

# THE **pcb** **design** MAGAZINE

October 2016

an IConnect007 publication

Inspiring Millennials  
in the PCB Design  
Community p.12

What's the Difference  
Between a Manager  
and a True  
Leader? p.18

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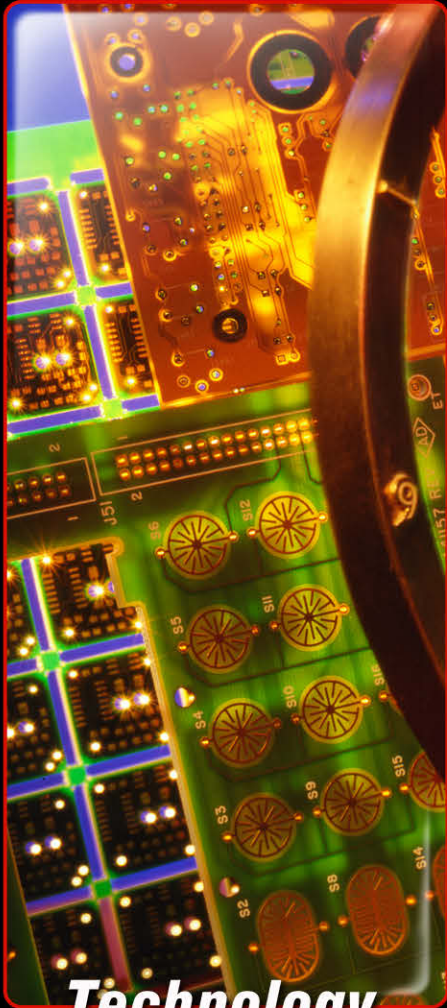
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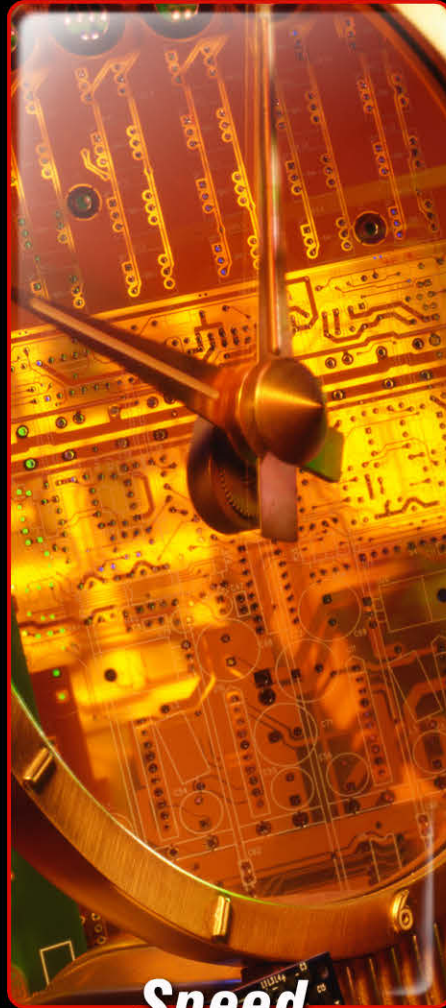


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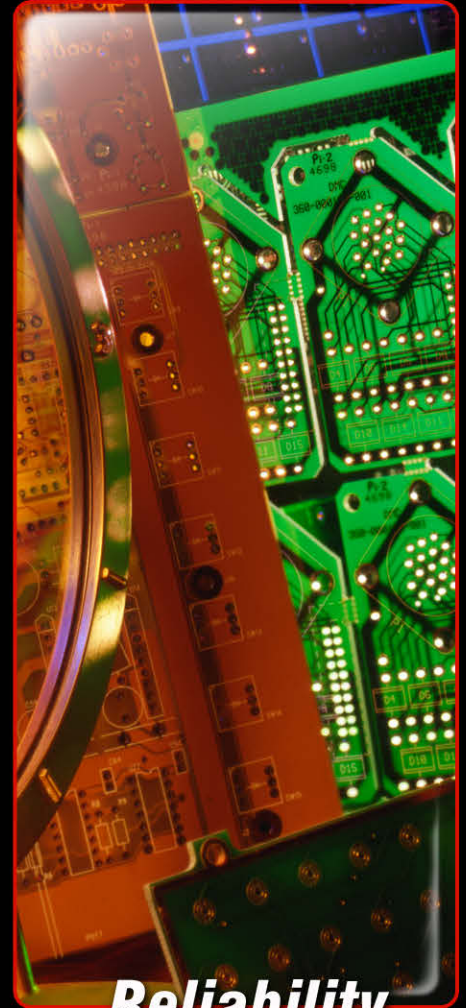
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# Leadership

What does leadership mean to you? This month, we focus on leadership, and the difference between a good manager and a great leader. We feature articles by SnapEDA founder Natasha Baker, Mentor Graphics' Michael Ford, IPC President John W. Mitchell, David Dibble of Dibble Leaders, and an interview with Leo Lambert, vice president of the training provider EPTAC. We'll also share the results of our I-Connect007 leadership survey. Lead, follow, or get out of the way!



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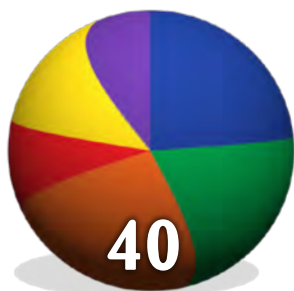


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# Leadership vs. Management

by **Andy Shaughnessy**

I-CONNECT007

Is your manager one of the great ones, a true leader? Many of your colleagues would probably answer with a pointed “No.”

Or maybe you’re a manager. Many PCB designers have moved, sometimes reluctantly, into positions of project manager and CAD manager.

So which is it: Are you a leader, or just a manager?

Instead of covering a tech topic like signal integrity or DFM this month, we’re focusing on leadership, and what it means to be a leader and manager. This topic came about after seeing replies to our surveys over the last year or so.

In some of those reader surveys, we asked, “What is your biggest challenge?” Every time we posed that question, we received replies that I would paraphrase as, “Management doesn’t

know what the hell they’re doing.” Some comments are much more colorful and emotional.

Let’s face it: A bad manager can make your job hell on earth.

Now, PCB designers are known to complain (I’m kidding, somewhat), but we also see this kind of comment from PCB fabricators, assembly providers, and suppliers. It turns out that a wide variety of technologists in this industry cast a jaundiced eye toward their management.

Naturally, we started this venture with another survey, this time to the subscribers of all three of our magazines; the results can be found on page of this issue. Open-ended questions often provide us with some of our best insights into our readers’ challenges, and this time was no exception.





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Here is Question 1, followed by the top responses and the percentage of respondents who chose each.

### **What are the three most important traits and skill sets of a great leader today?**

1. Ability to inspire others – 72.7%
2. Empowerment of employees – 47.7%
3. Integrity – 40.9%

Inspiration is the big winner here. Almost three-fourths of respondents want a leader who inspires them. They want to be inspired—they need to be inspired, or they'll leave a job. That's one of the most common points we hear regarding millennial staff.

Coming in second is employee empowerment. Do you feel free to make decisions on your job? Some designers I know say they like their job primarily because they do get to take the initiative and make decisions on the fly. But some managers just have a difficult time letting go—they'd rather micromanage every single decision than let their employees make decisions.

In third place is integrity. I thought it was interesting that integrity wasn't higher up on the list. I guess for most people in this industry, their manager's integrity is important, but not that important.

Give it some thought: Does your manager possess these three qualities?

Whether you're currently a manager or not, this issue is a must-read. This month, we have quite a lineup for you. Natasha Baker, founder of SnapEDA, discusses what it takes to motivate members of the millennial generation, and what it means to be a manager vs. a true leader. Michael Ford of Mentor Graphics focuses on the evolving role of managers in the electronics industry, and some of the challenges and exciting opportunities the boss may face in the upcoming years. IPC President John Mitchell shares six leadership lessons he's learned in 20 years this industry. (I really liked No. 4: Remove the bad apples.)

Next, Leo Lambert of EPTAC talks about the changing landscape of training for electronics professionals, and how training companies like his can help managers who have lost technologists to "brain drain" over the years. And Dave Dibble of Dibble Leaders shares the results of the Biz Brain IQ Test, co-developed with I-Connect007, that we offered to readers inside our publications. The answers may surprise you.

We also feature the results of our leadership survey. Give it a look—do you see yourself in any of the answers? Finally, we bring you columns by regular contributors: Barry Olney of In-Circuit Design Pty Ltd., John Coonrod of Rogers Corporation, and Alistair Little of Electrolube.

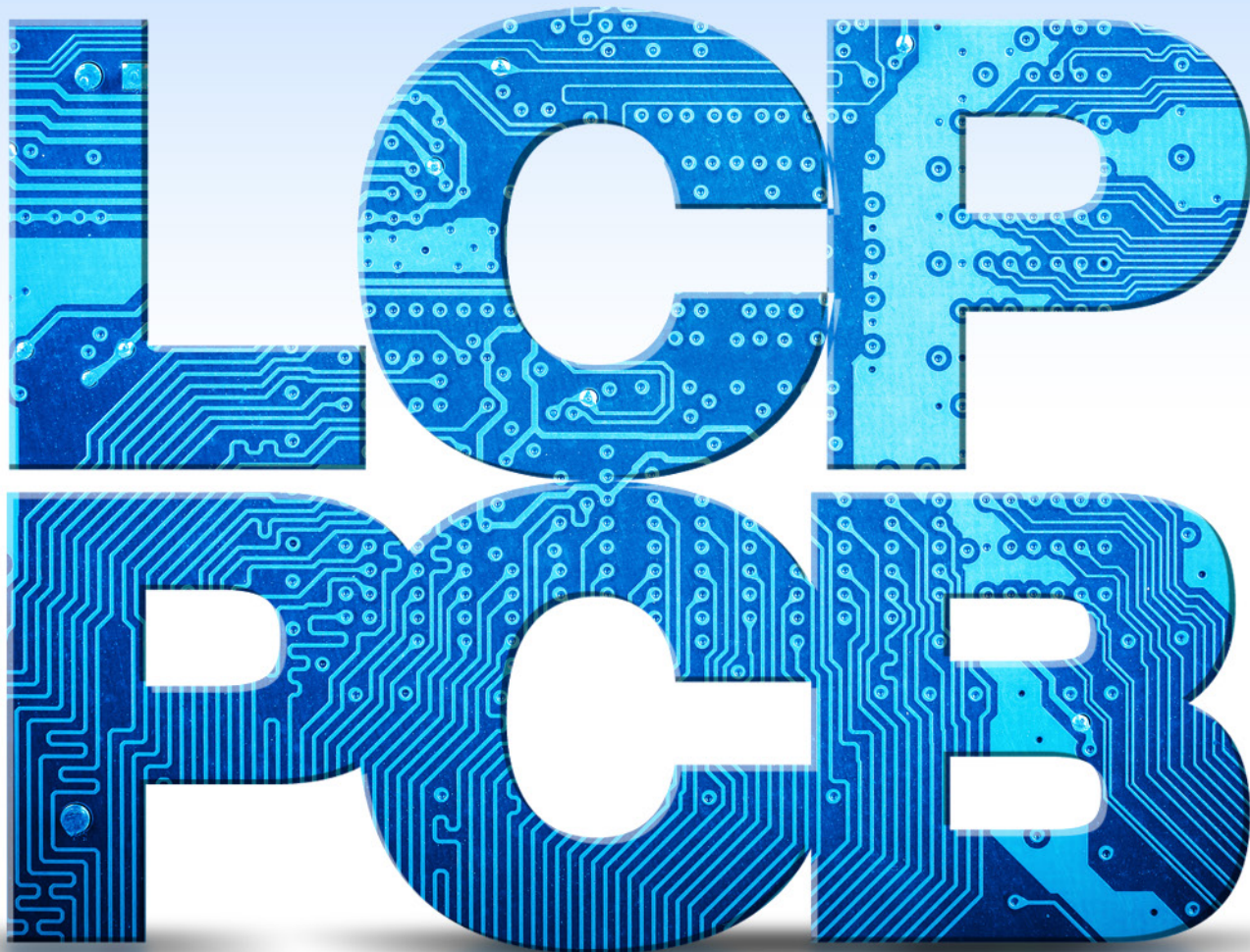
It was great seeing some of you at SMTA International in Chicago. We'll be seeing you all on the road again soon. Until then, see you next month. **PCBDDESIGN**



**Andy Shaughnessy** is managing editor of *The PCB Design Magazine*. He has been covering PCB design for 17 years. He can be reached by clicking [here](#).



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# Inspiring Millennials in the PCB Design Community

Natasha Baker, founder of SnapEDA, is part of the new breed of entrepreneurs. She manages a group of millennials who are not much younger than she is, and the company aims to change the way PCB designers use PCB footprints and schematic symbols.

Fresh off the launch of InstaPart, an on-demand delivery service for CAD parts, Natasha discusses what it means to be a manager vs. a leader, what motivates millennial engineers, and some of the changes in the world of EDA that managers have to contend with to succeed.



Natasha Baker

**Andy Shaughnessy:** *What's the difference between being a manager and a leader?*

**Natasha Baker:** Leadership is about inspiring and empowering people to drive towards a vision. Management is about the operational side: optimizing your resources, and making sure things happen on a timeline.

Because we're a startup and our team (for the most part) sit directly beside each other,

we don't have a need for huge amounts of people management. We have a roadmap and a plan, but we also have the flexibility to determine how to most effectively contribute towards the vision.

At SnapEDA, this is the vision of making PCB design data, such as footprints and symbols, more accessible; specifically, we're making our parts library comprehensive, interoperable, and transparent.

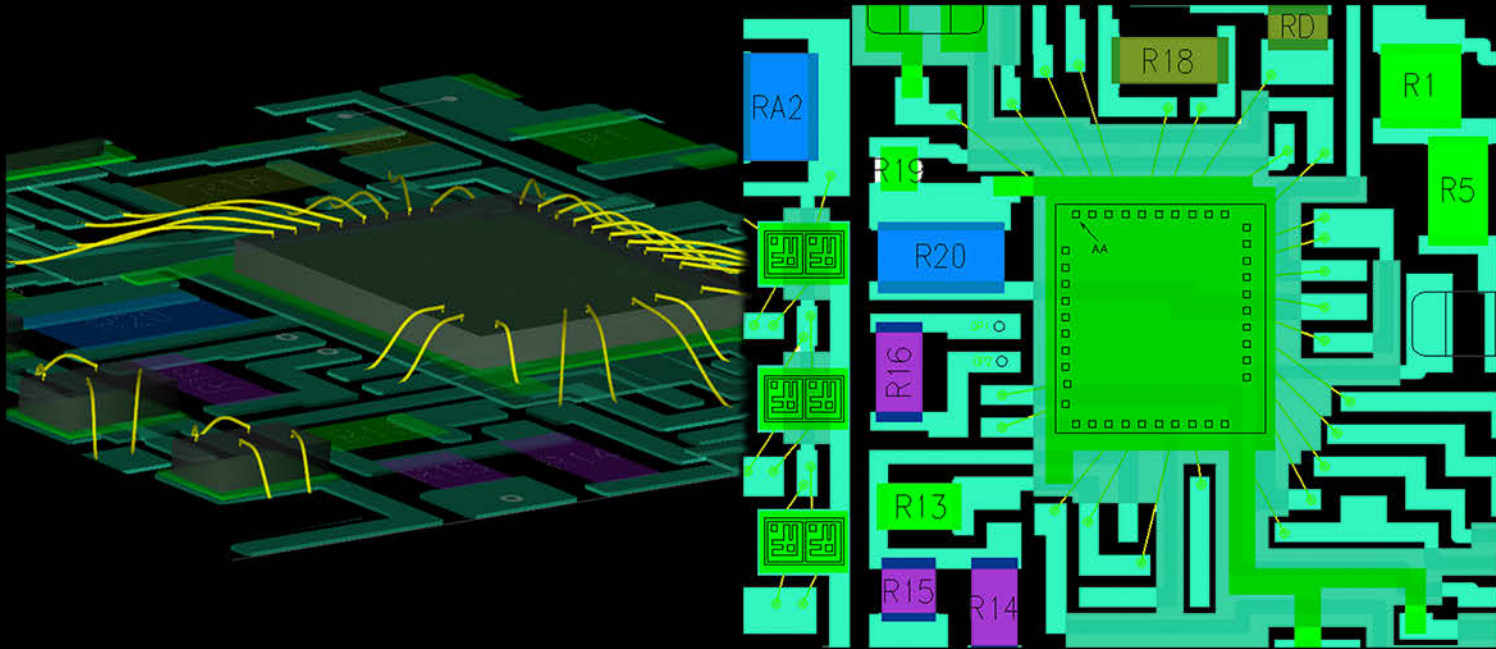
**Shaughnessy:** *Your staff is entirely made up of millennials. Is it a challenge to get them interested and keep them motivated?*

**Baker:** We've been extremely pleased to have a wealth of bright and experienced candidates applying. At first, this was a bit surprising, considering that CAD data doesn't appear nearly as exciting on the surface as, say, artificial intelligence, self-driving cars, or virtual reality.

But I think there are three reasons why we've been able to garner so much interest.



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First, we're tackling a massive data problem, which is exciting to engineers. We're thinking about how we can throw the most cutting-edge technologies at this decades-old problem. One of our employees, Aaron Goebel, a recent Stanford engineering grad who is now a data engineer at SnapEDA, is applying the latest technologies like machine learning and image recognition in our mission to automate and verify design data. There is no shortage of learning opportunities, and every day is a new challenge. For our product manager, Mike Tang, this is what keeps him driven.

Second, we empower millennials to have ownership and impact immediately. Before the end of their first week, they have generally deployed code benefitting thousands of engineers who use SnapEDA, which is hugely rewarding.

And finally, our employees are drawn to the impact we're having in the world. The data we're creating is helping engineers create everything from drones, to medical devices, to industrial monitoring systems. Millennials want to know they're making a difference in the world, and seeing this impact is tremendously inspiring.

My advice to companies trying to recruit millennials would be to give them the opportunity to flex their creative muscles, empower them by giving them ownership so they can make an impact in your teams, and connect

and remind them of the bigger impact they're having. How does your team's work affect the company? How does it affect the world? These are the things that many millennials get excited about. They want to make a difference.

**Shaughnessy:** *You're a young, female business owner in an industry dominated by "graybeards." How does this affect the way you run your company?*

**Baker:** It doesn't. I wake up thinking about how we can make our vision come to life faster, and create value for users, customers, partners, and investors so that's where my focus is.

**Shaughnessy:** *SnapEDA has a pretty revolutionary business model. Do you think your young staff is a critical piece of this?*

**Baker:** Absolutely. Although this business model isn't new, SnapEDA was one of the first times it was deployed in the PCB and EDA industries, which raised a lot of eyebrows initially.

But it's a natural fit for how our team views services. We all grew up with the Internet — meaning we grew up using free services, such as Google. Not only are millennials accustomed to Freemium business models, they've come to





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expect them, so we're going to continue seeing a shift to these types of models.

While coming up with the idea for the company, I was reading the book "Free" by Chris Anderson, which is a look at how free services are monetized, and why they make sense for software where the incremental cost of serving an additional customer approaches zero.

I'd encourage any business owner in our industry to read this book. I don't think this model works for everything, but I do think it's important to be aware of the dynamics behind them, and consider how to incorporate these philosophies.

**Shaughnessy:** *Is there anything else you'd like to add?*

**Baker:** We're starting to see a lot of activity and innovation in the EDA and PCB industries, which is definitely something we can all lever-

age to bring the brightest minds into to our industry.

For example, we're seeing M-CAD companies acquiring E-CAD products because they see huge opportunities with the Internet of Things. We're seeing a growing expansion in terms of the accessibility of making circuit boards and chips, and also a broadening of the industry to include not just PCB designers, but also software developers who want to rapidly get an electronic idea to market.

It's a great time to be in the PCB industry, and we should all be leveraging this to help grow our industry by recruiting the best and brightest talent.

**Shaughnessy:** *Thanks for your time, Natasha. I know we'll be seeing you again.*

**Baker:** Thank you. **PCBDESIGN**

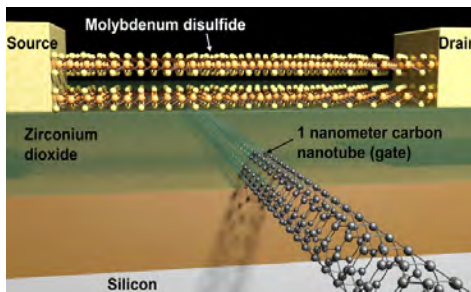
## Smallest. Transistor. Ever.

A research team led by faculty scientist Ali Javey at the Department of Energy's Lawrence Berkeley National Laboratory has created a transistor with a working 1-nanometer gate.

"We made the smallest transistor reported to date," said Javey, lead principal investigator of the Electronic Materials program in Berkeley Lab's Materials Science Division. "We demonstrated a 1-nanometer-gate transistor, showing that with the choice of proper materials, there is a lot more room to shrink our electronics."

The key was to use carbon nanotubes and molybdenum disulfide ( $\text{MoS}_2$ ), an engine lubricant commonly sold in auto parts shops. The findings were published today in the journal Science. The development could be key to keeping alive Intel co-founder Gordon Moore's prediction that the density of transistors on integrated circuits would double every two years.

Both silicon and  $\text{MoS}_2$  have a crystalline lattice structure, but electrons flowing through silicon



are lighter and encounter less resistance compared with  $\text{MoS}_2$ . That is a boon when the gate is 5 nanometers or longer. But below that length, a quantum mechanical phenomenon called tunneling kicks in, and the gate barrier is no longer able to keep the electrons from

barging through from the source to the drain terminals.

Once they settled on  $\text{MoS}_2$  as the semiconductor material, it was time to construct the gate. Making a 1-nanometer structure, it turns out, is no small feat. Conventional lithography techniques don't work well at that scale, so the researchers turned to carbon nanotubes, hollow cylindrical tubes with diameters as small as 1 nanometer.

They then measured the electrical properties of the devices to show that the  $\text{MoS}_2$  transistor with the carbon-nanotube gate effectively controlled the flow of electrons.

"This work demonstrated the shortest transistor ever," said Javey.



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# What's the Difference Between a Manager and a True Leader?

by **Michael Ford**  
MENTOR GRAPHICS

Why would I want to work for you? The role of the manager is complex; it means balancing business needs with creative opportunity and flexibility, building trust and providing inspiration with a team. With the recruitment of Generation X, and now the millennials, the expectations of employees are changing, accompanied by an unprecedented growth of technology. How can today's manager maintain an effective and motivated team?

I could be fresh out of college, or perhaps I am a seasoned veteran of the industry; it does not matter. As I am looking for a new role, I have my CV or resume that tells the recruiting manager all about me, highlighting my unique strengths and abilities, effectively selling myself. However, no formal process exists for me to assess the manager. I may have been attracted to the company and job position through a combination of things, such as the location, job content, potential opportunities, compensation, or even just the name and reputation of the company. These all got me into the building, but they are not my motivation to stay.

No, it is the manager who is the immediate point of contact, and the one person who holds the key to job satisfaction and career progression.

Working together day-by-day establishes my relationship with the manager. Good day-



to-day line management should be a given in any company, but the real test of management ability is to provide an environment of trust and respect, with encouragement to explore, to create ideas that add value, and seeing projects, whether team or individually based, through to fruition.

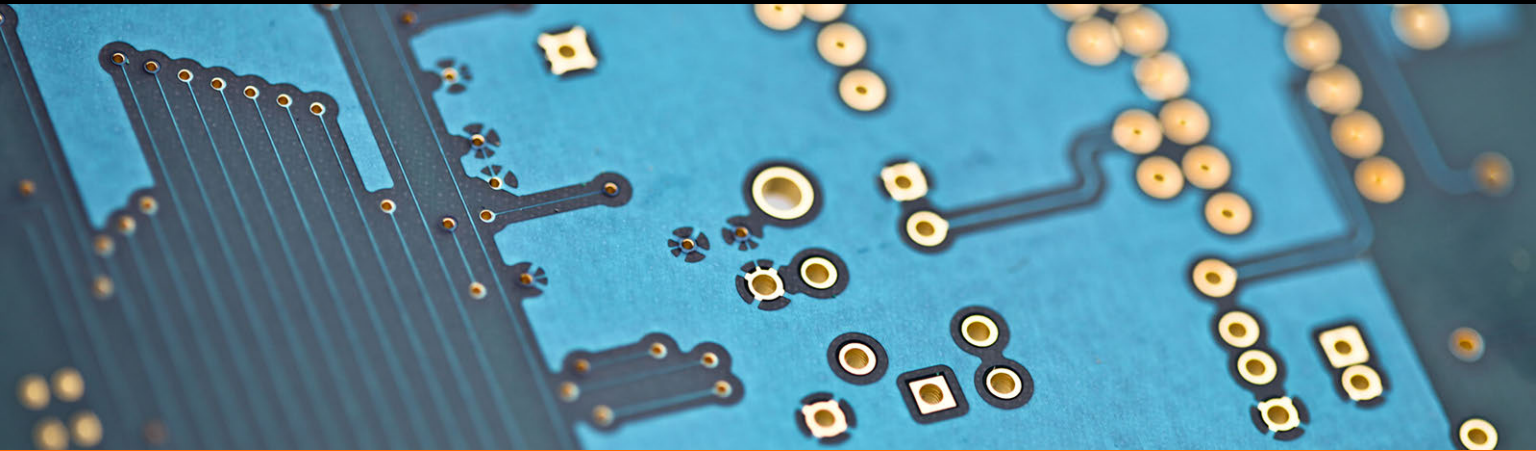
Managers must also bring their own ideas to the table, contributing to the progressive environment. They have a broader perspective of the area in which they are working, and they must understand how it relates to other teams and higher levels of management. They should research the industry, seeing what trends are emerging, and bring those technologies and opportunities to the company.

Members of the team then see themselves as part of a progressive team, which is an essen-





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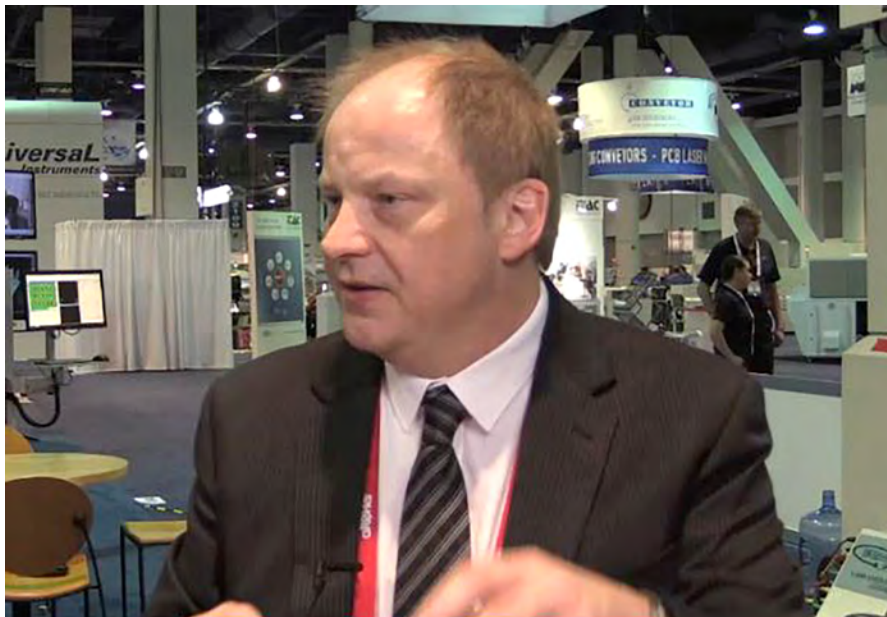
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tial incentive, especially at the start of their careers, for them to stay. Contrast this with organizational stagnation, which can demotivate team members after a while, forcing them to leave a company even though they were otherwise comfortable.

Technology is a key contributor to opportunity in the electronics industry, starting from the earliest point of design and extending out into the whole of manufacturing. The pioneers of the original CAD and CAM technologies in the industry have been reaching retirement age for a few years now, leaving a legacy of



Michael Ford

engineers and managers who have seen only a much more gradual change in the scope of their work. Computers made a huge difference initially in design and manufacturing, but they have progressed rather slowly lately, one update at a time, if we're lucky.

With the prospect of a massive change in the industry, as the so-called "smart factories" and Industry 4.0 take root, this change is coming to a team who isn't necessarily accustomed to change. If expectations from within the team are met with a management attitude such as 'this is not for us,' individuals will grow disillusioned. The manager of today is expected to be knowledgeable about the future of the industry and have a plan to lead the way for the team. These changes are exciting, but they are happening now much faster than can be confidently understood. This is where the manager needs to call on external support including consultants and solution providers, who must genuinely understand the new opportunities so they can provide help in the right way of execution and can assure confidence in an ultimate return on investment.

In these times of change, the manager of the team has to be more than a manager. He or she needs to be the leader of these initiatives, to bring the team forward, to select the right kinds of solutions, ideas and changes, leading the area

of the business for which he is responsible to perform at the increasing levels of expectation. The motivation of the manager to be the leader is good not only for the business, but also for the team.

Never in the last 20 years has there been so much excitement in the way that data is used. Where systems, whether design, layout, manufacturing process engineering, planning, supply chain, quality, etc. were once "islands of automation," they are now being brought together as part of a completely integrated flow. This brings a step change in the performance of such things as new product introduction, manufacturing flexibility, and overall business costs.

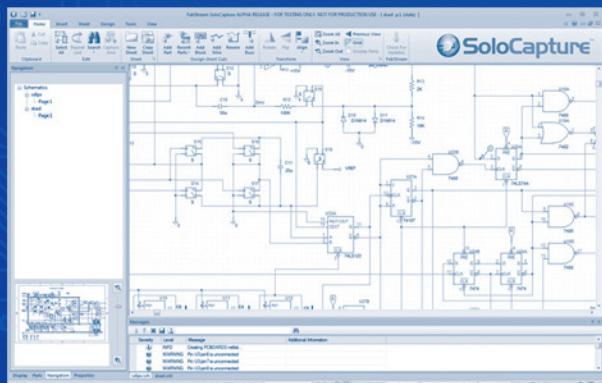
The opportunities are so significant that the tide of movement of volume manufacturing to lower-cost remote areas of the world also is now changing, as the real cost of the whole business process is exposed. The majority of cost to the end customer is actually waste because money is spent on needless shipping, storage, logistics, and covering bloated stocks suffering from depreciation. Local manufacturing in places like the United States and Europe, though with higher labor costs, can prove a better business model overall.

This opportunity for change in the manufacturing world encourages reactive business processes that have already taken shape for on-

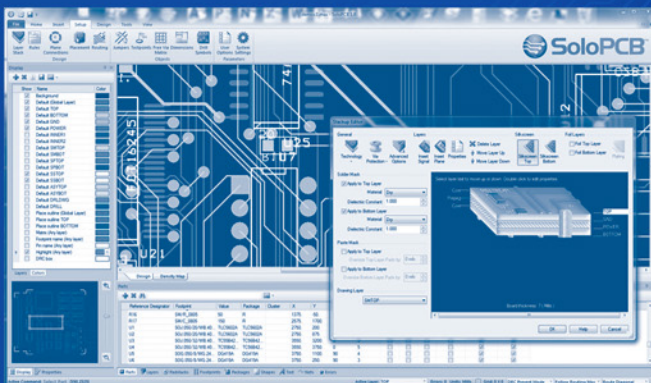


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line retail and electronics business-to-business ordering practices, which now put pressure on factories to produce only what is needed, almost on a daily basis. Such flexibility demands that individual automated processes themselves be automated, which will change the face of manufacturing forever. Design is included in these changes, as many more variant of products are needed on more frequent new product cycles.

Here, then, is the excitement. Every true leader and manager needs to embrace the reality of changes happening in the market and prepare for the emerging opportunities for their own team and individual operations, which also creates a much more progressive approach

to design, product engineering, and manufacturing. The latest software tools for design and manufacturing are awesome compared with those that most people are still using. So let's get the momentum going.

Managers, remember: You are the leaders!

### PCBDESIGN



**Michael Ford** is the marketing development manager of Mentor Graphics.

## Increasing Terrorism Compels Nations to Install Advanced Military Radar Systems

Growth witnessed by the global military radar market has remained steady over the last few years. The vendor landscape of the market for all these years has remained highly fragmented with local players, excluding a few leading companies holding around 46% of the market, based on value in 2013, finds Transparency Market Research (TMR). The top five companies holding lead in the global military radar market are Saab Sensis Corporation, ASELISAN Inc., Terma A/S, Harris Corporation, and DRS Technologies.

The global military radar market is poised to reach US\$8.4 billion by the end of 2019, from a valuation of US\$7.1 billion in 2013. The market is therefore poised to exhibit a CAGR of 2.9% between 2013 and 2019. Regionally, North America reported dominance in the global market with a share of 33% based on value in 2012. Besides this, Asia Pacific is also projected to exhibit lucrative opportunities for the market during the forecast peri-



od. By type, ground based and airborne segments led the market in 2012. Among these, the ground based radar segment dominated the market with a share of 30.50% in terms of value in the year.

Nations around the world have been increasing their defense budget to enhance their capabilities in naval vessels, missile defense systems, and military aircrafts. Several countries are witnessing border protection issues with illegal trespassing and trafficking on the rise.

The situation has motivated nations to empower their border security using virtual electronic fence systems. This will boost installation of military radars around the world. Moreover, various nations are looking to develop domestic military radar producing capabilities by establishing strategic alliances and technology transfer agreements. This trend is expected to bolster opportunities for military radar manufacturers in both national and international markets.



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# Training

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## LEO LAMBERT Discusses EPTAC's Evolving Mission

by **Andy Shaughnessy**

This month we've been dealing with challenges related to being a great manager and a great leader. One of the biggest problems a manager faces is training—getting employees trained, and keeping them current on constantly changing technologies. I asked Leo Lambert, VP and CTO of EPTAC what his thoughts were on the subject of leadership, and more specifically, what strategies EPTAC embraces with regard to training—both initial and ongoing.

**Andy Shaughnessy:** *Leo, please give us a quick background on EPTAC and the training you provide.*

**Leo Lambert:** EPTAC is a certified IPC training center, and we train to all the IPC programs, including IPC-A-600, IPC-A-610, J-STD-001, WHMA/IPC-A-620, IPC-7711/7721, and IPC-6012. We hold these classes all over the country and in our local facility in Manchester, New Hampshire. We are the largest training center supplying IPC training to the industry.

We offer and sell training materials to support our customers who train their own person-

nel and conduct webinars on a monthly basis, discussing current topics within our industry. We answer customers' questions in our Solder Tips section and believe this Q&A is really helpful to the industry. Our Ask Helena & Leo section allows anyone to ask questions related to electronic manufacturing and more. We also provide news about the latest things happening within the industry and within EPTAC itself.

**Shaughnessy:** *Have your training methods evolved over time?*

**Lambert:** Our offerings to the industry include a manual soldering program, along with an advance manual soldering program dealing with 0402, 0201 and 01005 component sizes. This program is modified at the request of our customers to fit their needs.

We also have incorporated additional workmanship programs to the IPC 610 and 620 programs where we teach the students how to inspect the product and physically build a cable with the appropriate crimps and strip lengths.

Additionally, we've developed workshops designed for engineers and supervisors to provide them with a quick look at the standards,



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so that they can understand the content and intent of the programs.

**Shaughnessy:** *How has the curriculum itself changed?*

**Lambert:** The curriculum is always changing based upon the existing and changing technology in tooling, materials, products and documentation. We don't normally focus on the computer skills necessary to run the equipment, but from what I've seen on the manufacturing floor, the skill levels needed are to troubleshoot the equipment when the unit malfunctions or stops. The operators are trained to read the screens, selecting the various programs to be run depending upon the product, and to get in touch with maintenance if a major deviation occurs.

**Shaughnessy:** *How do you train people from so many different backgrounds and cultures?*

**Lambert:** Our students are sent to us by their company, so we have no choice in the selection of students who come to our classes. When the documents are written, we take the language

barrier into consideration by not using words which are difficult to translate into foreign languages. Currently there are many IPC specifications which have been translated into different languages. This also applies to the electronic test as released by IPC, so when the students sign up for a class they can select a language for the testing program.

**Shaughnessy:** *Do your instructors find themselves battling tribal knowledge and undocumented processes?*

**Lambert:** This still exists in some environments, but it is getting less and less commonplace as the OEMs are demanding the training records of the employees from the contract manufacturers. The upper tier manufacturers and OEMs are pretty much up to date on the requirements for training and the appropriate specifications needed to be able to manufacture the product.

It's the small manufacturers that build prototypes who have the weakest documentation packages and internal infrastructure, and they will find it difficult when the tribal knowledge disappears.

**Shaughnessy:** *We keep hearing about the "brain drain" that occurred in the PCB industry during the two recent downturns. Do you think this has led companies to outsource training to companies like yours?*

**Lambert:** I'm sure it has increased the outsourcing of training, as the individuals left within each of those facilities are now wearing many hats and the demand for their time is increasing exponentially. Although we are training many more instructors (CIT), we are also training more operators (CIS), which is an indicator of the changes. We are also training more people on the basics of soldering, which, again is an indication that the people who were in that business have left for other opportunities and the workforce has to be retrained to verify their competency and capabilities.

**Shaughnessy:** *Are you seeing many millennials in EPTAC classes? And do you think young people are more challenging to train?*



Leo Lambert





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**Lambert:** Yes, we are seeing the millennials come through the facility, be they either college graduates or non-graduates. As for the challenge to conduct the training for this particular generation, we have to look at the methods being used to transfer the information and this is the item we must address. Although the subject matter is still similar, the methodology of delivery must be updated, and this is a challenge for the industry. We need to address long-distance learning, as well as long-distance testing, and review the questions and the way they are created and written to challenge those individuals. The other phase of this change is providing more information relative to the reasoning behind the conditions or statements. In providing the answers we need to also provide the why's for those answers as this is becoming more common with the younger generation.



**Shaughnessy:** *Anything else you'd like to add?*

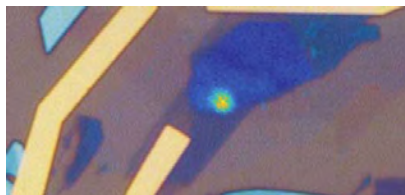
**Lambert:** Training is changing both in concepts and delivery, and one of the difficult issues we need to address is the upgrade of our own instructors. As the old saying goes, we need to keep up with the times, and since change is constant this is one of the most difficult issues facing training centers, other than hiring younger instructors who can relate to the students in the classes.

**Shaughnessy:** *Thanks for your time, Leo. See you at a trade show.*

**Lambert:** Thank you, Andy. Happy to help.  
**PCBDESIGN**

## Ultra-thin Quantum LEDs Could Accelerate Development of Quantum Networks

Researchers have developed all-electrical ultra-thin quantum LEDs, which have potential as on-chip photon sources in quantum information applications, including quantum networks for quantum computers.



Ultra-thin quantum light emitting diodes (LEDs) – made of layered materials just a few atoms thick – have been developed by researchers at the University of Cambridge. Constructed of layers of different ultra-thin materials, the devices could be used in the development of new computing and sensing technologies.

A computer built on the principles of quantum mechanics would be both far more powerful and more secure than current technologies, and would be capable of performing calculations that cannot be performed otherwise. However, in order to make such a device possible, researchers need to develop reliable methods of electrically generating single, indistinguishable photons as carriers of information across quantum networks.

The ultra-thin platform developed by the Cambridge researchers offers high levels of tunability,

design freedom, and integration capabilities. Typically, single photon generation requires large-scale optical set-ups with several lasers and precise alignment of optical components. This new research

brings on-chip single photon emission for quantum communication a step closer. The results are reported in the journal *Nature Communications*.

The layered nature of TMDs makes them ideal for use in ultra-thin structures on chips. They also offer an advantage over some other single-photon emitters for feasible and effective integration into nanophotonic circuits.

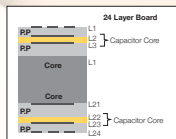
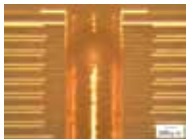
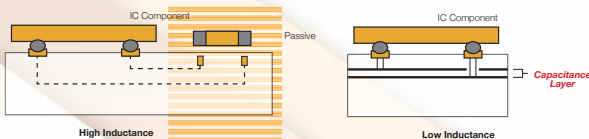
"We are just scratching the surface of the many possible applications of devices prepared by combining graphene with other materials," said senior co-author Professor Andrea Ferrari, Director of the Cambridge Graphene. "In this case, not only have we demonstrated controllable photon sources, but we have also shown that the field of quantum technologies can greatly benefit from layered materials. Many more exciting results and applications will surely follow."



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# BizBrain IQ Test:

**by David Dibble**  
DIBBLE LEADERS

*With an introduction by Barry Matties,  
publisher, I-Connect007*

## Introduction

When David Dibble was only 24 years old, with just \$5,000, he started a PCB company—in a garage. He built it to a profitable \$10 million in sales and 200 employees making printed circuit boards.

Focusing upon the work of W. Edwards Deming, Peter Senge, Buckminster Fuller, Ilya Prigogine, and John S. Bell, David became an expert in workplace systems improvement. Since 1990, he has been training and consulting using his *Four New Agreements for Leaders and Managers* as a proven model for sustainable organizational transformation, with remarkable results. Today, he is the president of Dibble Leaders.

I-Connect007 worked with David to formulate the *Biz Brain IQ Test*, which we offered to readers during the last several months within I-Connect007 publications. Below are the combined responses from the 170 people who completed the quiz, representing a cross-section of disciplines from our industry.

The highest possible score for the Biz Brain IQ Test is 200. The average result was 120, while the highest score we saw was 167.

## Discussion of Results and Answers

1. The culture of a company is most shaped by:

The mindset of top management	32%
Values	25%
Company policies	15%
Vision	15%
Mission	13%

This question is probably a bit too easy in that there is more than one best answer. The culture of a company is most shaped by *the mindset*

*of top management.* Having said that, we see that values and vision are part of the mindset of top management. *Mission* also falls in there somewhere. We can even make a case that *company policies* many times come from the mindset of top management.

2. The most important aspect of being a good manager is:

Setting people up to be successful	50%
Immediately acting to solve problems	19%
Being a systems thinker	13%
Holding people accountable	8%
Controlling people's actions	4%
Being good to people	4%
Pushing people to reach goals	2%

This question starts to get to the heart of what it means to be a great manager. The best answer is *being a systems thinker*. Notice only 13% of responders picked this answer while 50% picked *setting people up to be successful*. Interestingly, it's very difficult to set people up to be successful unless the systems in which they work have been optimized in a systems-based manner. *Taking immediate action to solve problems* is usually a bad choice in that the “don't just stand there—do something” tenet driving most managers is seldom the best option. Doing something before understanding the problem (system) often makes things worse. How can we *hold people accountable*, if we haven't optimized the systems in which they work? Remember, approximately 94% of the results are a function of the systems in which people work, not the efforts of people. Most of the time when we measure results we attribute to people, we are measuring results produced by the systems.



# The Surprising Results

3. When a new employee is hired, the most important training should be:

Vision, mission, values of the company	38.6%
Specific job training by a superior	18.6%
Sexual harassment	11.4%
Policies and procedures	10.7%
Systems thinking and tools	10.7%
Informal get-togethers to meet peers	6.4%
Merit review process	3.6%

This question tests the responder in a couple of ways. First, it gets to the heart of systems thinking and if the responder is a systems thinker. The best answer is *systems thinking and tools*. Only 10.71% of responders chose this best answer while 38.57% chose *vision, mission and values*. If vision, mission and values do not include systems thinking and tools, it is very difficult to set people or the company up to be successful—or at least optimally successful. Second, although a widely accepted practice, *specific job training by a superior* is simply wrong. It adds variation to systems making them less efficient over time. While *sexual harassment* training is important, sexual harassment itself in the workplace is a cultural problem that must be addressed at that higher level before training itself will be effective. *Policies and procedures* are useful, but usually only in disciplining employees. Instead, build policies and procedures around optimized systems.

4. Do you consider yourself to be a systems thinker?

Most of the time	36.4%
Sometimes	23.6%
Absolutely	18.6%
I'm not familiar with systems thinking	18.6%
Occasionally	0.0%

This question looks at the responder's understanding of systems thinking. There is only one best answer to this question and that is *absolutely*. You either are a systems thinker or not. If you are a systems thinker, you know it absolutely. If you're not a systems thinker or only on your way to becoming a systems thinker, you will have responded something other than absolutely. Systems thinking is much like learning a foreign language. At first we translate the foreign language back into our native thinking to make sense of it. As we progress, we are able to translate more and more back into our native thinking. One day, with ongoing practice, we reach a point where we don't have to translate back. We simply *think* in the foreign language. At that point we are fluent. Systems thinking can be a curse in that, when you think in systems, it's often difficult to believe the workplace works at all with all the non-systematic thinking entrenched within the vast majority of leaders and managers.

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## 5. How do you prioritize your work or projects?

I put things in proper sequence	37%
I work on my top 20% important issues	22%
I work on whatever is most pressing	20%
I do what I think best	12%
I don't formally prioritize very much	5%
I mostly work on the things I like to do	3.6%

This question looks at systems thinking and tools. One of the most useful and powerful systems optimization tools is the 80/20 rule. This Pareto principle tells us that usually 20% of the variables create 80% of the outputs. If you look in your closet, you'll see that 80% of the time you wear 20% of the clothes in your closet. It's the same for most systems. If you want to get the most out of your systems, identify the critical 20% of the variables. In fact, as a leader or manager, you want your people working only on the critical 20% of their systems/projects.

The best answer here is *I work on only my top 20% of important issues*. A close second is *I put things in proper sequence*. However, note that you can't put things in proper sequence unless you have first identified the critical 20%. *I work on whatever is most pressing* is wrong unless one has done the systems work to know what's most pressing and specifically the critical 20%. *I do what I think is best* is mostly wrong. Unless data indicates that what you think is best is really best, you'll usually be working on the wrong issues or symptoms of root causes.

## 6. What do you think the most important goal for leaders should be?

Providing value to customers	29.3%
Optimizing systems/growing employees	28.6%
Setting people up to be successful	15%
Making money	6%
Optimizing our systems	6%
Growing employees	5%
Hitting our numbers	2%
Growing the business	0%

The best answer here is *optimizing systems and growing employees*. If a leader focuses on optimizing systems and growing employees, both the employees and customers will feel valued and taken care of. *Setting people up to be successful* is second in that it entails optimizing systems and growing people. *Optimizing systems* is third and *growing employees* is fourth. *Providing value to customers* garnered nearly 30% of the vote but this is the wrong place to focus. Customer satisfaction and value received is much more a function of happy, systems-literate employees, management and leadership than anything else. In fact, some studies suggest that customers will feel that same about the company as employees over time.

## 7. What do you think is the best way to deal with problems?

Looking to systems as source of problem	32%
Putting our best people on the problem	29%
Getting people to behave differently	11%
Cracking the whip	11%
Telling people how to fix the problem	10%
Holding people accountable	6%

*Looking to the systems as source of the problem* is easily the best answer here. If 94% of the problem is systems-related, why would you look anywhere else? From a systems thinking perspective, there are no other good answers here. While *putting our best people on the problem* is a traditional approach, it is badly flawed. Unless the "best people" take a systems-based approach, problem solving will be a firefighting exercise and solutions will not be sustainable. The remainder of the answers to the question are also flawed and, in some cases, make things worse. Taking any action without knowledge of the systems is simply tampering, which adds variation to already stressed systems.



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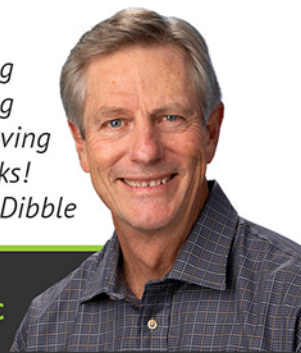


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Learn more about the roadmap used to build great companies with a high level of profitability in this article from the March 2016 issue of **The PCB Magazine**.

*For 25 years we have been doing Four New Agreements consulting and training, significantly improving businesses. This stuff really works!*

—David Dibble



### 8. What do you think is the best way to optimize the performance of a company?

Rally the people through teambuilding	29%
Fix or optimize a few key systems	27%
Implement latest information technology	10%
Increase profit-margin goals	10%
Bring in new people in key areas	10%
Increase revenue growth rate goals	6%
Reduce real costs	4%
Cut expenses across the board	4%

The best answer here is *fix or optimize a few key systems*. In most cases, nothing improves performance like optimizing the few key systems that are holding the company back. Because all systems are connected, optimization in key areas creates synergies throughout the organization and even to customers and suppliers. The second best answer is to reduce real costs. Systems optimization naturally reduces real costs, usually significantly. In certain circumstances, people really are the issue and require us to *bring in new people in key areas*. Remember, however, that bringing in new people will not change results unless systems are optimized. Like bringing in new people, in some cases we must *implement the latest information technology*. Be aware that, even when absolutely necessary, implementing new technology will take longer and be more expensive than even the highest estimates. *Rally the people through teambuilding* may give a short-term boost to the company but it won't last without systems work. The other answer options will usually make performance worse, not better.

### 9. In making decisions in a business, what do you think most influences those decisions?

80% logic / 20% emotion	47%
50% logic / 50% emotion	17%
100% logic	16.5%
20% logic / 80% emotion	12%
100% emotion	6.5%

The answer to this question will likely surprise many. The best answer is *100% emotion*.

In fact, every decision that the human mind makes is driven by emotional energy and only later backed up with logic. It doesn't matter if we're running numbers in a spreadsheet, picking out a dress or ordering dessert, the mechanics are the same—emotion before logic. Think how this may affect your decision-making. Notice most leaders and managers believe that logic drives emotion rather than vice versa. The further you get away from 100% emotion as the driver, the worse your answer. For those who are not convinced, we have an exercise we do with skeptical executives which proves the point.

### 10. What causes the most frustration for people in the workplace?

Poor leadership	24%
Poor direct management	21%
No passion for the job	19%
Poor systems	11%
Not enough private life	10%
Poor business planning	9%
Not enough money	4%
Too far from work	2%

This question is really a look in the mirror for leaders and managers. Without doubt, the root causes of most frustration in the workplace is *poor leadership*, *poor direct management* and *poor systems* where people cannot feel successful in their jobs. The mind of top management shapes the culture of the company. Poor or faulty thinking by leadership equals a troubled culture. Poor direct management impinges on every aspect of the workplace experience for most employees. Poor systems imprison an employee in a no-win situation. Is it any wonder that 70% of the U.S. workforce is disengaged in the workplace? If I could wish any single improvement to leadership and management worldwide, it is systems thinking. No matter how poor leadership or management may be, systems thinking will create a dramatic improvement.



### Bonus Question

I have one final bonus question for those of you who are interested in the costs of bringing sustainable systems optimization to your company and people:

What is the average ROI for doing in-depth, sustainable, systems optimization work in conjunction with systems-based staff training?

- A. 300%–1000%
- B. 100%–300%
- C. 50%–100%
- D. 47%
- E. 28%
- F. 10-25%

The answer to this question can be found after the scoring summary below.

The Biz Brain IQ Test is designed to introduce you to the power of systems thinking and the roles of leadership and management in harnessing that power. The test challenges many of the old beliefs about leadership and management that now go unexamined. It is also an opportunity for you to get a feel for where you stand in relation to other leaders and managers as relates to systems thinking and the use of systems optimization tools as your best bet for resolving problems and significantly improving the performance of your company.

Check out your score and, if you have questions, feel free to contact me anytime.

### Scoring

**150–200**—You are a genius leader or manager. You're probably in the top 1–2% of all leaders or managers. Your business will likely dramatically outperform those of your competitors. You are probably being recognized as a leader in your industry and business in general.

**130–149**—Congratulations! You are for the most part a good leader or manager. Your business is probably doing well in relation to

your competitors. You may be seen as a leader in your industry.

**110–129**—You are about average and probably a somewhat effective leader or manager. Your business is probably performing about the same of your competitors. Your company could be doing significantly better.

**90–109**—You are below average in your knowledge of systems and growing your people. Your business is probably struggling at times and needs work in both systems optimization and growing people.

**89 or less**—You may have difficulty sustainably solving problems, motivating people or growing the business. Your business will often be filled with drama and expensive firefights. You may well be feeling somewhat overwhelmed or exhausted.

### Bonus Question Answer

The answer is A: 300%–1000%. Because ROIs like this are very rare in most businesses, for most leaders and managers this is a hard number to fathom. Yet, throughout a 25-year period of doing this type of work, 300–1000% first year ROIs are where the returns on the vast majority of implementations fell. The point of this question is to get leaders and managers thinking about what they might do to raise their game and most benefit their people and companies. **PCBDESIGN**

### References

1. [Biz Brain IQ Test](#) by Dibble Leaders.



**David Dibble** is a keynote speaker, trainer, consultant, executive coach, and systems thinker. For more than 25 years he has consulted and trained in the workplace, with a focus on his systems-based book [The New Agreements in the Workplace](#). To reach Dibble, [click here](#).



# Six Leadership Lessons from 20 Years in the Electronics Industry

by **John Mitchell**

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The orchestra conductor is an apt metaphor for the successful leader.

Effective leadership often boils down to the ability to inspire others (the symphony) to their best work, while keeping and driving the overall vision of the organization (the musical score).

Freed from the minutiae of day-to-day operations, leaders are called upon to consider the “big picture” and then make the tough strategic decisions that could make or break their team’s work.

I’ve spent more than 20 years in the electronics industry, beginning as an engineer for General Electric in upstate New York.

For the last four years, I have served as president and CEO of IPC, a global trade association for the electronics industry. In this role, I have been exposed to all types of problems faced by the CEOs of our more than 3,700 member companies worldwide. In addition, I have witnessed innovative management and leadership techniques employed across dozens of different cultures.

It would be impossible for me to capture all of the qualities exhibited by the most successful executives of the world’s largest electronics manufacturers in this short space. I can, howev-

er, highlight the themes I’ve observed and the lessons I’ve learned in my own career.

## 1. Integrity trumps all.

It’s trite to say that the world is small, but it’s true.

Customers, suppliers, and manufacturers all talk to each other. Those who have the best reputations and longest tenures in this industry are honest to a fault. In addition, to succeed in the most demanding jobs, you have to be able to sleep well at night.

The lesson here? Always, always do the right thing. The dividends will follow.

## 2. Stretch.

Do not be satisfied with the status quo. Understand and consistently seek to learn how things might be better and what resources are required to get there. Then, build a plan and start executing and refining until you get there.

The moment you become complacent is the moment you begin to lose market share to your competitors.

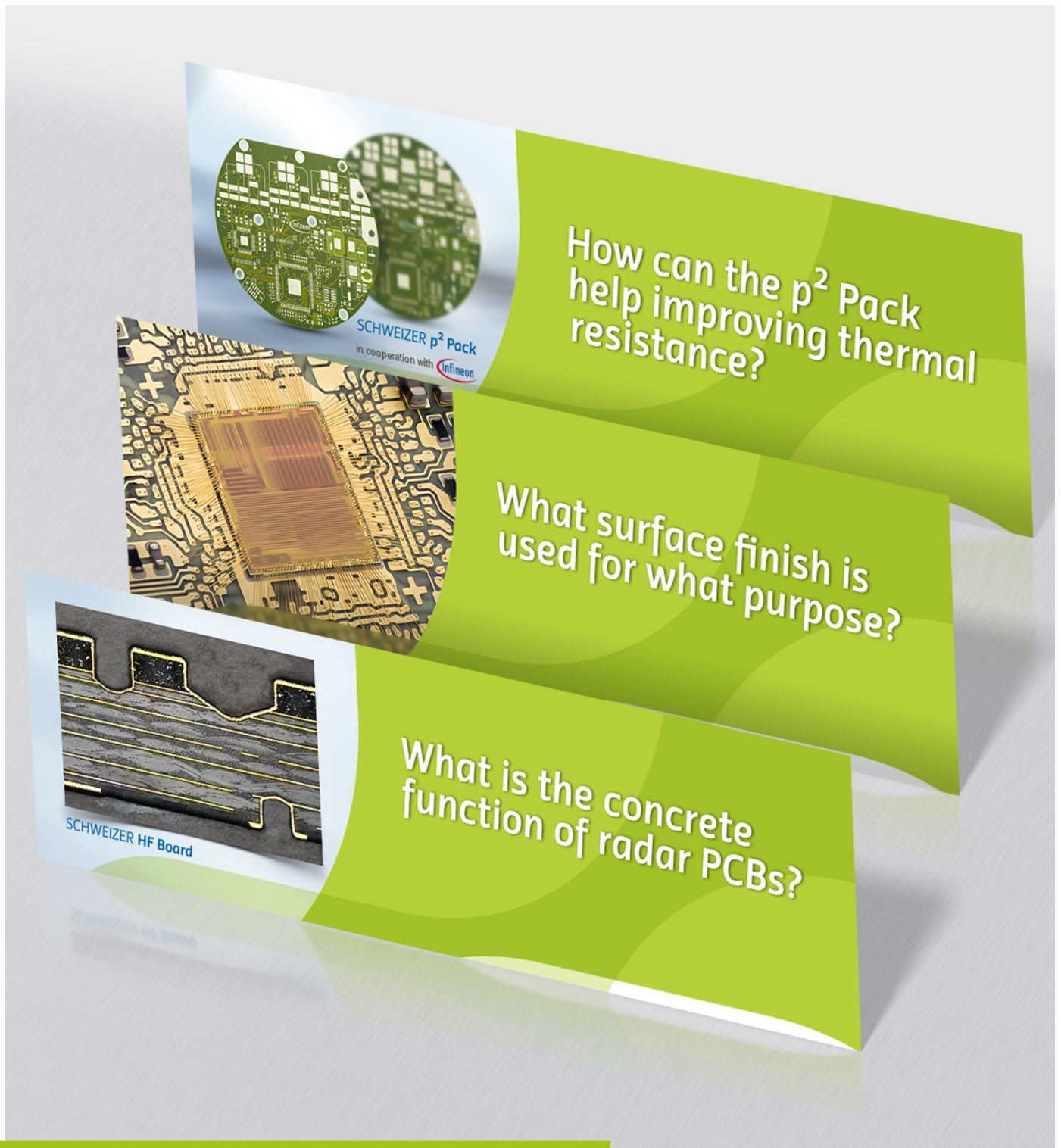
## 3. It is all about the people.

There’s an adage in HR circles that “people don’t quit companies, they quit managers.”

Regardless of your business, at a certain level you’re only as good as your team. Thus, the utmost care must be taken to identify, recruit,



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train, engage, and retain your best employees at all levels:

- Identify and hire the right people. Whether it's through an employee referral program, aggressive recruiting, targeted advertising, or a combination of the above, casting a wide net will ensure you have a robust talent pipeline.
- Take care of your staff. Ensure that they are a diverse group and not just clones of you. Mix it up a bit (incorporating different personalities, experience levels, backgrounds, etc.) to craft the best team.

Most importantly, encourage and enable an open culture where constructive feedback and different opinions are embraced and encouraged. By embracing a positive and safe corporate culture, ideas can be hashed out on their merits, allowing the best to emerge.

## 4. Remove the bad apples.

This is a team, not a family.

With your family you have to deal with your sister-in-law because she married your brother—there's no other option.

In contrast, teams are carefully assembled by owners and managers. As in sports, if a player is no longer good for the team (either by choice or by capability), it's time for a trade.

Further, trades are often best for the poor teammates in the long run. People deserve to work where they will flourish into their best selves—so leaders should not shy away from tough decisions when some are not in the right place or not living up to their potential.

## 5. Tackle the hard things first.

It's critical for leaders to recognize and understand their most critical tasks of the moment and focus on them. The key word here is focus—to avoid the distraction of the million other things that are easier, more interesting, more fun, more whatever. Then grind away at that most important thing.

The results? You finish the most important thing. You discover your other tasks, if still relevant, are easier to do once you've accomplished that first thing. And you find that day in, day out, week after week and month after month, your best efforts have been spent on the areas most valuable to you and your organization.

## 6. Take care of yourself.

If you are not eating well, sleeping enough, or exercising with regularity, your performance—and that of your team—will suffer. You owe it to yourself, your team, and your stakeholders to perform at your best. So ensure you are appropriately balancing your work and health—emotional as well as physical.

While far from an exhaustive list, these six keys have helped me grow in my career in the fast-changing field of the electronics industry. I hope they are of value to you as well. **PCBDISIGN**



**John Mitchell** is president and CEO of IPC—Association Connecting Electronics Industries.

## Nano Dimension Will Transition its Bio-Printing Activity to a New Subsidiary

Nano Dimension Ltd. will form a new subsidiary and will transition its bio-printing activities to the new entity. Following initial successful bio-printing trials, the new subsidiary will expedite research and development in this field.

In May, Nano Dimension announced a successful proof of concept for 3D printing of bio-ink containing stem cells. The feasibility tests demonstrated the potential to print tissues de-



rived from viable stem cells.

Recently several companies have expressed interest in Nano Dimension's bio-printing technology, as a result, the board of directors of the company has approved the transition of this activity to a new entity. IDTechEx forecasts the market for 3D bio-printing will grow rapidly over the next decade from a market size of \$481 million in 2014 to as much as \$6 billion in 2024.



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# Leadership and...You

by I-Connect007 Research Team

In our now well-known monthly topic survey, we got some very interesting results on leadership. Most of the questions were designed to be open-ended (i.e., not multiple choice), specifically to encourage original answers—to keep our respondents from just checking off a few boxes.

Many of the answers were rather intriguing—and unexpected. Here is a breakdown of the survey questions/responses:

**QUESTION 1:**  
**What are the three most important traits and skill sets of a great leader today?**

The top three responses were:

1. Ability to inspire others	72.7%
2. Empowerment of employees	47.7%
3. Integrity	40.9%

These were closely followed by:

4. Clarity of vision	38.6%
5. Positive attitude	34.1%

It's pretty clear that most people want to be inspired. Perhaps at this moment you may be asking, "Do I inspire others?"

Much further down the list were:

6. Creating a great business plan and following it	18.1%
7. Passion	13.6%

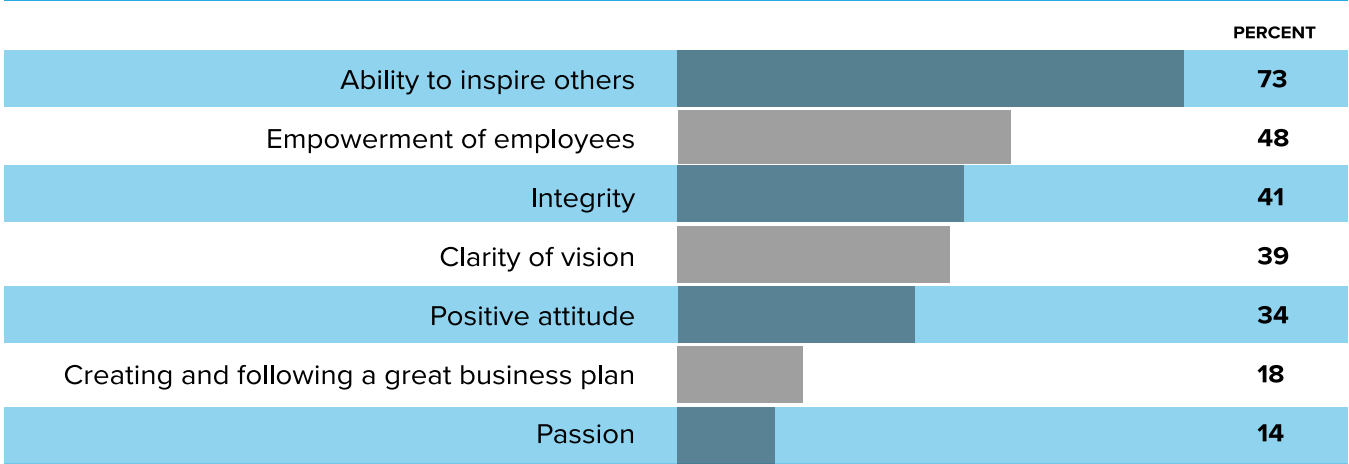
And way down the list were the following: courage, commitment to the company, decisiveness, organization and visiting customers. So there you have it. Now you know what to focus on.

**QUESTION 2:**  
**How do you see leadership evolving?**

Sometimes it's hard to notice change because evolution can be...so...slow. Keep in mind, evolution does not happen at the same pace for every person...you could be far behind the next person, which could make you appear to be an outdated leader. Are you?

The responses to this open-ended question were perhaps the most difficult to categorize of all the responses we got. Answers ranged from "becoming more team-based than single hero-based" to "getting more hands-on" to "better organization and execution of plan" to "much more collaborative, less prescriptive."

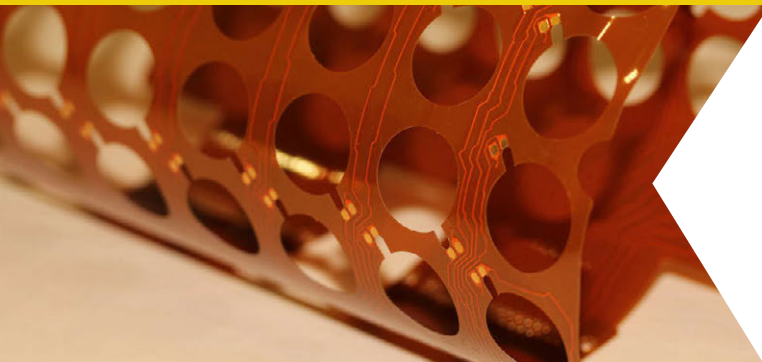
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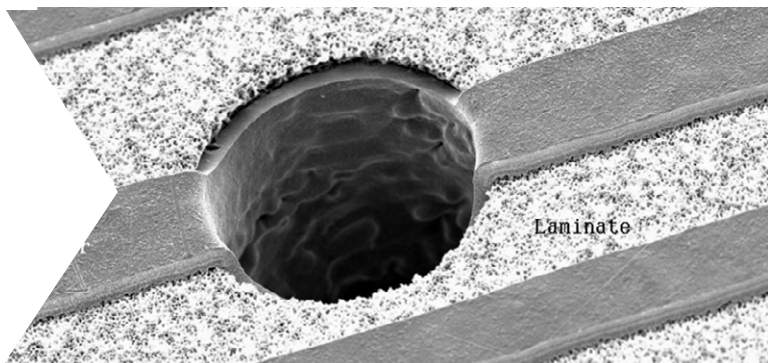
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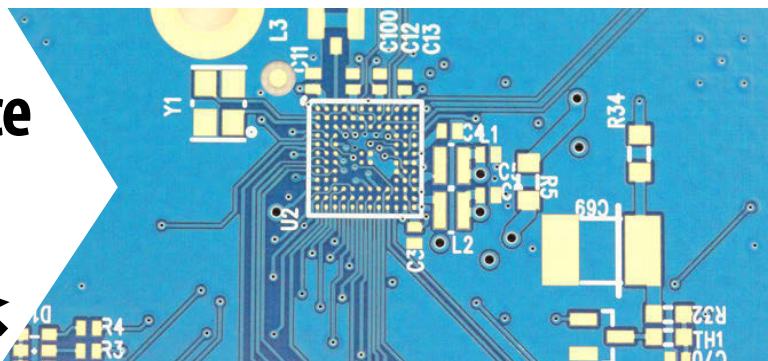
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As a general breakdown, the recurring themes were team building, growing people, and clarity of vision, with a small but respectable number feeling things haven't improved much at all. However, several insightful comments are worth passing along:

- "The good leaders have to focus on identifying subordinates who have the ability to clearly understand the company goals and how to achieve them and then give them the responsibility and freedom to achieve them."
- "I think great leaders will have to continue to provide positive and timely communication to their employees."
- "Fundamentally, leadership never changes. Having the clarity of vision and the courage to strive for that vision along with inspiring people to join in on the adventure is a constant. The changing elements are the current means needed to get there, whether that be product technology or market savvy, and the technical tools to deliver the message."
- "Not sure if the question means 'evolving' within the individual or 'evolving' in general. If the latter: Leadership skills will continue to be tested as pressure for short term performance clashes with long term stability and growth."
- "Management experts have been talking for 20+ years on the importance of presence, positive feedback and delegated responsibility. This is continuing and, especially with new generations entering the managerial bodies, less people will accept a workplace with instructive leadership."
- "The principles of leadership remain unchanged. The challenges arise due to changing societal norms that amplify personal, generational and cultural differences."

### QUESTION 3:

**What do you see as the three most important challenges in leading a team?**

Leading a team is perhaps one of the most difficult leadership skills to master. This was

another fill-in-the-blanks or short-answer question, so answers varied. There was familiar theme throughout the responses that show most people want to be valued and empowered; however, they also want a clear focus for their company's direction. Let us do our jobs!

	%
Plan/ focus/alignment	69.4
People/personality	72.2
Building teams	30.6
Communication	25.0
Empowerment	22.2
Resource management	22.2
Gaining respect/trust	16.7

### QUESTION 4:

**What do you see as the most important impact of great leadership in a company?**

Higher employee retention/happier employees	40.48%
Improved efficiency of operations	26.19%
Better margin/profitability	14.29%
Other (please specify):	9.52%
Consistency	7.14%
Process control	2.38%

The takeaway here: Great leadership leads to happy employees. Indeed, several comments further emphasized the importance of one's employees: "When you have long term, happy employees, much of the other [choices] happen naturally." And, "Without good and happy employees the rest becomes so much more difficult to achieve." And, "A good workforce will generally generate a good profit margin through excellent product quality and minimum scrap/rectification costs."

Are you surprised by these results and responses?

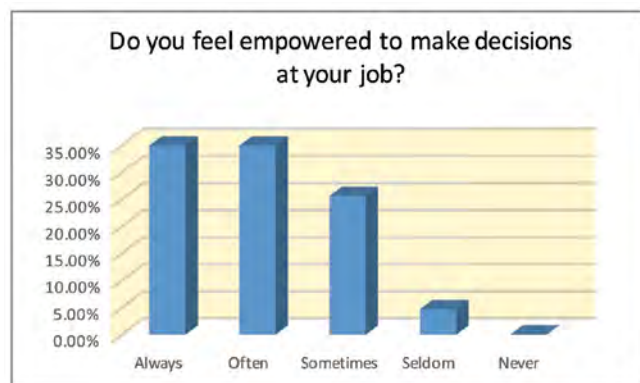
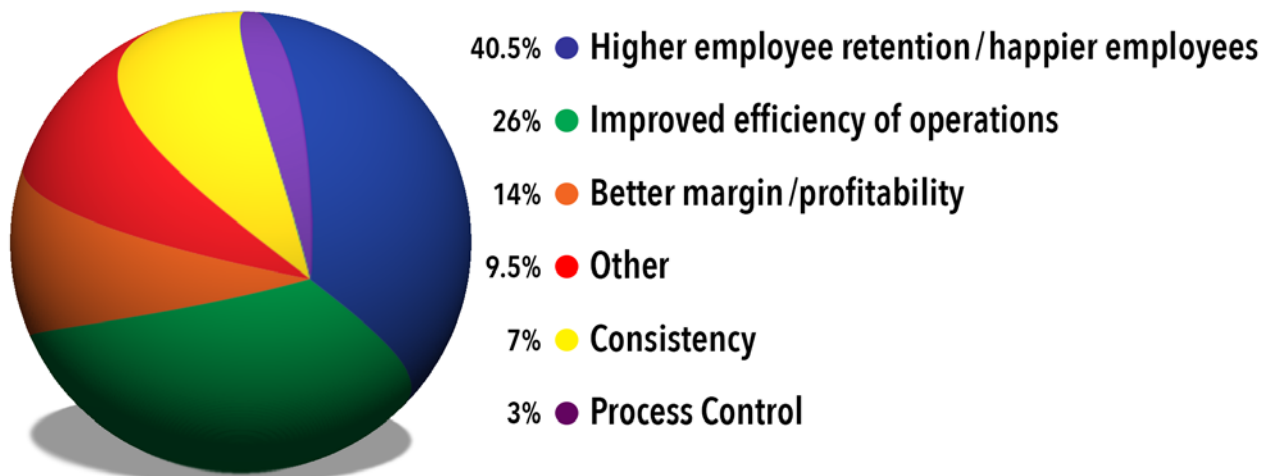
### QUESTION 5:

**Do you feel empowered to make decisions at your job?**

Not being empowered can be a miserable feeling... But the good news is that more than



## Most Important Impact of Great Leadership



71% of the respondents feel quite empowered to make decisions, plus another almost 24% felt empowered at least some of the time. Perhaps we should have asked for positions in the company; hopefully, higher level employees will have more decision-making authority. More good news—no one said “never.”

### QUESTION 6:

#### How does your leader motivate you in your job?

This was an open-ended question and we asked for three responses. Keeping in mind that the goal is happy employees...

While many different words were used, several themes emerged. The most frequently used words were support, compliments, recognition, accountability, trust and sense of involvement. Others were empowerment, feedback and new challenges, with the very occasional mention



of money or compensation (though compensation could mean other things also).

Perhaps we should have followed this with a question as to position within the company but we do believe we received a representative cross-section in the responses. And we also believe that level in a company really has little to do with what truly motivates individuals.

### QUESTION 7:

#### Does your company invest in leadership training?

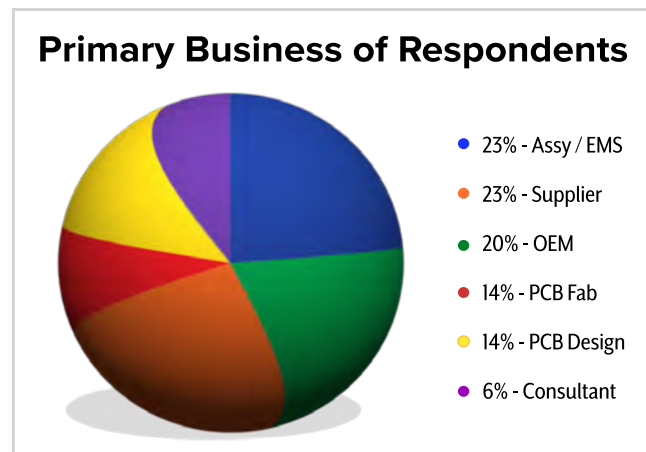
Happily, over 50% of respondents answered yes, while 31% said no, and some 17% were not sure. We asked what type and how often but the answers were rather vague for the most part. Which leaves no doubt that there is plenty of room for improvement, even at those companies that offer training.

**QUESTION 8:**

**Regarding millennials: How do you lead a generation that says it doesn't want to be managed?**

Talk about an open-ended question! And the answers were pretty broad also, but a few themes emerged. People wrote things like “show the need for,” “challenge them,” “inspire a shared vision,” “teach team dynamics,” “present clear goals,” “communication,” “don't micromanage, give them all participation trophies.” The last one was noted by the respondent as sarcasm.

Wait a minute; aren't these the things we all want in a job? To wit, millennials is just a catch-phrase; they want the same things the rest of us do but they are perhaps less willing to wait for it—less patient. They also have many more options outside of manufacturing—in fact, manufacturing is for the most part barely recognized as an option. And that is the real problem in our industry. One respondent com-



mented, “Not all young people are archetypal millennials.” Aha!

And another person pretty much summed it all up this way, “The key is to manage someone without them knowing they are being managed. And that is not a trick, that is the essence of good leadership.” How perfectly said on both counts. **PCBDESIGN**

## Autonomous Cars will Reach Sales of 24 Million Units in 2030

According to a new research report from Berg Insight, the first autonomous cars will debut in 2020. The total number of new registrations of autonomous cars is forecasted to grow at a compound annual growth rate (CAGR) of 62 percent from 0.2 million units in 2020 to reach 24 million units in 2030. The active installed base of autonomous cars is forecasted to have reached about 71 million at the end of 2030.



Several automobile manufacturers have initiated projects to develop self-driving features in their cars. The incumbent automakers are joined by multiple new actors such as IT companies and other technology-oriented firms. Most incumbent automotive companies pursue an incremental approach with step-by-step roll-out of autonomous systems while startups and IT companies take a

more revolutionary direction and aim at developing fully autonomous cars immediately from scratch.

The advent of autonomous cars is expected to have a tremendous impact on our society in several ways. Cars are among the most costly as well as inefficiently used assets of today. When cars can operate around the clock on a service based business

model it results in a tremendous increase of their utilization rate. Furthermore, autonomous cars will improve life quality for people unable to drive, reduce the number of fatalities and accidents in road traffic and increase overall traffic efficiency. The economic benefits are vast – the challenge is to succeed in making self-driving cars sufficiently reliable at a reasonable cost to enable commercialization.



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### **Weiner's World**

People in the printed circuit and electronic packaging industries often ask me about re-shoring. My response generally is that re-shoring is a myth. It seems that whenever I try to contact someone by email I get an automated response stating, "I am currently in China and will return to my office on..."

### **Happy's Essential Skills:** **Computer-Aided-Manufacturing,** **Part 1—Automation Protocols**

I have addressed automation planning previously in this series, so I hope by now you realize the difference between automation and mechanization. In printed circuit fabrication and assembly, most of what is advertised is mechanization. But when you get to assembly test, then you begin to see true automated solutions.

### **All About Flex: FAQ on RoHS** **for Flex Circuits**

In 2003, the European Union (EU) adopted RoHS, which restricts the use of certain materials in electronic products and electronic equipment. The intent is to reduce the environmental impact of known hazardous materials and has driven changes in manufacturing processes and materials used to manufacture a wide array of electronic products.

### **EPTE Newsletter: Sony Sells Battery** **Division to Murata**

Large electronics companies in Japan continue to lose market share in the global arena. This erosion of market share has had a ripple effect on Japanese printed circuit manufacturers that supplied these electronic companies; when they sneeze, printed circuit manufacturers catch cold.

### **Happy's Essential Skills:** **CIM and Automation Planning, Part 1**

There is a lot of talk and information about automation, but I find that there is very little available on automation planning. This is one of my specialties. I started by getting a master's in EE in control

theory. This went well with my B.S. in chemical engineering as I specialized in process control and IC manufacturing.

### **Printed Circuits, Inc. Hires Ed Andrews** **as Director of Quality Systems**

Rigid-flex circuit board manufacturer Printed Circuits Inc. has hired Ed Andrews as their director of quality systems.

### **Happy's Essential Skills:** **CIM and Automation Planning,** **Part 2—Six Principles of Automation**

In Part 1 of this column, I discussed the foundation of CIM and the principles of automation planning. In Part 2, we will assume that all the necessary preparations in strategy and tactics have been completed. How does it all fit together for successful implementation? This problem affects large, wealthy companies as well as the smallest job shop.

### **Standard of Excellence:** **Communication Breeds Success**

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### **Sunstone Circuits Announces** **RF/Microwave Capabilities**

Sunstone Circuits has announced the addition of RF/microwave materials (high speed/low loss) for 1- and 2-layer boards.

### **Continuous Roll-process Technology** **for Transferring and Packaging Flexible** **Large-scale Integrated Circuits**

A research team led by Professor Keon Jae Lee from KAIST and by Dr. Jae-Hyun Kim from KIMM has jointly developed a continuous roll-processing technology that transfers and packages flexible large-scale integrated circuits.



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# Rock Steady Design

by Barry Olney

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How do we ensure that our high-speed digital design performs to expectations, is stable given all possible diverse environments, and is reliable over the product's projected life cycle? One word: Impedance!

For the perfect transfer of energy and to benefit from the highest possible bandwidth, the impedance of the driver must match the impedance of the transmission line and be constant along its entire length. Also, the power distribution network (PDN) must provide low AC impedance up to the maximum bandwidth and deliver an undisrupted, minimal return path for high-current switching devices. These two seemingly unrelated concepts are controlled by the PCB stackup configuration including mate-

rial selection and should be analyzed concurrently.

For a sufficiently large number of electronics products, failures are distributed in time as shown in Figure 1. This curve is called “the bathtub curve” and displays the typical reliability of diverse products regardless of their functionality. One would expect a product to fail after some years of service, but preferably long after the product becomes obsolete. Premature failures are of particular concern and are typically the result of poor design practice or sub-standard manufacture. This column will focus on the design aspects.

In a previous column, [Intro to Board-Level Simulation and the PCB Design Process](#), I men-

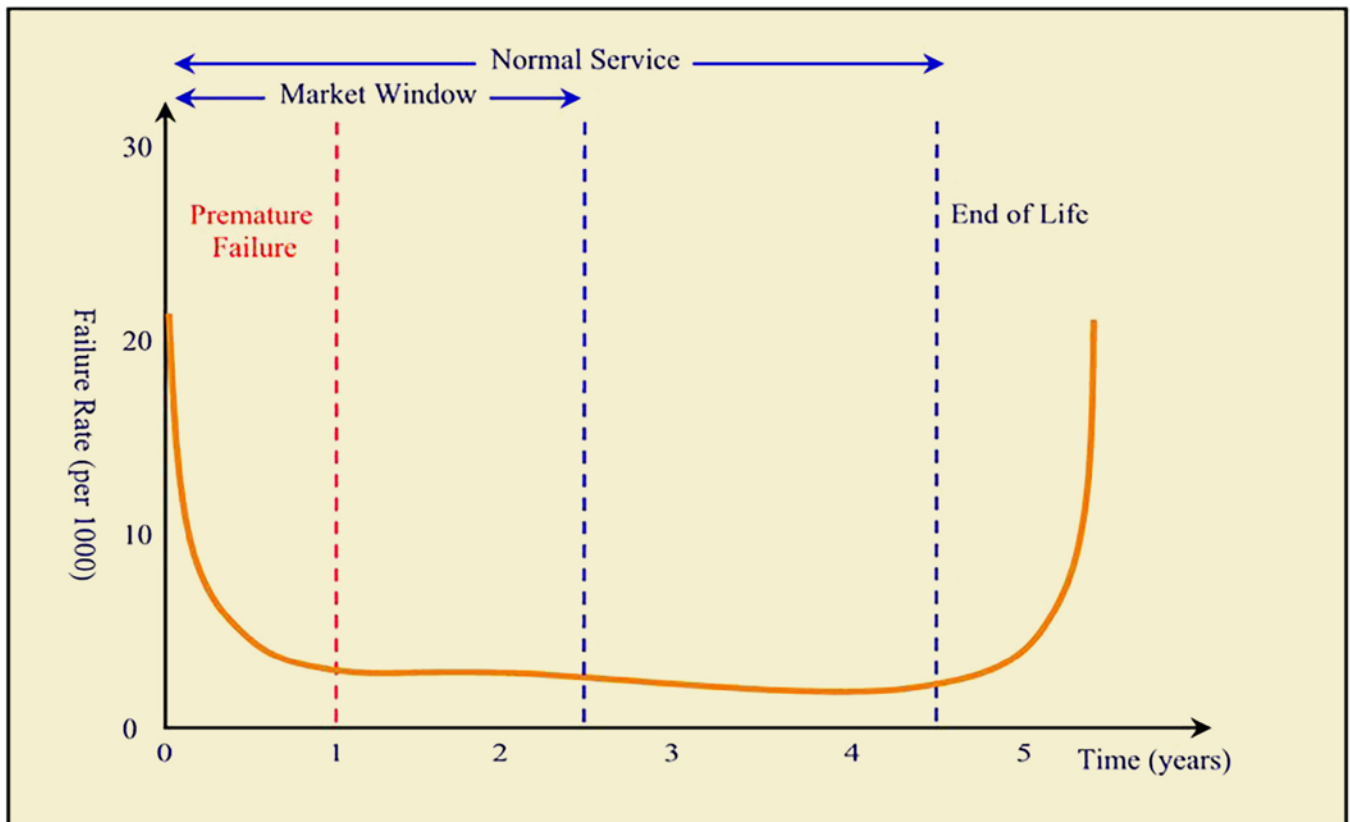


Figure 1: Product reliability life cycle—the bathtub curve.



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tioned that the cost of development is dramatically reduced if simulation is employed early in the design cycle. If changes are made late in the design process, then it takes more time, people, material and therefore money to complete the project. The advantage of simulation is that it identifies issues early in the design process and rectifies them before they become a major problem. Design changes that occur:

- In the conceptual stage cost nothing;
- During the design stage requires just a little extra time;
- During the test stage means that you have to regress one stage;
- During production, or worse still, in the field, can cost millions to fix and possibly damage the company's reputation.

Reference designs are arguably the cause of many reliability issues. Many reference designs are developed by academics who are lacking the knowledge of DFM and reliability and have little appreciation for real-world industry expectations. And although their design may work on the test bench, it may not work in an adverse

environment or with a variance of vendor components where the margins become borderline.

So, what are the key pillars of stability?

## 1. Stackup Impedance

First of all, one needs to plan the most efficient stackup configuration for the design. For a typical digital design, 50–60 ohms of impedance is recommended. However, more than one impedance is generally required to convey differential pairs of various technologies. Therefore, all combinations of impedances must be defined on the one substrate, which can sometimes be a difficult task unless you have the right tool.

Also, dielectric materials vary in both dielectric constant and dissipation loss with frequency. And, although we may be tempted to use the fundamental frequency of the clock as the operating frequency, the maximum bandwidth is determined by the signal rise time. An upper knee frequency of  $0.5/T_r$ , forms a crude but useful translation between time and frequency domains. So if, for instance, the rise time is 500ps, which is typical these days, then the upper bandwidth is actually 1GHz regardless of the clock frequency.

Layer No.	Via Span & Hole Diameter	Description	Layer Name	Material Type	Dielectric Constant	Dielectric Thickness	Copper Thickness	Trace Clearance	Trace Width	Current (Amps)	Characteristic Impedance (Zo)	Edge Coupled Differential (Zdiff)	Broadside Coupled Differential (Zdb)
1	8 4 4 8	Soldermask	Top	Conductive	3.5	0.5	2.2	12	4	0.43	51.67	98.65	
2		Prepreg		370HR; 1080; Rc= 66% (1GHz)	3.97	2.9							
3		Plane	GND	Conductive			1.4						
4		Core		370HR; 1-1652; Rc=43% (1GHz)	4.4	5							
5		Signal	Inner 3	Conductive			1.4	16	4	0.31	51.23	99.63	48.89
6		Prepreg		370HR; 2116; Rc= 56% (1GHz)	4.14	4.8							
7		Signal	Signal	Conductive			1.4	16	4	0.31	51.23	99.63	48.89
8		Core		370HR; 1-1652; Rc=43% (1GHz)	4.4	5							
9		Plane	PWR	Conductive			1.4						
10		Prepreg		370HR; 106; Rc= 76% (1GHz)	3.74	2.3							
11		Plane	GND	Conductive			1.4						
12		Core		370HR; 1-1652; Rc=43% (1GHz)	4.4	5							
13		Signal	Inner 7	Conductive			1.4	16	4	0.31	51.23	99.63	48.89
14		Prepreg		370HR; 2116; Rc= 56% (1GHz)	4.14	4.8							
15		Signal	Inner 8	Conductive			1.4	16	4	0.31	51.23	99.63	48.89
16		Core		370HR; 1-1652; Rc=43% (1GHz)	4.4	5							
17		Plane	GND	Conductive			1.4						
18		Prepreg		370HR; 1080; Rc= 66% (1GHz)	3.97	2.9							
19		Signal	Bottom	Conductive			2.2	12	4	0.43	51.67	98.65	
20		Soldermask		PSR-4000 HFX Satin / CA-40 HF LPI	3.5	0.5							

Figure 2: Typical 10-layer stackup.



Target Impedance	Tol +/- %	Layer No.	Trace Clearance	Trace Width	Current (Amps)	Characteristic Impedance (Zo)	Edge Coupled Differential (Zdiff)	Broadside Coupled Differential (Zdbs)
50/100 Digital	10	1	12	4	0.43	51.67	98.65	
50/100 Digital	10	3	16	4	0.31	51.23	99.63	48.89
50/100 Digital	10	4	16	4	0.31	51.23	99.63	48.89
50/100 Digital	10	7	16	4	0.31	51.23	99.63	48.89
50/100 Digital	10	8	16	4	0.31	51.23	99.63	48.89
50/100 Digital	10	10	12	4	0.43	51.67	98.65	
40/80 DDR3	10	1	12	6	0.58	42.53	81.33	
40/80 DDR3	10	3	12	6	0.42	43.15	82.31	37.58
40/80 DDR3	10	4	12	6	0.42	43.15	82.31	37.58
40/80 DDR3	10	7	12	6	0.42	43.15	82.31	37.58
40/80 DDR3	10	8	12	6	0.42	43.15	82.31	37.58
40/80 DDR3	10	10	12	6	0.58	42.53	81.33	
90 USB	10	1	6	4	0.43	52.07	91.41	
90 USB	10	3	8	4	0.31	50.99	90.58	48.89
90 USB	10	4	8	4	0.31	50.99	90.58	48.89
90 USB	10	7	8	4	0.31	50.99	90.58	48.89
90 USB	10	8	8	4	0.31	50.99	90.58	48.89
90 USB	10	10	6	4	0.43	52.07	91.41	

Figure 3: Target impedance chart for all required variations.

The stackup configuration in Figure 2 has been set up for multiple single-ended and differential impedances. The material selected in this case is Isola 370HR, which is a high-performance E-glass fabric for applications where maximum thermal performance and reliability are required. You should work closely with your preferred fab shop to ensure they stock the selected materials. As mentioned, the dielectric constant and dissipation factor vary with frequency so I have selected the data from the library at 1GHz to match the maximum bandwidth required. Blind and buried via spans have also been defined.

Figure 3, is a target impedance chart that includes characteristic, edge-coupled and broadside-coupled impedance that is exported as part of a fabrication drawing. This drawing also includes dielectric material definitions, trace/clearance properties and via spans.

## 2. Impedance Matching

Now that the stackup is finalized, let's look at impedance matching the source to the transmission lines. In a previous column, I pointed out all of the possible termination strategies. The easiest way is to use a resistive element. Termination can be made at the source or at the load. Series termination is excellent for point to point routes (such as data signals), one load per

net. It works well for traces that are electrically short and is also used to fanout multiple loads radially from a common source. Whereas, parallel termination is preferred for address buses.

The impedance of the trace is extremely important, as any mismatch along the transmission path will result in a reduction in signal quality and possibly the radiation of noise. Mismatched impedance causes signals to reflect back and forth along the lines, which causes ringing at the load. The ringing (as displayed in Figure 4) reduces the dynamic range of the receiver, eats into the noise budget and can cause false triggering.

As signal rise times increase, consideration should be given to the propagation time and reflections of a routed trace. If the propagation time and reflection, from source to load, are longer than the edge transition time, an electrically long trace will exist. If the transmission line is short, reflections still occur but will be overwhelmed by the rising or falling edge and may not pose a problem. But even if the trace is short, termination may still be required if the load is capacitive or highly inductive to prevent ringing. Generally, when the trace length exceeds one sixth of the electrical length of the rising edge rate, then termination is required.

Unfortunately, the driver impedance is always lower than 50 ohms and as such, does not

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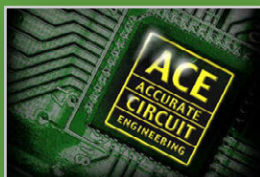
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match the transmission line impedance. Given that the impedance of the transmission lines has been established, how do we calculate the value of the series terminator required for the configuration? The source impedance from the IBIS model of the driver needs to be determined. I defined this method in detail in a previous column. Basically, the series element is given by:

$$Z_{series} = Z_o - Z_{source}$$

*e.g. for a 50-ohm transmission line:*

$$Z_{series} = 50 - 26.16 = 23.84 \text{ ohms}$$

Impedance matching slows down the rise and fall times, reduces the ringing (over/under shoot) of clock drivers and enhances the signal integrity of a high-speed design.

### 3. Power Distribution Network Impedance

Now that the stackup impedance and terminations have been defined, to provide stable signal propagation, we need to ensure that the power planes and associated decoupling can handle the high switching current demanded by the processor and memory devices. Inadequate power delivery can exhibit intermittent signal integrity issues. These include high crosstalk and excessive emission of electromagnetic radiation, degrading performance and reliability of the product. The PDN must accommodate variances of current transients, with as little change in power supply voltages as possible. So, the goal of PDN planning is to design a stable power source for all the required power supplies. As with stackup planning, the PDN design is required before a single IC is placed on the board.

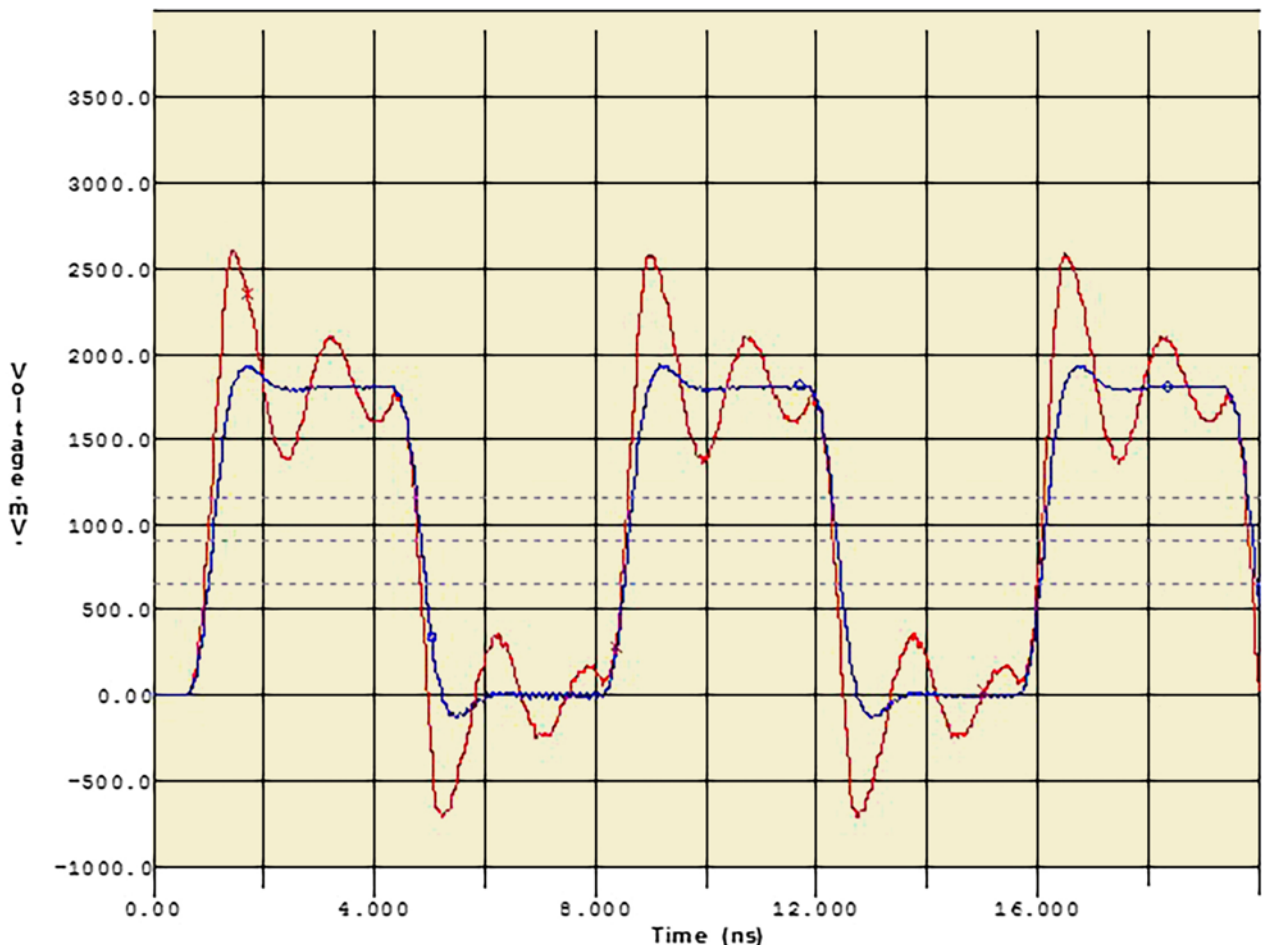


Figure 4: Ringing is reduced dramatically by adding a series terminator (simulated in HyperLynx).



# Engineering And Providing Balanced Interconnect Solutions



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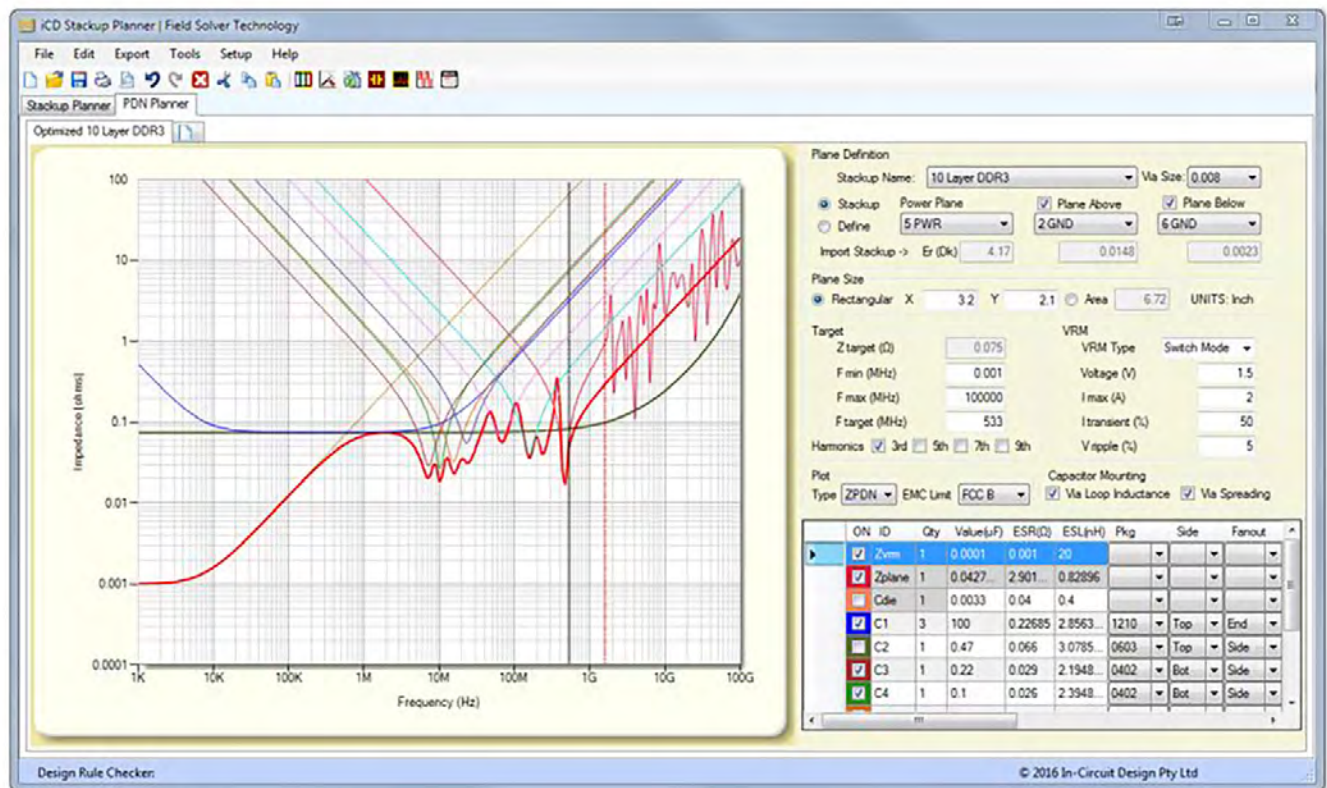


Figure 5: Optimized DDR3 PDN.

Also, the same PDN connections (planes) that are used to transport high transient currents are used to carry the return currents for critical signal transmission lines. If high frequency switching noise exists, on the planes, coupling may occur resulting in ground (supply) bounce, bit failure or timing errors. Many of the failures to pass electromagnetic compatibility (EMC) are due to excessive noise on the PDN coupling into external cables and radiating emissions.

Figure 5 illustrates a PDN with optimized capacitor values. This has 21 capacitors of different values and numbers to optimize the overall AC impedance. In this case, 21 capacitors from 100uF to 4.7nF are used. This approach gives a response close to the target impedance from DC to 700MHz. There are, in this case, a few anti-resonance peaks but they are way below the fundamental frequency and there is very low impedance right on 533MHz. When the capacitor's self-resonant frequencies are spread, the parallel resonant impedance sets the limits to the PDN performance.

The PDN is linked to the stackup and therefore any adjustments to the stackup configuration whether it be materials, vias or trace, clearance or thickness parameters will also be reflected in the PDN. The PDN can be fine-tuned by adding more planar capacitance without affecting transmission line impedance. The optimization of the PDN is a trial and error process that needs to be done in conjunction with the stackup materials to fully exploit all avenues.

It is amazing how many designers do not get the basic key pillars of stability right. For very little extra effort, your design can have improved performance and reliability over a wide range of operating environments giving you greater confidence in your products performance for the projected lifetime.

### Points to Remember

- The impedance of the driver must match the impedance of the transmission line.
- The PDN must provide low AC impedance up to the maximum bandwidth.



- The “bathtub curve” displays the typical reliability of diverse products regardless of their functionality.
- Premature failures are typically the result of poor design practice or substandard manufacture.
- The cost of development is dramatically reduced if simulation is employed early in the design cycle.
- Reference designs are arguably the cause of many reliability issues.
- The key pillars of stability: Firstly, plan the most efficient stackup configuration for the design. Dielectric materials vary in both dielectric constant and dissipation loss with frequency so the maximum bandwidth is used.
- Secondly, impedance match the source to the transmission lines. To do this, the source impedance from the IBIS model of the driver needs to be calculated.
- Finally, ensure that the power planes and associated decoupling can handle the high switching current demanded by the processor and memory devices.

- Optimization of the PDN is a trial-and-error process that needs to be done in conjunction with the stackup materials to fully exploit all avenues. **PCBDISIGN**

### References:

1. Barry Olney's Beyond Design columns: [Intro to Board-Level Simulation and the PCB Design Process](#), [Impedance Matching: Terminations](#), [Learning the Curve](#), [PDN Planning and Capacitor Selection, Part 1 & 2](#), [Master “Black Magic” with Howard Johnson’s Seminars](#).
2. Art and Engineering in Product Design, by Andrew Taylor.

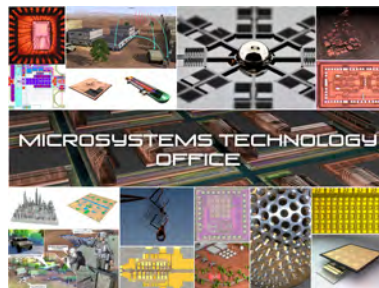


**Barry Olney** is managing director of In-Circuit Design Pty Ltd (ICD) Australia. The company is a PCB design service bureau that specializes in board-level simulation. ICD has developed the ICD Stackup Planner and ICD PDN Planner software, which is available [here](#). To contact Barry, [click here](#).

## DARPA's Microsystems Technology Office Streamlines Contracting for Innovators

DARPA's Microsystems Technology Office (MTO) has a proud history of making seminal investments in breakthrough technologies that ultimately became critical components in our electronics-filled world, from flash memory to radio frequency (RF) semiconductors to microelectromechanical systems (MEMS). But DARPA does not develop technologies on its own. The Agency's approach is to set extremely challenging goals and then offer innovators at universities and companies the support they need to pursue those remote but exciting frontiers.

MTO's commitment to that catalytic role—and the opportunity to engage with DARPA on the next generation of cutting-edge advances—is now expanding with the introduction of a simpler contracting approach for companies and other entities that have not previously worked with DARPA or had large contracts with the Defense Department.



This new approach aims to help the Agency and the nation take fuller advantage of the enormous depth and breadth of private-sector creativity that is currently brewing in the fast-evolving domains of networked sensors, spectrum access, machine learning, and hardware security. In particular, it aims to reduce barriers for innovative companies that don't engage in the standard federal contracting process.

For example, DARPA recently worked with two small companies on twin advances that could enable next-generation radio frequency (RF) arrays for both military systems and commercial wireless communications. The newly announced approach takes advantage of DARPA's so-called Other Transactional (OT) authority, which grants the Agency certain alternatives to provisions in the standard Defense Department contracting rules, known as the Federal Acquisition Regulation, or FAR.

## **Summit Interconnect Subsidiary KCA Electronics Recognized at Lockheed Martin Small Business Awards Event**

Summit Interconnect, Inc. subsidiary KCA Electronics was recently recognized by Lockheed Martin Corporation at their Small Business Awards Event. An award for KCA's outstanding product quality, service and support was presented to Shane Whiteside, President and CEO of Summit Interconnect and Eva Alcantar, Inside Sales Manager for KCA Electronics.

## **The European Space Agency on Reliability**

Stan Heltzel is a materials engineer working for the European Space Agency, and he is tasked with the job of procuring and qualifying PCBs that end up in satellites. I met with Stan at EIPC's Summer Conference to discuss his presentation on qualifying a fabricator, his role at the ESA, and updating of space standards.

## **Ventec VT-901 Reliability Validated by Key Israeli Customers' HATS Testing**

Ventec International is proud to announce that the reliability of its VT-901 polyimide laminates, prepregs and low-flow prepregs has been conclusively demonstrated by Highly Accelerated Thermal Stress (HATS) testing by two leading PCB manufacturers in Israel.

## **Let's Talk Testing: Does your Product have a Military Application?**

Just like any other industry segment within the circuit board world, the military sector has its own share of documents...and likely many more than most! These documents have been developed over the years to guide, shape, and test anything and everything that might go into a jet fighter, a radar system, a warship, a weapons system, etc.

## **Mil/Aero Markets: F-35 Declared Combat-Ready**

Electronic subsystems are an integral part of all modern military fighter jets, with a substantial portion of the electronics supporting intelligence, surveillance and reconnaissance (ISR) systems, elec-

tro-optical/infrared (EO/IR), avionics, munitions and radar related subassemblies. This equates to a very high content of PCBs and SMT assembly requirements.

## **Testing Todd: Testing Military/Aerospace—Houston, We Have a Solution**

This month we will dive into the testing of aerospace and military product. These designs require special processing in many cases above and beyond the IPC standards. The main specifications used when testing military product are MIL-PRF-55110, MIL-PRF-50884 and MILPRF-31032.

## **The Blackfox Advanced Manufacturing Program for Military Veterans**

You might be wondering why you should hire a military veteran, especially if your company has nothing to do with the military. But hiring veterans can bring a wealth of benefits, and this article highlights them. It also focuses on the Blackfox Veteran's Training Program, the first program of its kind to provide veterans with little to no industry experience with the skills to grow their careers in the electronic assembly industry.

## **Firan Technology Group Announces Organizational Changes**

Firan Technology Group Corporation announced today the retirement of Joseph R. Ricci, vice president and CFO. Joe will remain with FTG in an advisory role to ensure an orderly leadership transition to the new CFO over the next number of months.

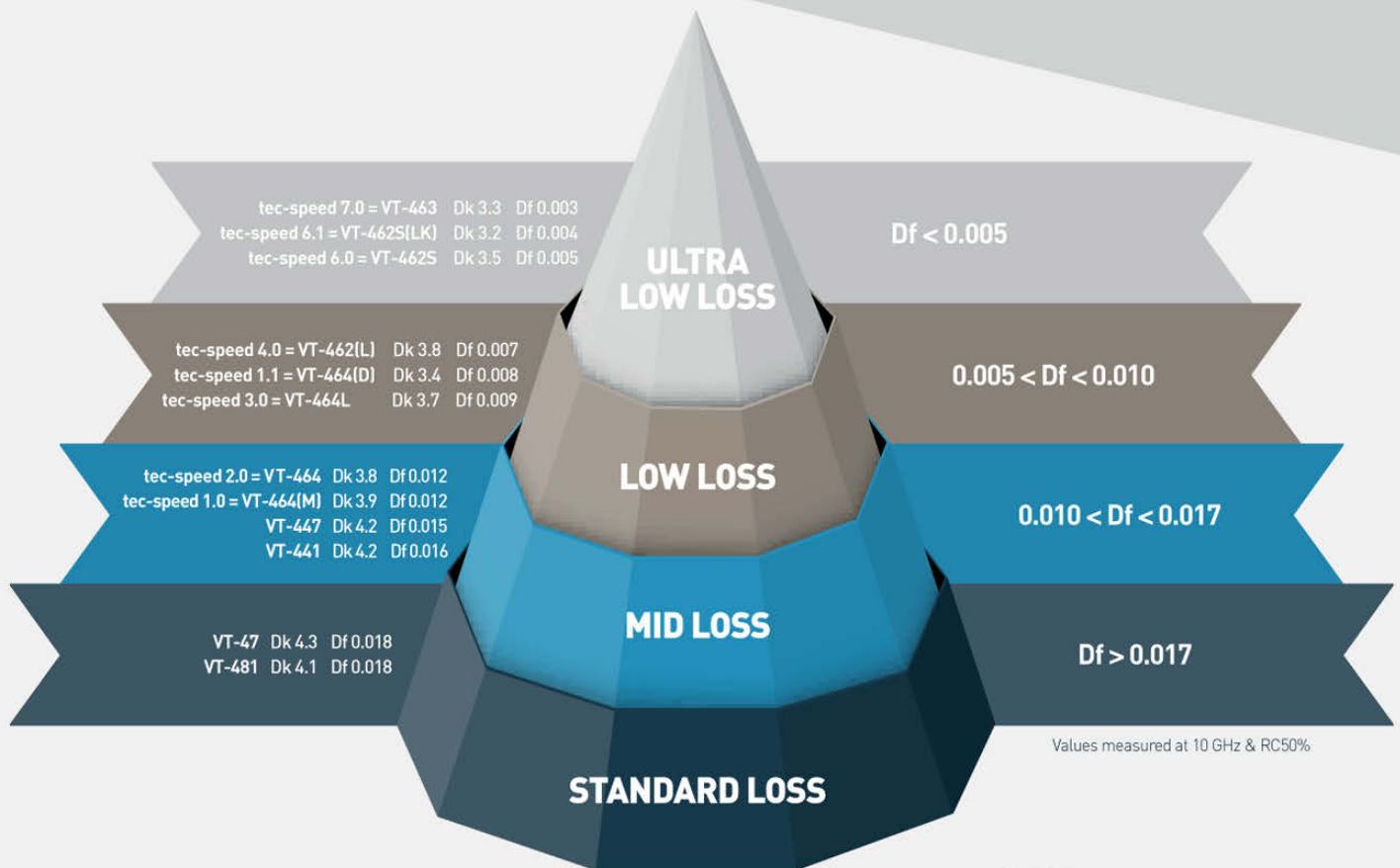
## **L-3 Selected by All Nippon Airways to Supply Airbus A320 Full Flight Simulator**

L-3 Communications announced today that its Commercial Training Solutions (L-3 CTS) business has been awarded a contract by All Nippon Airways (ANA) to build and deliver an Airbus A320 Full Flight Simulator (FFS). Based on L-3's Reality-Seven flight training simulation solution, the device will be installed at ANA's flight training facility in Tokyo, Japan, and ready to deliver training in September 2017.

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# The Blending of High-Speed Digital and High-Frequency RF

by John Coonrod

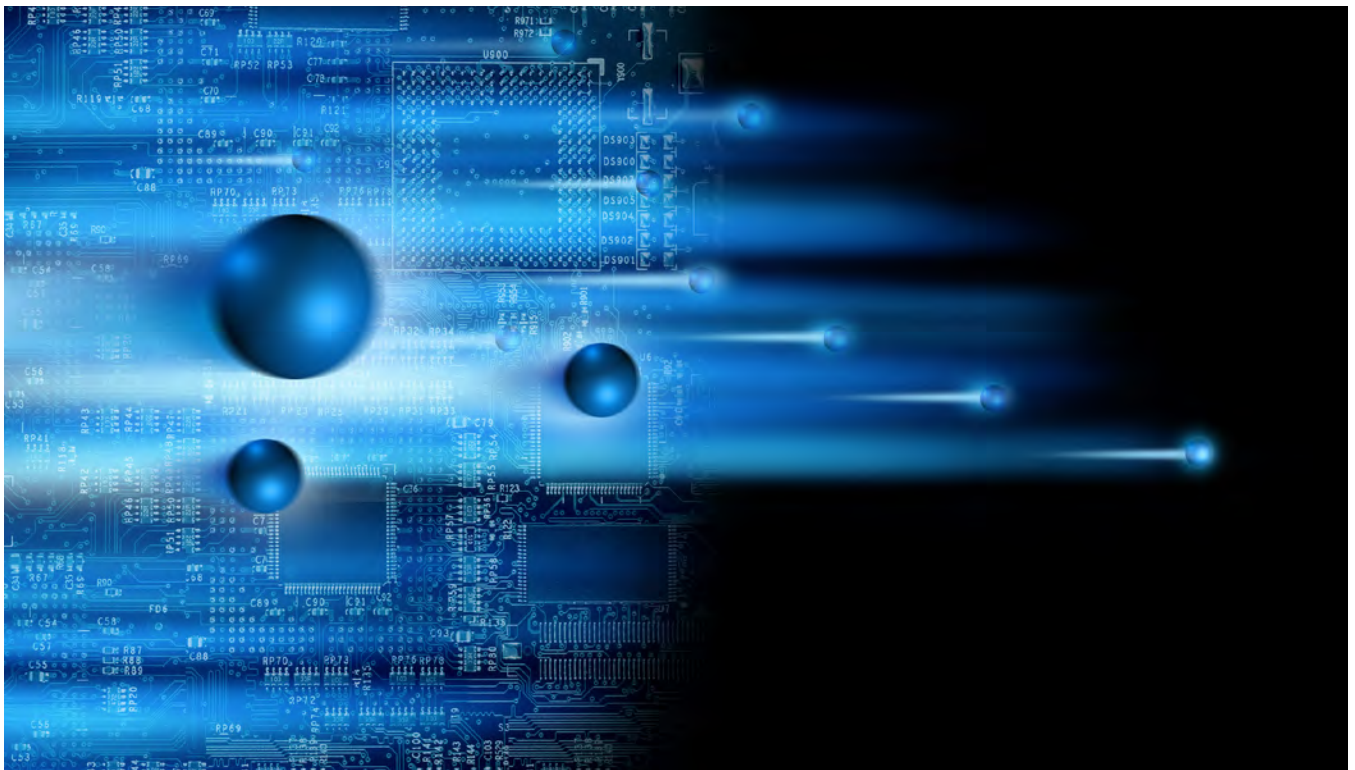
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When the terms high-speed and high-frequency are mentioned, people think they describe the same issue. But in reality, they can be two very different matters. The term high-speed generally refers to digital technology which transfers data at very high rates. But the term high-frequency is typically related to radio frequency (RF), which involves analog signals moving energy at high frequencies.

An easy way to think of the two technologies is that one is related to time domain and the other is frequency domain. In other words, high-speed digital (HSD) applications have concerns with time related items such as rise time of the pulse which defines the 0's and 1's of the digital information. The high frequency applications are interested in how an electromagnetic wave responds at a certain frequency or a

range (band) of frequencies. Many times, charts which describe the different technologies will be related to time for HSD and frequency for RF high-frequency applications.

There is a fundamental relationship between HSD and RF technology. The pulses used for digital information transfer are generated by RF waveforms. Basically, a sine wave can be thought of as a RF waveform, and when several sine waves, which are at different frequencies, are combined, they can form a square wave. The square wave is used for the pulse generation of the digital signals. As a simple example, a digital pulse speed (clock speed) that is 2 GB/s is formed by RF signals at frequencies of approximately 1 GHz, 3 GHz, 5 GHz, 7 GHz, etc. In the order of frequencies given they are: the fundamental frequency (1 GHz), the 3<sup>rd</sup> harmonic





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(3 GHz) of the fundamental frequency, the 5<sup>th</sup> harmonic (5 GHz) and the 7<sup>th</sup> harmonic (7 GHz) frequencies.

The frequencies given for the 2 GB/s example are generally not considered high frequency for RF concerns. However, when the frequency is high, many extra design considerations must be utilized in order to ensure good quality definition of the digital waveform. This concern for HSD signal quality is the focus of a term known as signal integrity (SI).

Many years ago when HSD speeds were lower, SI was primarily focused on time domain issues and there were many concerns to be addressed. Now, as HSD speeds are higher, the SI focus is still on time domain which is even more difficult but now RF issues become much more important and the SI engineer has to deal with frequency related issues as well. The job of the SI engineer is getting much more complicated as HSD speeds are increasing.

“The job of the SI engineer is getting much more complicated as HSD speeds are increasing.”

As a very general statement, RF issues are moderate up to 10 or 15 GHz. But from 15 to 30 GHz they become more difficult, and from 30 to 60 GHz they can be very difficult. Beyond 60 GHz, the RF issues are really tricky but these generalities also depend on the circuit configuration. Achieving good RF performance is more difficult at higher frequencies. RF performance is affected by the circuit design. Some circuit designs are more robust at higher frequencies than others.

High-speed digital processing currently done at 10 GB/s is relatively well understood, however not trivial, nonetheless the drive to higher speeds gets more difficult due to the influence of the high frequency RF components. As another example, a HSD application oper-

ating at 28 GB/s has RF signals at 14 GHz, 42 GHz, 70 GHz and 98 GHz. The higher-frequency harmonics are very influential on the clarity of the rise time of the digital pulse and in order to have a well-shaped digital pulse, the circuit response to the RF frequencies at 70 and 98 GHz is very important. The frequencies in this range are considered millimeter-wave RF technology and the variables for having good wave behavior at these frequencies are incredibly tough to deal with in PCB design.

When designing a PCB at millimeter-wave frequencies, the wavelength relationship to PCB design features is critical. The wavelength at 70 GHz for a stripline PCB using material with a Dk of about 3 is approximately 0.100" (2.54 mm). Fractions of the wavelength can affect the circuit performance. When circuit features are about the size of ½ the wavelength, wave performance can be affected significantly, which will impact the definition of the digital pulse. However, even at a ¼ wavelength, there are influences and a safe number is to have circuit features less than 1/8 wavelength to avoid the feature having an unwanted impact on wave performance.

The physical size related to 1/8 wavelength at 70 GHz with the stripline example is 12.5 mils (0.32 mm). Basically anything larger than 1/8 wavelength can impact the wave performance at 70 GHz and just trying to get the energy from the connector into the circuit can be a problem. For a stripline circuit, the plated through-hole via which transitions the signal from the connector down into the circuit at the signal layer can have dimensions greater than 12.5 mils and may cause the energy to be distorted when it gets to the signal layer. Even more concerning is the 70 GHz issue is only the 5<sup>th</sup> harmonic for the 28 GB/s signal and the 7<sup>th</sup> harmonic is at 98 GHz. The 1/8 wavelength dimension for that frequency is 8.6 mils (0.22 mm).

Fractions of a wavelength at millimeter-wave frequencies can impact circuit performance. However, material properties can influence the RF performance of the circuit. Most circuit materials used in high-frequency PCBs have layers of woven glass reinforcement to help mechanically stabilize the material. Some



physical features of woven glass can have dimensions which are  $1/8$  wavelength or larger at millimeter-wave frequencies. One issue is so-called “glass knuckles,” which occurs when the different strands of the glass weave overlay and these knuckles have a concentration of glass. The glass is usually a much different  $D_k$  than the resin system and this difference, combined with the dimensions of areas of glass (knuckles) and no-glass (open areas between knuckles), can be a major issue for signal integrity. There are several ways to deal with the glass weave issue and a simple one is to put the circuit conductor runs on an angle related to the glass weave pattern. This angle helps average the effect of the glass weave. Also, materials using a spread-glass

or flat-glass can be used to help minimize differences in glass weave effect.

This column very quickly touches on a vast topic, so it is highly recommended that the PCB designer contact their material supplier to understand the different material issues when dealing with HSD designs as well as millimeter-wave applications. **PCBDESIGN**

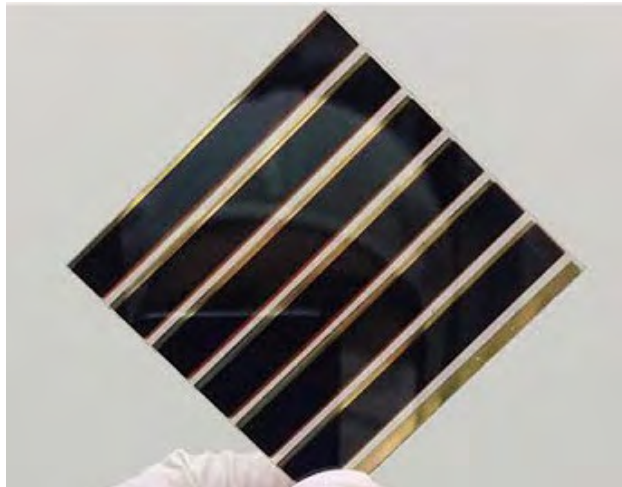


**John Coonrod** is the technical marketing manager at Rogers Corporation. To contact him, [click here](#).

## New Advances in Solar Cell Technology

With the high environmental cost of conventional energy sources and the finite supply of fossil fuels, the importance of renewable energy sources has become much more apparent in recent years. However, efficiently harnessing solar energy for human use has been a difficult task. While silicon-based solar cells can be used to capture sunlight energy, they are costly to produce on an industrial scale. Research from the Energy Materials and Surface Sciences Unit at the Okinawa Institute of Science and Technology Graduate University (OIST), led by Prof. Yabing Qi, has focused on using organo-metal halide perovskite films in solar cells. These perovskite films are highly crystalline materials that can be formed by a large number of different chemical combinations and can be deposited at low cost.

In order to be useful as solar cells, perovskite films must be able to harvest solar energy at a high efficiency that is cost-effective, be relatively easy to manufacture, and be able to withstand the out-



door environment over a long period of time. Dr. Yan Jiang in Prof. Qi's lab has recently published research in *Materials Horizons* that may help increase the solar efficiency of the organo-metal halide perovskite  $\text{MAPbI}_3$ . He discovered that the use of a methylamine solution during post-annealing led to a decrease in problems associated with grain

boundaries. Grain boundaries manifest as gaps between crystalline domains and can lead to unwanted charge recombination. This is a common occurrence in perovskite films and can reduce their efficiency, making the improvement of grain boundary issues essential to maintain high device performance.

Research from Prof. Qi's research unit has brought perovskite solar cells one step closer to mass production by providing solutions to problems of efficiency, life-span, and scalability. With more exciting research on the horizon, the unit is bringing the dream of utilizing cost-effective renewable energy resources into reality.

# Why are Resin Properties So Important?

by Alistair Little

ELECTROLUBE

Last month, I started this series of columns on resins by going back to basics, questioning the core rationale for potting and encapsulation with resins, their fundamental chemistries and how each resin type differs one from the other—indeed, how their individual properties can be exploited to maximise performance under a wide range of environmental conditions. I hope readers found this useful. Of course, when it comes to the choice and applications of resins, there's a great deal more to discuss, and over the following months I hope to provide some useful tips and design advice that will help you in your quest for reliable circuit protection.

For this month's column, I'm placing a bit more emphasis on the critical points that arise when you embark on resin selection. We need to get down to the real nitty gritty here because it's important that circuit designers have an understanding of some of the basic properties of resins before deciding which is the most suitable for the task in hand.

But let's not get too technical at this stage; instead, I'd like to simplify the selection criteria and try to make life a bit easier for those who have to make the decisions. So, picking up on my colleague Phil Kinner's format of providing a five-point guide in his previous articles on conformal coatings, let's take a look at five key resin properties that, if not taken carefully into consideration, could have serious implications for the performance of your application.

## Hardness

Perhaps counterintuitively, bearing in mind that a resin is there to protect, the cured hardness of the resin is actually rather important as the higher the hardness, typically the stiffer the resin will be. For example, if cured too hard, the resin may place too much stress upon components, particularly those with fragile connection legs. On the other hand, if too soft, then the resin will be easy to remove and it will provide reduced protection against chemicals and





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					<T <sub>g</sub>	>T <sub>g</sub>				
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leave components vulnerable to mechanical shock and vibration. Cured resin hardness is measured on the Shore A (softer polyurethanes) and D (harder epoxies) scales.

Of course, there are applications in which the encapsulation resin must have an extremely low hardness—in order to maintain flexibility at low temperatures, for example. This is particularly critical for devices that not only have

“In general, encapsulation resins can be difficult to remove; however, specialist formulations are available that allow the bulk of the resin to be cut out of the unit for this purpose.”

sensitive components but which are also frequently exposed to rapid changes in temperature. Moreover, as some devices may need to be reworked, it will be necessary to remove the resin. In general, encapsulation resins can be difficult to remove; however, specialist formulations are available that allow the bulk of the resin to be cut out of the unit for this purpose.

### Colour

What many might consider to be the least important property—colour—could actually be critical for certain applications. Optically clear resins may be desirable for a variety of reasons and this property is of particular importance when it comes to the potting of LED lighting fixtures, as the cured resin will obviously need to retain its clarity for the life of the unit. It must also be UV resistant, particularly for outdoor LED fixtures. Colourless resins are also useful for prototyping applications as the encapsulated components are easily viewed during and after environmental and mechanical testing.

As well as providing physical protection, coloured/opaque potting and encapsulation res-

ins are also useful for identifying certain circuit areas. Moreover, they conceal what lies beneath the encapsulant surface, providing an effective foil against counterfeiters or those wishing to copy a circuit layout, and helping you to protect your intellectual property.

### Viscosity

The viscosity of a two-part mixed resin will influence the way it flows around the components that are to be potted. Too low a viscosity and the resin will find every gap in the board; too high and the resin will not flow around and under components, creating voids and leading to potential weak points, which may shorten the service life of the components.

Thixotropic resins that regain their high viscosity once dispensed are ideal for ‘glob-top’ applications where a select component or area of a PCB needs to be protected, as opposed to encapsulating the entire unit.

Where a low dielectric constant is required (such as for RF applications), some resin systems may include specialist fillers to obtain the lowest possible value. These fillers can make the resin harder to mix and dispense due to the resultant high viscosity, and specialist formulations that avoid fillers altogether may be needed.

### Flame Retardancy

Fillers can also be added in order to render potting resins flame retardant up to the highest UL-94 V-0 standard. Aluminium hydroxide fillers are commonly used, resulting in low smoke emission and a low level of toxic fumes; however, the necessary high filler volumes will increase the viscosity of the resin as well as its density, incurring both dispensing and weight penalties. Bromine compound fillers used in smaller volumes have a lesser effect on resin viscosity and density but these can give rise to higher levels of smoke and toxic fumes. However, new phosphorus based flame retardant technologies are being introduced, offering the promise of lower viscosity and low toxicity.

### Cure Time

Cure times for two-part resins vary enormously. As a rule-of-thumb, a good 24 hours at room temperature will be required to obtain

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a minimum of 80% of full strength and specified properties. Gel time is the interval between mixing and the point at which the resin has just set and cannot flow. In this state, it is still relatively soft and can often be re-shaped by applying slight pressure.

Choice of hardener is the main way of altering the speed of cure of two-part resin systems. While hardeners will have their own exothermic effect, raising the temperature of the two-part mix, an external heat source may still be required to speed things up. It should be noted, however, that if heat is applied too early in the curing process, viscosity may reduce and the

resin will flow more freely, leaking from holes and gaps.

Well, hopefully the foregoing will help get you started as far as resin selection is concerned. Look out for next month's column, in which I will take a closer look at the main considerations relating to mixing resin. **PCBDESIGN**



**Alistair Little** is global business/technical director for the Resin Division of Electrolube.

## Disorderly Conduct

Solid materials whose atoms are arranged in a well-ordered crystalline structure are usually better conductors of electricity than randomly structured, or amorphous, solids. Recently, however, A\*STAR researchers found that iron-tellurium (FeTe) breaks this rule, displaying higher conductivity, and optical reflectivity, in the amorphous phase.

A recent study published in the journal *Acta Materialia* describes their efforts to understand why FeTe's behavior is counterintuitive to expectations.

FeTe is a phase-change material, with the ability to rapidly switch its state from crystalline to amorphous and back again when it is heated or cooled, a property which makes it useful for data storage and memory applications. Conventional phase-change materials such as germanium-antimony-tellurium (GST), commonly used in rewritable DVDs, display higher optical reflectivity and electrical conductivity in their crystalline state because the highly-ordered structuring of atoms in the crystal results in more electron vacancies, or holes, that act as charge carriers.



The team prepared thin films of FeTe at room temperature to produce amorphous structures, and at 220 degrees Celsius to acquire crystalline samples, and showed that the films could be flipped between the two states using a fast pulsing laser. They analyzed the molecular structure of the different films using X-ray spectroscopy,

electron microscopy and first-principle calculations.

The researchers confirmed the existence of lone-pair electrons in both the amorphous and crystalline phases. In the crystalline phase, electrons were engaged in strong hybridization, meaning their orbitals overlapped and caused their electrons to localize.

In contrast, when FeTe entered its amorphous phase, some Te atoms were orientated so that their lone-pair electrons delocalized from the atoms, resulting in holes that acted as charge carriers.

"We are hopeful that FeTe could prove to be useful material for phase-change memory," says Bai. "It could also act as an effective thermo-electric material, generating electric current in response to temperature."





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# TOP TEN



## Recent Highlights from PCBDesign007

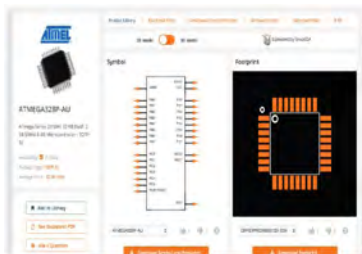
### 1 John Cardone on Designing Flex for Spacecraft

If you watched footage of the Mars rover driving all over the red planet, you're familiar with some of John Cardone's handiwork. He's been designing rigid, flex, and rigid-flex circuitry for spacecraft since he joined JPL in the early '80s. I caught up with John recently and asked him to give us the straight scoop on designing boards for spacecraft.



### 2 SnapEDA Launches InstaPart: Symbols and Footprints in 24 Hours

SnapEDA, the Internet's market-leading electronics design library, has launched InstaPart, an on-demand service that delivers symbols and footprints to designers' inboxes in less than 24 hours for only \$29 per component, keeping designers focused on innovation, and product development on track.



### 3 Quiet Power: Evaluating Evaluation Boards

Evaluation boards are very helpful. Manufacturers of complex circuits such as DC-DC converters provide boards with those circuits ready to try out, saving us time and effort. Evaluation boards are supposed to help us to understand the capabilities of the device. But with the many potential user applications, what should a particular user expect and look for in an evaluation board? We need to know how to properly evaluate an evaluation board.



### 4 EMA Enterprise Integrate Links PLM and ERP Systems With OrCAD

EMA Design Automation has just announced EMA Enterprise Integrate to enable OrCAD customers to bring products to market faster with a direct integration between OrCAD data and corporate PLM and ERP/MRP systems.





## 5 The Fundamentals of Improving PCB Thermal Design

Continental's automobile engineers have years of experience building critical parts and systems for automobiles. Making sure that automotive electronics are reliable, safe, and properly designed begins at the component level.

Heat must be addressed early in the design process for these goals to be achieved. The most important thermal resistance for heat, outside the IC package, is the PCB.



## 6 Mentor's SystemVision Improves Siemens Building Tech's Worldwide Flow

Siemens Building Technologies has deployed Mentor's SystemVision product with Siemens PCB design teams around the world, providing an upfront, mechatronic simulation environment and a qualified, central library for the Mentor Graphics Xpedition Enterprise PCB design flow. Early simulation using the SystemVision tool allows designers to make design decisions regarding component tradeoffs, find design mistakes, and verify their designs before PCB layout.



## 7 Mike Creeden: Care and Training of Your Designers

The I-Connect007 team recently visited San Diego PCB Inc. and received a warm welcome from CEO Mike Creeden and his youthful-looking (relatively speaking) team of designers. Creeden spoke with Barry Mat-



ties and Judy Warner about what it takes to run a successful design service center, how to properly care for the PCB designers of today and tomorrow, and why IPC's design training is paramount when training a new designer.

## 8 PCB West Attendance up 3% YOY

PCB West show attendance rose 3% year-over-year, to nearly 2,000 attendees.

This marks the annual PCB industry trade show's highest turnout since 2001. Registration for the 25th annual show was up 6% from 2015 registrants.



## 9 Beyond Design: How to Handle the Dreaded Dangers, Part 1

Dangling via stubs can distort signals passing through your interconnect, and decrease the usable bandwidth of the signal. A via stub acts as a transmission line antenna, and has a resonant frequency determined by the quarter wavelength of the structure. At this frequency, the transmitted signal is greatly attenuated, by up to 3dB.



## 10 Zuken USA Announces Dates for Zuken Innovation World 2017

Zuken Innovation World (ZIW) Americas 2017 will take place April 24-26, 2017 at the Hilton Head Marriott Resort & Spa in Hilton Head Island, SC. The annual event includes Zuken University classes, Expert Bar and a Technology Showcase on April 26.



***PCBDesign007.com for the latest circuit design news and information—anywhere, anytime.***



# Events



For IPC Calendar of Events,  
[click here](#).

For the SMTA Calendar of Events,  
[click here](#).

For a complete listing, check out  
The PCB Design Magazine's  
[event calendar](#).

## [electronicAsia](#)

October 13–16, 2016  
Hong Kong

## [TPCA Show 2016](#)

October 26–28, 2016  
Taipei, Taiwan

## [Electronica](#)

November 8–11, 2016  
Munich, Germany

## [FUTURECAR: New Era of Automotive Electronics Workshop](#)

November 9–10, 2016  
Atlanta, Georgia, USA

## [Printed Electronics USA](#)

November 16–17, 2016  
Santa Clara, California, USA

## [International Printed Circuit & Apex South China Fair \(HKPCA\)](#)

December 7–9, 2016  
Shenzhen, China

## [DesignCon 2017](#)

January 31–February 2, 2016  
Santa Clara, California, USA

## [MD&M West](#)

February 7–9  
Anaheim, California, USA

## [IPC APEX EXPO 2017 Conference and Exhibition](#)

February 14–15, 2017  
San Diego, California, USA



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