonnegut was a favorite author of mine during the 1960s. He wrote several fanciful and entertaining novels over his career, and he always managed to slip in a thoughtful message here and there for his readers to ponder. The above quote is from his first novel, *Player Piano,* published in 1952.

It is the story of engineer Paul Proteus, struggling to find a way to live in a world dominated by a supercomputer and run completely by machines. Side note: Proteus was the Greek god of water and of change, and it is also a name for a PCB design software tool, but that is coincidental. As an aspiring young science geek in the nascent technical mecca of electronics technology, Santa Clara Valley (the name before Silicon Valley), its theme was very entertaining to me. But as we are learning—and others have warned over the ensuing seven decades—it also turned out to be pretty close to current reality, but I digress.

Given the theme of *Design007 Magazine* this month, where this column finds its home, Vonnegut's quote is a good one for designers to hang on their walls near their design stations. As I have stated in previous columns, designers are the drum majors of the electronics industry—the leaders of the electronic interconnection industry band and parade. The decisions made by designers have an impact all the way down the manufacturing line. Designers are generally called upon to design products that conform to norms and admonished not to challenge the status quo. In the past, I have written that the designer should design with manufacturing rather than for manufacturing. I hold fast to that notion. However, a hallmark quality of the best

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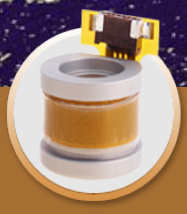

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designers I've had the privilege to know over the years has been their penchant for thinking "differently." They would come up with ideas that were outside normal design practice, often pushing the limits of design norms.

I had the pleasure of working with one such designer, John Goodrich, when he was with National Semiconductor and founder and president/CEO Charlie Sporck was still at the helm. It was in the mid-1980s when, while running process development at Printed Circuit Builders Inc.—a small but spunky PCB company in Silicon Valley—that I first met John. He came into the shop with an unusual idea. He wanted us to make a multichip module comprised of a castellated package with chips that would be wire bonded on the top and bottom, encapsulated, and then a third chip a UV EPROM beneath a windowed cap; this was then surface-mounted to the top of the first assembly. He needed it to demonstrate a new product to Ford less than three weeks later in order to secure a multi-million-dollar contract from the customer. The company had already made the product, which consisted of two ceramic packages bonded one on top of the other. It had form and function, but it did not fit.

Printed Circuit Builders Inc. had experience making many of the things John needed, but there were many other new things that needed to be learned. John and I worked closely to make it happen, trying to accommodate the needs of the other in getting the process defined. He asked if it could be done and if it would work. I told him I felt it could be done and that we would yield some good assemblies, but I could not predict what the yield would be. To make a long story short, our cooperative exercise was a success, and the contract was secured. Our company received a nice, personal letter of thanks from Sporck—a most thoughtful and gentlemanly gesture from one of the men recognized as a founding father of Silicon Valley.

What John envisioned at the moment was outside the box of normal design. The solution demanded it, and John responded accordingly. It was many more years before I saw something akin to what we did back then finally showcased in technical literature. I have known other designers as well who refused to be hemmed in or corralled by convention. They have been mavericks, and the industry needs mavericks. It needs more designers willing to follow Peter Proteus to the edge. In the center is the known, but it's at the edge where change is found—and progress comes only from change.

Think differently, embrace change, and you will cause change. It is the only way change has ever come or ever will come about.

Stay safe and stay well. **FLEX007**

Joe Fjelstad is founder and CEO of Verdant Electronics and an international authority and innovator in the field of electronic interconnection and packaging technologies with more than 185 patents issued or pending. To read past columns or contact Fjelstad, click here.

1 Altium 365 Helps Designers Stay Productive From Home ▶

From home offices to virtual workplaces, the working environment has changed. For the PCB design industry, Altium has helped make the transition seamless, empowering collaboration across every aspect of the design process. With Altium 365, the world's only cloud-based platform for PCB design and realization, many of Altium's customers were able to stay in motion even during this challenging time.

2 Beyond Design: The Impact of Signal Rise Time on Bandwidth ▶

The term bandwidth was first used years ago in the RF world to represent the range of frequencies in a signal. In digital electronics, we also use the term to describe the signal spectrum since square waves are made up of numerous sine waves (harmonics) of the fundamental frequency.

3 DownStream Technologies Update With Joe Clark ▶


Joe Clark

On June 15, Andy Shaughnessy spoke with Joe Clark, co-founder of DownStream Technologies, about the company's drive to take care of its customers and employees throughout the pandemic and beyond. Joe discusses some of his customers' current challenges, especially those working from home for the first time.

4 Dana Korf: What Fabricators Expect From Designers ▶

Andy Shaughnessy and Barry Matties spoke with Dana Korf, former chief PCB technologist for Huawei and currently principal consultant of Korf Consultancy, about the breakdown in communication between manufacturers and designers. Dana discusses exactly what a fabricator expects from a PCB designer, why these expectations are often not met.

5 Letter to the Editor: Rick Hartley Offers Addendum on App Notes ▸

In the June 2020 issue of *Design007 Magazine,* the I-Connect007 editorial team interviewed design instructors Rick Hartley and Dan Beeker regarding their belief that designers should not trust app notes until they've been proven to be accurate. After the issue was published this week, Rick emailed us with a few more points that he wished to contribute to the ongoing app note conversation.

6 Beyond Design: Predicting and Measuring Impedance ▸

To control the impedance of high-speed signal interconnects, one first needs to predict the impedance of a specific multilayer stackup configuration. Barry Olney describes how a precision field solver is arguably the most accurate way to calculate the single-ended, edge-coupled, and broadside-coupled differential impedance.

7 PCB Builder from Digi-Key Lets Customers Order Directly From Board Shops ▸

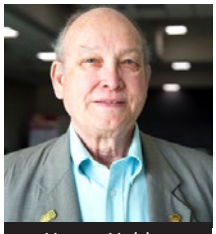

Josh Mickolio

On June 2, components distributor Digi-Key Electronics announced the release of PCB Builder, a tool that lets customers have PCBs shipped directly from the fabricator. PCB Builder also allows customers to perform file layer checks and receive instant quotes from multiple fabricators. Andy Shaughnessy spoke with Josh Mickolio, supplier business development manager for Digi-Key, about the development of PCB Builder and what this tool means to PCB designers and design engineers.

8 Book Excerpt: Producing the Perfect Data Package ▸

The following is an excerpt from Chapter 1 of Mark Thompson's I-Connect007 eBook *The Printed Circuit Designer's Guide to… Producing the Perfect Data Package*. Mark is in engineering support at Prototron Circuits and a Design007 columnist.

9 Just Ask Happy: The Proper Order of Design Techniques to Improve Connectivity ▸


Happy Holden

We asked for you to send in your questions for Happy Holden, and you took us up on it! The questions you've posed run the gamut, covering technology, the worldwide fab market, and everything in between.

10 This Month in Design007 Magazine: Thermal Management–Keeping Cool Starts From Within ▸


Jade Bridges

Thermal management plays a significant role in protecting electronic circuitry. Jade Bridges takes a fresh look at popular subjects within the field of thermal management and explores what occurs when devices overheat, as well as the benefits of thermal gap fillers and how to best avoid pump-out.

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Responsible for developing and optimizing Lenthor's manufacturing processes from start up to implementation, reducing cost, improving sustainability and continuous improvement.

Position Duties

- Senior process engineer's role is to monitor process performance through tracking and enhance through continuous improvement initiatives. Process engineer implements continuous improvement programs to drive up yields.
- Participate in the evaluation of processes, new equipment, facility improvements and procedures.
- Improve process capability, yields, costs and production volume while maintaining safety and improving quality standards.
- Work with customers in developing cost-effective production processes.
- Engage suppliers in quality improvements and process control issues as required.
- Generate process control plan for manufacturing processes, and identify opportunities for capability or process improvement.
- Participate in FMEA activities as required.
- Create detailed plans for IQ, OQ, PQ and maintain validated status as required.
- Participate in existing change control mechanisms such as ECOs and PCRs.
- Perform defect reduction analysis and activities.

Qualifications

- BS degree in engineering
- 5-10 years of proven work experience
- Excellent technical skills

Salary negotiable and dependent on experience. Full range of benefits.

Lenthor Engineering, Inc. is the leader in Flex and Rigid-Flex PWB design, fabrication and assembly with over 30 years of experience meeting and exceeding our customers' expectations.

Contact Oscar Akbar at: hr@lenthor.com

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Career Opportunities

Quality Engineer

SUMMARY

Quality engineer with supervisory responsibilities, reporting to operations manager at Indium Corporation, European Operations. Candidate should be based within one-hour travel distance of Milton Keynes, U.K. M-F, 40 hours per week. Open until filled.

RESPONSIBILITIES

- Preventive/predictive maintenance, servicing, calibrations of equipment and facility in the work area
- Overseeing document control
- Approval of departmentally controlled docs
- SOP updates
- Full involvement in external audits, supported by the rest of the supervisor team and operations manager
- Internal and supplier auditing
- Product audits
- Sign off on TEOs and MRBs
- Reporting KPI performance to operations manager
- PPAP
- FMEA, control plan
- Customer complaints, RMAs investigation and reporting
- Project lead
- MSA design and implementation
- Maintenance of approved supplier list (ASL) and approved parts list (APL)
- Supplier risk assessments
- CAPAs, including SCARs
- Product qualifications
- Maintenance of equipment list
- Control of non-conforming product
- Sign off on change management (minor)

REQUIREMENTS

- IT literate
- Excellent written and verbal communication skills
- Strong interpersonal skills
- Numerate
- Six Sigma green belt
- Core Tools trained and certificate held
- Experienced auditor to IATF standard
- VDA trained auditor
- Several years' experience in a quality department within the automotive industry, including experience of IATF16949
- A recognised degree-level qualification in science
- Member of a certified industry organisation (CQI) or equivalent

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Image Department Operator

Alpha Circuit Corporation is a manufacturer of printed circuit boards located in Elmhurst, IL. We are currently seeking an operator in our Image department.

- All safety gear will be provided
- No experience required but a plus
- Full paid training provided
- Benefits: Health Insurance, 401(k), paid time off

Responsibilities:

- Expose dry film and liquid photo imageable ink
- Develop exposed photo imageable ink
- Develop exposed dry film
- Laminate dry film resist on inner layer and outer layer printed circuit panels
- Learn, understand, apply, and accept responsibility for in-process quality standards
- Be able to lift up to 15 lbs. shoulder high

If you are interested in this position, please contact Nita Buccino.
Email: nvb@alphacircuit.com,
cell: +1-847-489-2341.

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Career Opportunities

BURKLE
NORTH AMERICA, INC.

Service Engineer
Schmoll Laser Drilling and Direct Imaging

Burkle North America seeks a full-time service engineer in the Northeastern U.S. This position will provide expert-level service on multiple laser drilling and direct imaging product lines. Install, commission, and maintain Schmoll products at multiple customer sites across the Northeast. The candidate will perform modifications and retrofits as needed. Maintain complete and detailed knowledge of Schmoll products and applications and handle a wide variety of problems, issues, and inquiries to provide the highest level of customer satisfaction. Assist customers with the potential optimization of their machine functions and work with clients on application improvements.

Qualifications

Required: Bachelor's degree from a technical college/university in an associated field. Three years directly related experience, or equivalent combination of education and experience. Must possess a valid driver's license and have a clean driving record.

Preferred: Experience in control systems and electronic troubleshooting, as well as in general electrical and mechanical service tasks. Experience and knowledge in the PCB manufacturing process, with a focus on laser drilling and/or direct imaging.

Send resume to hr@burkleamerica.com.

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WHELEN®
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Process Engineering Director

Whelen Engineering Co., Inc. seeks full-time process engineering director in Concord, NH, to develop, plan and execute GreenSource Fabrication, LLC Div.'s process technology business strategy; manage process engineering activities, staff and compliance; improve process design, cost, quality and resource utilization; interact w/ customers and incorporate feedback; develop financial capital and labor projections; travel internationally for conferences, supplier and customer visits (15-25% worktime); write white papers, IP applications and give talks re. Division's products/processes.

Min. req.: U.S. Bachelor's or foreign equivalency in environmental science or engineering; min. 10 yrs. work exp. in: PCB fabrication process engineering; comprehensive and current experience in PCB fabrication/substrate markets w/ SAP tech; developing chemical and mechanical processes, chemistries and equipment for PCB manufacturing demonstrated by international experience implementing complex processes; ability to direct and troubleshoot PCB manufacturing problems; min. 5 years exp. leading, managing and training process engineering teams, developing and executing process technology business strategies and plans in worldwide PCB markets, including Japan, Taiwan, China, Europe; min. 3 years exp. giving talks, writing and presenting white papers; ability to travel internationally (15-25% worktime).

Send CVs to: Corinne Tuthill,
ctuthill@greensourcefab.com
or GreenSource Fabrication, LLC,
99 Ceda Road, Charlestown, NH 03603.

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Career Opportunities

eptac

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Become a Certified IPC Master Instructor

Opportunities are available in Canada, New England, California, and Chicago. If you love teaching people, choosing the classes and times you want to work, and basically being your own boss, this may be the career for you. EPTAC Corporation is the leading provider of electronics training and IPC certification and we are looking for instructors that have a passion for working with people to develop their skills and knowledge. If you have a background in electronics manufacturing and enthusiasm for education, drop us a line or send us your resume. We would love to chat with you. Ability to travel required. IPC-7711/7721 or IPC-A-620 CIT certification a big plus.

Qualifications and skills

- A love of teaching and enthusiasm to help others learn
- Background in electronics manufacturing
- Soldering and/or electronics/cable assembly experience
- IPC certification a plus, but will certify the right candidate

Benefits

- Ability to operate from home. No required in-office schedule
- Flexible schedule. Control your own schedule
- IRA retirement matching contributions after one year of service
- Training and certifications provided and maintained by EPTAC

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APCT

Passion | Commitment | Trust

APCT, Printed Circuit Board Solutions: Opportunities Await

APCT, a leading manufacturer of printed circuit boards, has experienced rapid growth over the past year and has multiple opportunities for highly skilled individuals looking to join a progressive and growing company. APCT is always eager to speak with professionals who understand the value of hard work, quality craftsmanship, and being part of a culture that not only serves the customer but one another.

APCT currently has opportunities in Santa Clara, CA; Orange County, CA; Anaheim, CA; Wallingford, CT; and Austin, TX. Positions available range from manufacturing to quality control, sales, and finance.

We invite you to read about APCT at APCT.com and encourage you to understand our core values of passion, commitment, and trust. If you can embrace these principles and what they entail, then you may be a great match to join our team! Peruse the opportunities by clicking the link below.

Thank you, and we look forward to hearing from you soon.

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Career Opportunities

Development Chemist
Carson City, NV

Develop new products and modify existing products as identified by the sales staff and company management. Conduct laboratory evaluations and tests of the industry's products and processes. Prepare detailed written reports regarding chemical characteristics. The development chemist will also have supervisory responsibility for R&D technicians.

Essential Duties:

- Prepare design of experiments (DOE) to aid in the development of new products related to the solar energy industry, printed electronics, inkjet technologies, specialty coatings and additives, and nanotechnologies and applications
- Compile feasibility studies for bringing new products and emerging technologies through manufacturing to the marketplace
- Provide product and manufacturing support
- Provide product quality control and support
- Must comply with all OSHA and company workplace safety requirements at all times
- Participate in multifunctional teams

Required Education/Experience:

- Minimum 4-year college degree in engineering or chemistry
- Preferred: 5-10 years of work experience in designing 3D and inkjet materials, radiation cured chemical technologies, and polymer science
- Knowledge of advanced materials and emerging technologies, including nanotechnologies

Working Conditions:

- Chemical laboratory environment
- Occasional weekend or overtime work
- Travel may be required

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SMT Field Technician
Huntingdon Valley, PA

Manncorp, a leader in the electronics assembly industry, is looking for an additional SMT Field Technician to join our existing East Coast team and install and support our wide array of SMT equipment.

Duties and Responsibilities:

- Manage on-site equipment installation and customer training
- Provide post-installation service and support, including troubleshooting and diagnosing technical problems by phone, email, or on-site visit
- Assist with demonstrations of equipment to potential customers
- Build and maintain positive relationships with customers
- Participate in the ongoing development and improvement of both our machines and the customer experience we offer

Requirements and Qualifications:

- Prior experience with SMT equipment, or equivalent technical degree
- Proven strong mechanical and electrical troubleshooting skills
- Proficiency in reading and verifying electrical, pneumatic, and mechanical schematics/drawings
- Travel and overnight stays
- Ability to arrange and schedule service trips

We Offer:

- Health and dental insurance
- Retirement fund matching
- Continuing training as the industry develops

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Career Opportunities

U.S. CIRCUIT

Sales Representatives (Specific Territories)

Escondido-based printed circuit fabricator U.S. Circuit is looking to hire sales representatives in the following territories:

- Florida
- Denver
- Washington
- Los Angeles

Experience:

- Candidates must have previous PCB sales experience.

Compensation:

- 7% commission

Contact Mike Fariba for more information.

mfariba@uscircuit.com

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ZENTECH

Zentech Manufacturing: Hiring Multiple Positions

Are you looking to excel in your career and grow professionally in a thriving business? Zentech, established in Baltimore, Maryland, in 1998, has proven to be one of the premier electronics contract manufacturers in the U.S.

Zentech is rapidly growing and seeking to add Manufacturing Engineers, Program Managers, and Sr. Test Technicians. Offering an excellent benefit package including health/dental insurance and an employer-matched 401k program, Zentech holds the ultimate set of certifications relating to the manufacture of mission-critical printed circuit card assemblies, including: ISO:9001, AS9100, DD2345, and ISO 13485.

Zentech is an IPC Trusted Source QML and ITAR registered. U.S. citizens only need apply.

Please email resume below.

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Career Opportunities

BLACKFOX
Premier Training & Certification

IPC Master Instructor

This position is responsible for IPC and skill-based instruction and certification at the training center as well as training events as assigned by company's sales/operations VP. This position may be part-time, full-time, and/or an independent contractor, depending upon the demand and the individual's situation. Must have the ability to work with little or no supervision and make appropriate and professional decisions. Candidate must have the ability to collaborate with the client managers to continually enhance the training program. Position is responsible for validating the program value and its overall success. Candidate will be trained/certified and recognized by IPC as a Master Instructor. Position requires the input and management of the training records. Will require some travel to client's facilities and other training centers.

For more information, click below.

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YOUR JOB AD HERE

For information, please contact:
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barb@iconnect007.com
+1 916.365.1727 (PACFIC)

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This professional has done it all. Built new businesses and turned around hurting businesses and made them successful. A proven record of success. This candidate is a game-changer for any company. He is seeking a full-time leadership position in a PCB or PCBA company.

General Manager PCB and PCBA

Senior manager with experience in operations and sales. He has overseen a number of successful operations in Canada. Very strong candidate and has experience in all aspects of PCB operations. He is looking for a new full-time position in Canada.

Regional Sales Manager/Business Development

Strong relationship management skills. Sales experience focused on defense-aerospace, medical, high-tech PCB sales. Specializes in technical sales. Also has experience in quality, engineering, and manufacturing of PCBs. He is looking for a fulltime position in the Southeastern U.S.

Field Application Engineer (FAE)

Has worked as a respected FAE in the U.S. for global companies. Specializes in working alongside sales teams. Large experience base within the interconnect industry. He is looking for a full-time position.

Business Development Manager

Understands all aspects of interconnect technical sales from PCB design and fabrication to assembly and all technologies from HDI microvias to flex and rigid-flex. Has also sold high-tech laminates and equipment. Proven record of sales success. He is looking for a full-time position.

CEO/President

Specializes in running multi-million dollar companies offering engineering, design, and manufacturing services. Proven leader. Supply chain manager. Expert at developing and implementing company strategy. Looking to lead a company into the future. He is looking for a full-time position.

PCB General Manager

Forty years of experience serving in all capacities, from GM to engineering manager to quality manager. Worked with both domestic and global companies. Available for turn-around or special engineering projects. He is looking for long-term project work.

Process Engineering Specialist

Strong history of new product introduction (NPI) manufacturing engineering experience: PCB/PCBA. Held numerous senior engineering management positions. Leads the industry in DFM/DFA and DFX (test) disciplines. He is looking for either a full-time position or project work.

VP Sales Global Printed Circuits

Worked with a very large, global company for a number of years. Built and managed international sales teams. Created sales strategies and communicated them to the team. One of the best sales leaders in our industry. He is looking for a full-time position.

Plant Manager

This professional has years of experience running PCBA companies. Led his companies with creative and innovative leaderships skills. Is a collaborative, hands-on leader. He is looking for a full-time position.

National Sales Manager

Seasoned professional has spent the past 20 years building and growing American sales teams for both global and domestic companies. Specializes in building and managing rep networks. He is looking for a full-time position.

Global Engineering Manager/Quality Manager

Has experience working with large, global PCB companies managing both engineering and quality staff. Very experienced in chemical controls. She is interested in working on a project-by-project basis.

CAM Operators and Front-end Engineers

These candidates want to work remotely from their home offices and are willing to do full-time or part-time projects.

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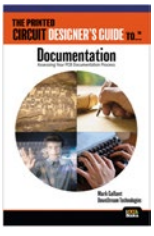
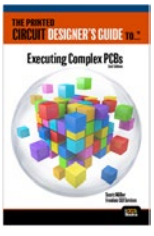
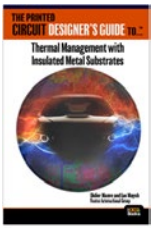


Documentation, by Mark Gallant, Downstream Technologies
When the PCB layout is finished, the designer is still not quite done. The designer's intent must still be communicated to the fabricator through accurate PCB documentation.



Executing Complex PCBs, by Scott Miller, Freedom CAD Services
Designing a complex circuit board today can be a daunting task. Never before have PCB designers on the cutting edge faced more formidable challenges, both electrical and mechanical.

Producing the Perfect Data Package, by Mark Thompson, Prototron Circuits
For PCB designers, producing a comprehensive data package is crucial. If even one important file is missing or output incorrectly, it can cause major delays and potentially ruin the experience for every stakeholder.



Thermal Management with Insulated Metal Substrates, by Didier Mauve and Ian Mayoh, Ventec International Group
Considering thermal issues in the earliest stages of the design process is critical. This book highlights the need to dissipate heat from electronic devices.

Fundamentals of RF/Microwave PCBs, by John Bushie and Anaya Vardya, American Standard Circuits
Today's designers are challenged more than ever with the task of finding the optimal balance between cost and performance when designing radio frequency/microwave PCBs.

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