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# Safety And Compliance Are Mostly Learned In The Real World, Not The Classroom

*by Kevin Parmenter, Chair, PSMA Safety and Compliance Committee*

Like everyone else, engineers are feeling the impact of the Covid-19 pandemic in their work life, with many working remotely from home, either partially or full time. Project schedules in some cases are being impacted, and there have been supply chain disruptions, either caused or exacerbated by the pandemic. Meanwhile, for some aspects of engineering such as compliance activities, it seems to be business as usual.

As has been discussed in previous Safety & Compliance columns, there are new environmental regulations coming into effect that change the disclosure requirements regarding the material composition of electronic products. With the pandemic disrupting companies' abilities to meet the new requirements, I am seeing companies requesting postponements of the new milestones in reporting, only to have these requests denied.

Perhaps these regulatory activities are not being paused because they mainly involve processing of data, which like other work, can be done remotely. Another way to look at them is that compliance requirements are considered so important, they must not be disrupted even in the face of a public health crises.

Perhaps this thought was on my mind as I came across an article written a few years ago by Lou Frenzel, titled "7 Critical Things They Don't Teach You in EE School" (see reference 1). The topics Frenzel focused on were "power supplies, pc board design, video, motors, test and measurement, wireless and digital signal processing" and he noted some of the reasons why each of these areas are important for EEs, why universities tend not to teach about them (at least in undergrad programs) and how engineers are largely left to learn these subjects on their own.

In reading about these neglected subjects, in my mind I could not help but add safety and compliance issues to the list. As with the topics that Frenzel discussed, knowledge of safety and compliance requirements and practices is critical to performing our jobs as electronics engineers. Yet so many aspects of S&C are never addressed in engineering studies.

Just consider the main areas we write about in this column:

- Safety and risk/hazard reduction requirements and regulations. Think fault conditions that lead to shock hazards or fire. Engineers need to understand how to prevent faults that lead to these events, while satisfying the global safety agency requirements that provide the legal assurances these problems will not occur.
- EMI-EMC issues. Electromagnetic interference (EMI) and electromagnetic compliance (EMC) issues encompass a range of potential problems that can make a product design perform poorly or make it unmarketable. These include your design interfering with itself or other equipment, or the ac power mains interfering with your design.
- Energy efficiency standards and guidelines. These encompass both voluntary and mandatory requirements. Naturally, power supply designers become very familiar with many of these requirements in their work, but in many cases power supply specifiers and other non-power specialists need to understand the requirements too.
- Environmental/materials compliance regulatory issues. These concern the chemical composition of all the components in your product and disclosure requirements to satisfy the raft of regional and global regulations like RoHS, REACH, WEEE, California Prop 65, etc.

It is pretty much a given that none of these topics will be covered in any kind of undergraduate engineering curriculum. But stepping back for a moment, the lack of attention to these issues is somewhat an extension of the "ideal" way in which electronics is taught in general.

For example, in your undergrad courses, they taught you that a capacitor is a schematic symbol or a simulation file or both. In any case it was a perfect component and in reality, there are no perfect or ideal components.

Nor is a capacitor a single type of device. There is a plethora of different capacitor styles. None of them are perfect, they all have ESR, equivalent series resistance which varies with frequency, voltage, and time and ESL, equivalent series inductance, too. What is more, capacitance varies with applied voltage on many or most types of capacitors. Similarly, inductors and transformers are often introduced to engineering students as perfect components. Yet these have resistance and capacitance as well. They likely will not teach you how to design magnetics either.

Understanding of these non-idealities and component variations is often essential to electronics engineering in practice, yet these issues add layers of complexity to the subject matter, so EE instructors avoid them. So, it is not surprising that they also steer clear of safety and compliance issues, which also require consideration of non-ideal components.

For example, capacitors and inductors come into play heavily for safety requirements as some of these components have safety agency approvals and some do not. So, engineers must learn when to use which types.

Similarly, there are safety aspects to transformer design. How do you get your magnetics to safely pass the regulatory requirements of UL, for instance, and how do you get your product to pass an agency approval review and get UL approval for your end product? Safety agencies will care about the electrical safety aspects of the design such as leakage currents as well as thermal aspects—components must run below certain temperatures under all conditions including fault conditions.

Safety agencies also want to know that fault conditions will not lead to fires, so they care about the flammability of power components and materials. And in general, the overall objective is that a fault will not lead to any unsafe condition for humans who are operating or in the vicinity of the product in question.

All these issues require knowledge of real components. The component parasitics that I just mentioned also come into play when you lay out your PCB. Here again we encounter many issues, which we were not taught about in EE school. Creepage and clearance on your PCB layout will need to be considered for safety and a poorly laid out PCB will create EMI that may cause your design to fail EMC testing, or simply prevent your design from functioning as designed. Conversely, a well-designed PCB will reduce EMI and make it easier to pass EMC.

Speaking of laying out PC boards, you should really know something about RF circuit design to be a good PCB layout person. RF circuit design teaches that the PCB is part of the circuit itself which of course is less true at dc, but it is still part of the circuit. This relates back to the EMI issues.

Although not necessarily related to the safety and compliance issues, the PCB layout tools themselves represent a subject that will confront you on the job. There are probably almost 100 PCB layout packages on the market, which one should you use? Does your organization make you use a specific one? How do you design a PCB on your computer with one of these packages? Do they teach PCB layout in school now?

Your career is only going to last long enough to learn one or perhaps two PCB layout tools. (You may need to learn a second, when the first becomes obsolete.) Learning to use a PCB layout tool typically involves on-the-job training and sticking with one software package to learn all its subtleties, tips, and tricks. These are simply more of the practical aspects of EE they will not teach you in school.

Closely related to PCB design are the issues of grounding and shielding your design. In practice, the more you know about grounding and shielding, the better. Ground, much like other real circuit elements, is nonideal. There are different methods for grounding your PCB and overall system. You will have to learn about these techniques on the job.

Grounding and shielding are especially important if your product takes power from the ac grid. The ac line is noisy, and your product will need to survive transients and surges and noise on the ac line. In general, it will be good if you know as much as possible about grounding and shielding, and what grounding methodology will be used on your PCB design and your overall system.

Additionally, regulatory agencies will require that the product not inject interference on the ac line, so typically products must have ac line filters installed. Should you build one or buy one? How do you know which approach to take? And if you buy one, how do you select an ac line filter from the many available? AC line filters require that you meet both safety as well as EMI-EMC requirements for the category of the product. For example, medical system requirements differ from industrial and commercial ones and military specifications are different once again.

Almost certainly, your EE instructors did not discuss the impact of market requirements on product approvals. Yet nothing can be built and sold without them.

Whether EMI is the problem, or there is some other aspect of your electronics design that does not work, at some point, you will need to troubleshoot. Unfortunately troubleshooting skills are generally not being taught. Some universities have stopped senior projects where you build things, which is tragic. How else do you learn to debug things?

Of course, part and parcel of troubleshooting is knowing how to run test and measurement equipment applicable to your kind of product. Instruments such as DMMs, oscilloscopes, frequency response analyzers, electronic loads, spectrum analyzers and others may come into play. PCB layout/human nature is to try to fix hardware with software, but troubleshooting, especially for compliance matters brings you back to the hardware realm.

Chances are your engineering education introduced you to simulation—an indispensable aspect of modern electronics engineering. But just because the simulations might say it will work, it might not. Simulation is not perfect. With homage to the late Bob Pease, his simulation tool was a soldering iron, and again, soldering is a skill they do not teach in engineering school, but one you must know.

Just as you were taught electronics as the study of ideal components, you were introduced to circuits from the ideal point of view. You were taught theory on *why circuits work* but not why they *do not work*. When your circuits do not work, in the world of EMI-EMC especially, they will need to be corrected. Troubleshooting, as noted above, and circuit debugging are essential skills. But not everything works like it says on the component datasheets. What makes something stop working for no apparent reason then start working again? Intermittent problems are hard to debug and troubleshoot.

The source could be another non-ideality you did not learn about in EE school. That is that the datasheets sometime have mistakes in them. Or they may have "undocumented features" which you will discover on the bench. Or you may find these surprises in software.

For example, on the hardware side, there's that mysterious NC—"No connect" on the pin on an IC. Its meaning is not clearly defined and it leads to a host of questions. Does NC mean that the pin is not connected inside the IC? Is it telling you "do not connect" anything to the pin? Or does it mean that it is tied to the substrate and it should be tied to – or GND? Is it for the IC supplier's testing needs? Will the EMC be impacted by the NC pins being addressed one way or another? Should you tie them to VCC? Tie them to GND or leave them floating?

A Google search may not tell you the answer. It is likely that only the IC company that made the part knows. But how do you get support out of the component company? They do not teach that in school either. Common sense tells you that "hey they will want to talk to me about this!" Depending on who you work for, that may or may not be the case. Today's high tech company wisdom is that "good and useful feedback only comes from key customers" This poor idea comes to you courtesy of the finance people who run all the companies now.

Now, sometimes the device supplier will help you and be thankful for your input and dialog if you work at a big key customer or a prospective one they would like to sell to. But then, sometimes, surprisingly, if you are at a customer they don't care about or never have heard of they will find your inputs annoying even though you are debugging their product for them for free. They will simply refer you to their website. So now how do you get things done? Again, nobody told you about this problem in EE school.

Another practical issue with your engineering education is that much of what you learn in school will at some point obsolete. Technology, especially component technology, keeps changing, often at a rapid pace. Keeping up with these changes can be a full-time job. From a compliance point of view, these changes are important, because they often impact EMI and EMC, and proper operation of your system in the real world.

Along with technology changing, industry standards and market requirements change, so all these things require continual learning. Energy efficiency standards are a case in point. These continue to evolve and expand across many applications, as power supply technology improves, we see how the energy efficiency requirements become more stringent. Engineers must learn how these apply specifically to their products and targeted markets. For example, do the relevant energy efficiency standards apply to both active and standby modes of operation? The lighting industry has a subset of lighting requirements which change rapidly as does the LED lighting efficacy.

The larger is issue is that engineers, in general, must learn what standards apply to the products they are designing. There is a long list of standards, directives, and regulations you were not introduced to in school. Some of these are produced by the large industry and academic organizations such as SAE, IEC, and the IEEE.

And of course, there are certain common considerations—any product needs to consider transients, surges, and fault conditions.

The move towards a circular economy and chemical sustainability means that your product will also have to meet the global requirements for environmental disclosure such as the latest RoHS, WEEE, and conflict materials policies as well as California prop 65 requirements. All these things are essential while little or none of them are taught in engineering school.

So how do you learn and stay current? I am pretty sure that 8080 assembly code I learned in microcontroller class is not going to benefit me anytime soon. However, learning how to learn and use information and stay current is a benefit that school did teach you that is still valid—how to absorb and apply large amounts of information quickly is a valuable and timeless skill. Standards change and evolve continuously, and engineers should do the same to keep current.

Online courses, webinars and even conferences have gone online. Many organizations are sharing information online including publications and standards organizations as well as engineers who work within the various compliance specialties. So, take advantage of these resources.

Putting aside my earlier comments about unresponsive suppliers, do not rule out the suppliers of components and their applications engineers as sources of information. Also, request demos of products, services, and software—try before you buy. For those of you that live in the United States I have a saying that the burger you get at the restaurant does not look like the picture on the wall. So, try before you buy or as Ronald Regan used to say "trust, but verify."

And as a CEO I once worked for said "the large print giveth and the small print taketh away. Test, demo and evaluate. This same CEO only asked me one question when he interviewed me—"can you get things done?" Now I understand why he asked me this. Looking around the world today, I see that we have a deficit of people who can.

While the various methods of self-learning noted above are necessary and useful, so much of what needs to be learned as an engineer can be learned more efficiently by working with more experienced peers. Of course, I am referring to mentoring.

There is simply no substitute for learning the practical aspects of engineering from those who have been in industry for many years and mastered the needed skillsets of designing, building, and getting products to market. Naturally, this applies to all aspects of safety and compliance activities. A mentor can help to steer young engineers in development of the skills and knowledge they will need to design compliant products.

However, corporate policies and priorities do not always encourage mentoring. Management that is more focused on today and the bottom line probably will not support mentoring, only to learn that critical skills have been lost when older engineers retire. (In the future I will write more on the topic of mentoring and bringing up the new generation of engineers to be successful.)

Engineers just starting their careers should weigh the opportunities for mentoring when interviewing with prospective employers. Likewise, those who are further along in their careers should take advantage of opportunities to pass on their knowledge, and when possible, advocating for companies to support such opportunities. The benefits of mentoring may not be quantifiable in the management metrics, but they are likely to have an impact on an organization's success in the long run.

**References**

1. "7 Critical Things They Don't Teach You in EE School" by Lou Frenzel, Electronic Design, June 13, 2016

*If you appreciate reference 1, you may also like this author's earlier article:*

2. "Top 10 Things They Do Not Teach You In Engineering School" by Lou Frenzel, Electronic Design, January 3, 2013. (Frenzel mentions standards in this one.)

 

**About the Author**

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For further reading on power supply-related safety and compliance issues, see How2Power's special section on Power Supply Safety and Compliance.