Speaker's Corner

Starting and Running a Business in the Megahertz to Terahertz Arena

■ **James C. Rautio**

The year was 1985, and personal computers (PCs) were just starting to become widely available. I was completing my Ph.D. degree in electromagnetics under Prof. Roger Harrington, the father of the method of moments, at Syracuse University in New York. I had developed a new technique to analyze planar circuits using computers to solve Maxwell's equations. I had written a matrix solve routine, the central numerical task in method of moments, in assembly language for maximum speed. I could do up to a 100-subsection circuit in about an hour for one frequency. Wow! Figure 1 shows a more reasonable 48-subsection circuit.

All the major microwave electronic design automation (EDA) companies at the time had turned down my offers to work with them to commercialize the software. I was faced with the choice of giving up and getting on with life or commercializing it myself.

I started reading up on being an entrepreneur. My first task was to learn how to spell that word. My second task was

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IMAGE LICENSED BY GRAPHIC STOCK

to write a business plan. This approach made sense and fit my engineering training. Entrepreneurship was just another engineering problem.

One calculation I did was to estimate the size of the problems we would be able to do in the foreseeable future, which would directly impact commercial viability. My 100-subsection problem was done on one of the first IBM PCs. The clock rate was just over 4 MHz. Yes, that is megahertz, kids, not gigahertz. That frequency is higher than the radio frequency (RF) I used for my first ham radio contact

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(3.726 MHz). It was amazing how far technology had advanced.

So, let us be wildly optimistic and say that in a few years, computers would be able to go to 40 MHz, which would be a very high frequency. Could computer clock rates ever get that high? It is hard to imagine. At 40 MHz, given that the matrix solve is an N-cubed-order problem, we would be able to solve, maybe, 200-subsection problems. Would this allow commercial viability? It is not likely.

I decided to ignore the numbers and go with my feelings. I made the jump. If you find yourself in a similar situation and you decide to make the jump, you will find that you get two kinds of advice—good advice and bad advice. Your job as an entrepreneur is to accept good advice and reject bad advice. Whenever I get advice, even (or especially) if it is from myself, I always do some soul-searching and ask if I might be accepting bad advice or if I might be rejecting good advice. Statisticians call this type I error and type II error. Being an engineer is great, is not it?

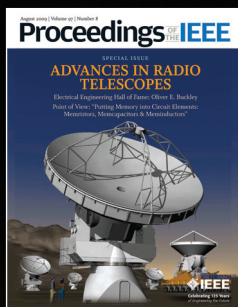There is a fair amount of luck involved in being a successful entrepreneur. The numerical self-advice
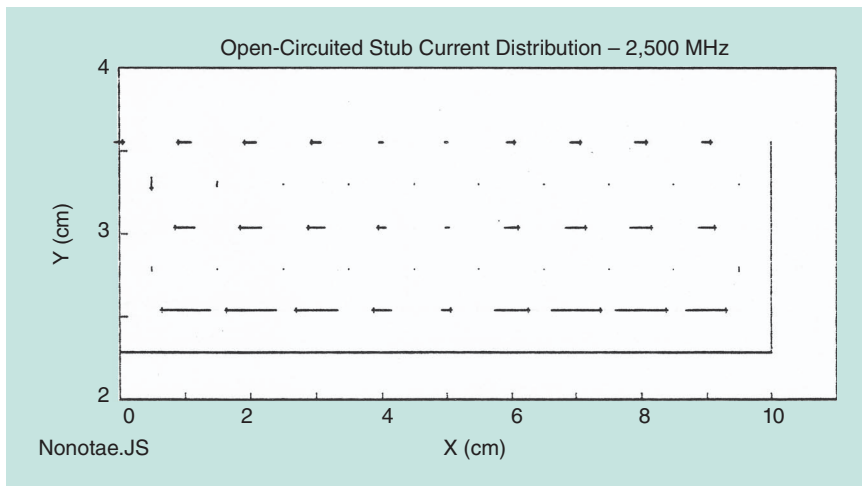
Figure 1. *An example of a 48-subsection open-circuited stub from my 1986 dissertation. The lower half of a symmetrical stub is fed at the left and open ended on the right. One arrow is plotted in the center of each subsection. Magnetic wall symmetry is assumed along the stub center line. The software was written in a mixture of Turbo Pascal and machine code on the first edition of the IBM PC.*

that my electromagnetic (EM) analysis would not be commercially viable in the foreseeable future was bad advice. I was fortunate that I rejected that advice. It was a lucky day, I guess. I still shake my head on that one.

I had some indication I made the right call by about 1990. The Sun SPARCstation had just come out, and we got one. It could go up to 64 MB of random-access memory (RAM), but I think we only had 16 MB. Doing up to 1,000 subsections in about an hour was
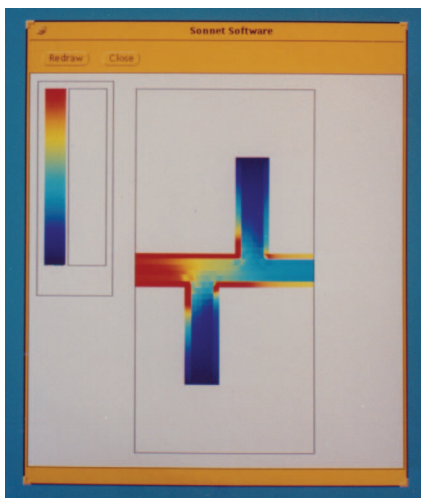

Figure 2. *A typical EM analysis result for several hundred subsections from around 1990 on a Sun UNIX-based SPARCstation. The software was written in C. This was the first time we could view the actual current distributions with ease.*

now possible. Figure 2 shows a sample circuit with about 200 subsections. This was the first machine that we ever used where we could do nice color plots of current distributions. I always wanted to do photography so I went out and bought a camera. This is one of the pictures I took. I still like taking pictures, but now they are all digital; I do not use film.

As hinted at in the preceding paragraphs, we can apply our engineering problem-solving talents to just about any kind of problem, including the problem of starting a company. In fact, from what I have seen, I think engineers as a group make the best, most successful entrepreneurs over and above any other group, including fully degreed MBAs. Just like with any problem, we first figure out where we are. Then we figure out where it is we want to be (and we are very careful about this because we might actually succeed). Next we figure out multiple ways to get from where we are to where we want to be. Finally, we trade off the options and go for it. Avoid what so many nonengineers do, which amounts to a random walk.

It is important in following these steps that we include both logic and

feelings. The winner will know when to listen to the logic and when to ignore it. He or she will know when to listen to the feelings and when to ignore them. We make a conscious effort to avoid both type I and type II errors when dealing with both logic and feelings. Even so, sometimes we still make the wrong choice. What counts is the statistical average and how we recover from the errors. In fact, an important part of this is simply recognizing when we make an error. This is hard to do sometimes, and it can be very humbling.

If you want to start a company, I highly recommend it. But do your research, make your business plan, and run it past trusted advisors. Politely thank those who say it is wonderful, but listen most closely to those who frankly criticize your ideas. Remember, some of their criticisms will be right and some will be wrong. Your success will be critically dependent on being able to correctly figure out which is which. Guess wrong, either way, and you make an error. If you make too many errors then you are finished.

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One of the most important things on which you will need to get up to speed is sales and marketing. If you cannot instantly say what the difference is between sales and marketing, give this one extra attention. There are many books out there on these subjects. I view much of the published work as first-class science. Get a few books, but pick the ones with good advice, not the ones with bad advice. You know how to do that, right?

As for hiring sales personnel, I have tried and never had any luck hiring high-powered "talks a really good talk" shiny-shoed salespeople. They have never been able to "walk the walk," at least for me. Instead, hire good engineer who also get along well with people (there are actually quite a few of them), and then train them in sales.

Selecting business partners and your first few employees is critical. People you have known for a long time are the first pool you should consider.

I have also had good luck with candidates referred by those in the first pool. Networking is critical. I have not had good luck with employment advertisements or professional recruiters.

If you find even the slightest inconsistency in a resume, reject the candidate immediately. Do not yield on this in any way. Carefully check and verify everything in the resume, looking for every possible discrepancy. Verify the employment dates and education of each applicant. If the candidate says he or she has a Ph.D., check ProQuest for a dissertation. If the candidate says he or she is a veteran, ask what a "gig line" is, and ask to see his or her DD Form 214. Get creative in finding ways to fact check. Remember, if you find any discrepancy do not walk away—run.

This one is critical: instead of dealing with technology, you will find you spend a lot of time dealing with people so read up on psychology. In particular, grab a couple of books on topics like the various manipulative psychologies, including things like antisocial personality disorder and sociopathy. An estimated 15% of the people we all deal with are moderately to highly manipulative (these people can be dealt with, but only if you recognize them), and 1–2% will be full-blown sociopaths (do not let them into your company under any circumstances). Since you will be at the top, you will be irresistibly attractive to these kinds of people. One clue: you will often find they can be fun to be around. You cannot be successful if you are ignorant of them. If you feel impervious to this type of person, you are especially vulnerable. Start reading.

Insist that your employees keep no secrets from you. They must tell you everything and anything that might be of importance in running your company. It is a two-way street. In return for their honesty, I never punish employees for telling me the truth and keeping me informed. If they made a huge mistake and then tell me all about it, I count it as part of the cost of education and thank them for keeping me informed. On the other hand, if an employee provides you with selective information or conceals information from you to manipulate your decisions (reread the above paragraph on psychology), you need to get him or her out of your organization.

For example, in the United States, if a member of your management team receives a complaint about sexual harassment, it does not matter if it is true or false, it is a legal requirement that you take action. However, if your managers keep it a secret and decide to do nothing about it (even if the complainer insists that nothing be done), your company is potentially exposed to a major lawsuit. No matter how valuable the secret-keeping manager is, as soon as the situation is handled, he or she should be terminated, even if the he or she says, "But I didn't know that doing nothing was illegal." If nothing else, it sends a clear message to the other employees that you must be kept informed. If you are going to run a company, you need to be firm and you need to be informed—the survival of your company depends on it.

One item in the "feelings" department for making your decisions: if you are starting a company to make money, I wish you luck. But I feel that is not a good reason to start a company. If you are starting a company because you love what you do and it just so happens that other people will pay you money to do it, I think your chances just went
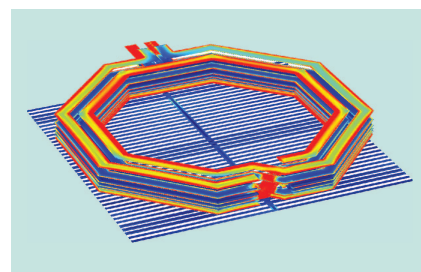
Figure 3. *A modern EM analysis of an Si RFIC spiral inductor with many layers and very fine meshing to show details in the current distribution. More than 129,000 subsections on a 12-core IBM PC with 96 GB of RAM, written in C++. The vertical component of the current on the sides of the lines has been made transparent so we can see the current inside the metal.*

way up, provided you can avoid the two types of errors.

And avoid the two types of errors, at least most of the time, we did. Figure 3 shows the modern EM analysis results. Notice the many layers [there are 50 layers in the stackup for this Si RF integrated circuit (RFIC) inductor]. Also notice that a very fine subsection size allows us to see a precise details in the current distribution. This can be critical in finding things like hot spots where the I^2R loss is getting bad. Today, on a 12-core machine with 96 GB of RAM, it is reasonable to do over 100,000 subsections. All this is without using the "fast" matrix solve techniques. A fast solve solution is a feature that our next generation (lead by my son) are preparing as I write this. The future is bright.

Make sure to consider the situation carefully before you jump. But if you jump, be ready for the ride of your life. At the very least, no matter the outcome, years from now when we all are sitting in our rocking chairs at the nursing home, we can close our eyes, think about the days gone by, and smile.