He Wrote the Book on EMC

"Whatever you did last time is never enough next time"

When Henry W. Ott wanted to learn more about EMC, he ran into a few problems. There was almost nothing written on the subject, not in the 1960s. Most electrical engineers at the time knew less about the topic than he did. To top it off, the term "EMC" hadn't yet been coined.

Armed with curiosity and perseverance, Ott eventually would write the first comprehensive book on EMC: "Noise Reduction Techniques in Electronic Systems." Now in its second edition, the book has been published in six languages and has become required reading for two generations of engineers concerned about EMC issues.

Senior PCB Engineer Rick Hartley (Applied Innovation) has been in the electronics industry for 35 years, focusing on high-speed design and EMI control. He remembers the first time he read "Noise Reduction Techniques in Electronic Systems."

"His book caused an evolutionary change in my thinking," said Hartley. "After reading it, I understood (for the first time, I might add) where both low- and high-frequency currents really flow, wave propagation, shielding of cables, etc."

Ott spent 30 years at AT&T Bell Laboratories (now Lucent Technologies) before devoting his full attention to running Henry Ott Consultants (www.hottconsultants.com) in Livingston, NJ. His business keeps him busy crisscrossing the country teaching courses on EMC. With four patents under his belt, he is an Honorary Life Member and former Distinguished Lecturer of the IEEE EMC Society.

Despite these accolades, Ott says he owes much of his career to the popularity of a 24-year-old book.

"I was just in the right place at the right time," said Ott.

A fascination with building things

As a child growing up in Newark, NJ, Ott enjoyed working on electrical and mechanical projects. For a time he even considered a career in mechanical engineering.

"I was going to take up mechanical engineering at one point because I like to do a lot of mechanical things—woodworking, building things with the hands—but I decided maybe electronics is more the future and I enjoyed that too," Ott explained. "Kind of glad I did."

Ott graduated from the New Jersey Institute of Technology with a bachelor's degree in engineering and then spent three years in the Air Force. After his enlistment was up, he went to work at Bell Labs and took postgraduate classes at New York University. Every engineer at Bell Labs was required to have a master's degree, but the company allowed employees to work part-time and go to school for their M.S.E.E.

"Of course they would support you and they made it convenient to go to school, and over the years they offered it in different ways," Ott said. "When I was there you had to go to a local school, but later on they changed it. People used to go to Stanford, even though they worked at Bell Labs in New Jersey."

The infancy of EMC

Ott obtained his master's from NYU in 1963 and began working full-time at Bell Labs. One of his earliest projects involved designing electronics in a noisy environment. Ott soon discovered that colleges taught students the basics of electrical engineering, but neglected to teach them anything about controlling noise. He would have to learn how to control noise just to get his project done.

"They didn't teach you about noise, interference, these things that theoretically aren't supposed to occur," said Ott. "And I found out—this was back in the mid-'60s—there wasn't much written in the library about it either. So therefore I kind of had to learn a lot of it on my own just to do the job, to do what I was being paid to do."

Ott managed to find one book that offered some pertinent information on controlling noise, "Fielding and Grounding in Instrumentation Systems" by Ralph Morrison, first published in 1967.

"He was a person I looked up to at that time, but that was mostly low-frequency analog, and I developed a lot of stuff mostly into the digital field," Ott said. "I met him last year for the first time."

Around 1970, Ott approached the manager in charge of in-house education at Bell Labs and suggested that they offer a class on noise and interference. Ott forgot about the idea until several months later when he was called back to the education office. Bell Labs had scoured the universities in New York and New Jersey looking for someone qualified to teach a class on electrical noise and interference and found no one. Would Ott like to teach it?

"Being young and naïve, I said I'd teach it," Ott said. "That's kind of how I got into EMC."

Publish or perish

Ott admits he felt that he was in over his head when he started teaching. He knew something about fighting noise but he was no expert.

"I learned that if you know more than somebody else, you're the expert, no matter how little you know," he said. "The first time, I had very little material."

Ott remembers being embarrassed when students asked him questions he couldn't answer. But by the next class, Ott usually had the answer. If he couldn't find the answer in a technical article, Ott would try to work out the answer on his own. He kept adding to his notes and each year he had more material to use in the course. By 1975 or so, Ott had developed what he considered to be a solid EMC course.

Somewhere along the way, Ott started thinking that his class notes might translate well into a book on EMC.

"Since there wasn't a lot written, there wasn't a lot in the library, I said, 'Well, maybe I should write a book about it. Do something with this stack of notes I've got,'" he said. "I'm not thinking this is my career—EMC."

Bell Labs was enthusiastic about his book idea and helped Ott promote it. The first edition of "Noise Reduction Techniques in Electronic Systems" was published in 1976 and it was snapped up by engineers from around the world. The book has served as an essential reference for EMC issues such as grounding and shielding. Many people found the book—with its no-nonsense style—easier to digest than similar technical tomes.

"I got many comments from people about how readable the book was, taking a very complex subject and making it very readable, very understandable," said Ott. "I often tell people that the reason it's simple is that I wrote it so I could understand it, not as a professor more or less writing to impress the students with how smart he or she is."

By 1977, Ott had become well known in engineering circles outside Bell Labs. Managers who had read the book asked him if he could come to their offices to teach an EMC course. Ott began teaching the in-plant courses during his time off from Bell Labs.

"Mostly I worked with a lot of computer companies out in Silicon Valley in those days. Personal computers were just beginning to come out in that time frame," he said. "And since Bell Labs AT&T were still a telephone monopoly, as long I didn't work with telephone companies, it wasn't considered a conflict of interest issue."

Hanging out a shingle

Ott formed Henry Ott Consultants in 1979, but kept working part-time at Bell Labs. He founded his company at an opportune time. In 1979, the FCC issued regulations governing EMC for commercial equipment. Up to that point, the military had been the primary proponents of EMC. Naturally, after the FCC regs came out, commercial entities began looking to the military with the intent of copying its EMC methods.

"Well, they found out they weren't going to copy quarter-inch-thick steel, welded shut for your commercial products. Since I was working for a commercial company, I had developed a lot of low-cost ways to do things rather than just put a big, heavy shield around it and weld it shut," laughed Ott. "That's where things started getting really busy. I've often said that I thank the FCC for that because if it wasn't for the FCC regulations, I would probably still be working for Bell Labs."

Ott began working on the second edition of his book in 1987, shortly before leaving Bell Labs. The company supported his writing efforts and provided him with editors to help finish the edition. Published in 1988, the second edition contained new chapters on controlling EMI in digital systems, a chapter on electrostatic discharge and more information on FCC regulations. But almost everything from the first edition was retained.

A lot has changed in the world of EMC in the past 12 years and it may be time for a third edition of "Noise Reduction Techniques in Electronic Systems." But Ott has to find the time to write it.

"Surely there's enough material now," Ott said. "I think it's going to occur, but I wouldn't hold my breath waiting for it. If you expect it next year, I would pretty much have to have it done right now because of the publishing cycle."

EMC challenges

The EMC playing field has changed significantly since Ott began studying it 30 years ago. One thing EMC engineers must keep in mind, Ott said, is that they can never stop educating themselves about EMC.

"If you go back to the '70s and early '80s, I used to tell people that if you did a careful board layout, you knew a little bit about EMC and you were careful and didn't do a sloppy design, you could make something pass the EMC requirements," Ott said. "Today it's not that easy."

Ott expects that engineers will be forced to explore "exotic" methods for preventing EMI, including loop cancellation techniques and spread spectrum clocks that spread the energy in a frequency spectrum to reduce the amplitude. He has seen plenty of engineers deploy what he calls "brute force" methods of fighting EMI, such as making loop areas smaller to prevent radiation. But when brute force goes up against technology, Ott will bet on technology every time.

"If you look at radiation from a loop, it's a function of the square of the frequency. When the Intel processors first came out in the late '70s, they were running about 400 KHz and they're well over 400 MHz today," explained Ott. "From 400 KHz to 400 MHz is three orders of magnitude and if you square that it's six orders of magnitude. So the loop radiation problem has increased a million-fold; therefore you just can't do the brute force thing."

The venerable FR4 laminate may develop its own EMC issues as board frequencies enter the gigahertz range. But because most alternatives to FR4 are prohibitively expensive, it will be up to the designer to find a solution.

"Somewhere around 1, 2 or 3 gigahertz, FR4 becomes a pretty lossy medium. The higher frequencies can be attenuated more than the lower frequencies. Therefore, what we're going to do is run real fast, real sharp-edged clock and the edge is going to lean over and slow down, according to how long the trace is, etc.," Ott said. "People get pretty innovative when the pocketbook's involved."

The merging of SI and EMC

As clock speeds increase into the gigahertz range, Ott predicts that the line will blur between signal integrity and EMC as engineers from both camps confront similar issues. The two groups may be driven by different concerns but they want essentially the same thing.

"Signal integrity people are worried about the functionality, the wave shape, things like that. EMC people are worried

about the emission mostly, susceptibility, too, but primarily emission," explained Ott. "They're talking about it for functionality for wave shape and I'm talking about it for radiation, so it's just a matter of what motivates us."

Ott is generally satisfied with the current SI software, but he believes some EMC vendors have promised more functionality than the tools can provide. At the same time, many EMC engineers want too much from their tools.

"What a lot of people would like from an EMC point of view is to offer tools that will take my board layout and tell me how much the product is going to radiate. I don't believe they're ever going to get that any time in their life, or in anyone else's life," Ott said. "The radiation problem is just too complex by too many different mechanisms involving too many parasitics to model."

Modeling just doesn't work as well for solving EMC issues as it does for SI, Ott said, because modeling every via and ground-to-plane chassis is impractical. But EMC tool vendors seem to be moving toward providing "expert systems" that list all the rules and check the layout for violations, but don't try to predict total radiation. On the other hand, modeling works well with SI tools because users are only concerned with finding an appropriate wave shape, a minimal number of traces and crosstalk from adjacent traces.

"I think that modeling for signal integrity, crosstalk, wave shape or delay is very useful," said Ott. "I kind of like that side and I'm kind of against the EMC tools other than maybe the expert system approach."

The future of EMC

When Ott was in the process of leaving Bell Labs in 1987, some of his co-workers expressed doubts about his decision to run a business devoted to EMC consulting. After all, wasn't fiber optics going to eliminate EMI?

Thirteen years later, Ott is busier than ever and the struggle for EMC goes on. Once an afterthought, EMC is now designed into most applications. With frequency and density increasing for even the simplest designs, EMC has become everyone's worry.

All of which is good news for Ott.

"Back when I was younger, when you learned something, you could use it for a while. It seems that today, you learn it, you use it once and you've got to learn something different,"Ott said. "I often say, 'Whatever you did last time is never enough next time.'"

Fitting words from a busy engineer who has also made learning and teaching a lifetime vocation.

Henry W. Ott will deliver the keynote address at PCB Design Conference East 2000 in the Worcester Centrum Centre, Worcester, MA, at noon on Tuesday, Sept. 12. He will speak on "EMC Aspects of Future High-Speed Digital Designs." For more information on the keynote and conference courses, go to www.pcbshows.com.

Want to nominate someone for future *People to Know* columns? Contact Andy Shaughnessy at ashaughnessy@cmp.com