Microwaves&RF

Inside Track with Dr. Ulrich L. Rohde, Chairman, Synergy Microwave Corp.

Microwave & RF's Jack Browne talks with Synergy Microwave's Dr. Ulrich L. Rohde about his extensive array of text books in the field and the latest on his company.

Jack Browne | Jul 01, 2016

Dr. Ulrich L. Rohde, Chairman of Synergy Microwave Corp., is a major guiding educational force in the RF/microwave industry through his text books and extensive volunteer work with the IEEE, which includes chairing technical sessions and judging student competitions. His generous educational efforts were acknowledged recently by the IEEE at the 2016 International Microwave Symposium (IMS)—he was given the prestigious 2016 MTT-S Microwave Application award. This is just one of the awards bestowed on Dr. Rohde by the IEEE over the years, along with, for example, the 2014 IEEE IFCS Sawyer Award and the 2015 IEEE IFCS Rabi Award.

His work on low-phase-noise oscillators and frequency synthesizers is well known in this industry, which has often been covered by this magazine over the years. Dr. Rohde works closely with Synergy Chief Scientist Dr. Ajay Kumar Poddar on the technical direction of Synergy.

MRF: Your text books have served as engineering resources for many of us in this industry *(see "A Look at the Books" below)*. How can you find the time to keep them up to date?

UR: About 20 years later , there are various sections in the books, such as the frequency synthesizer text with circuits based on discrete components, which must be updated. I am in the process of working out arrangements with young professionals and scientists from the industry, along the publisher of the book, John Wiley & Sons, to update that book. This arrangement will allow me to still be involved with the quality of the text, but they will receive the royalties for their efforts in updating the book.

Updating is necessary because of the constant turnover of electronic parts. Say, for example, that you are working on a frequency synthesizer design and you use an application note based on a certain set of components, and then they are no longer available. If no other available components are compatible, there is the difficulty of having to reproduce that synthesizer using other devices. The synthesizer textbook teaches engineers to think about what is really going on with these circuits and how to optimize the design. All of the mathematics required for designing synthesizers from scratch are in this book.

A critical component in many synthesizer designs is the transistor and many semiconductor manufacturers have stopped making discrete transistors for various reasons. And when they make a next-generation device, it may not have the same phase-noise characteristics as the previous-generation device. As a result, an oscillator or synthesizer design based on the original device must now be modified to achieve the same performance with the new device.

MRF: Can younger engineers rely too much on software design tools? Should they spend some time learning the essential education provided in these books?

UR: You should have both, with the appropriate text books to reinforce work performed on modern software tools.

MRF: How long does it take to write one of these text books?

UR: The first edition took 18 months. The book came out of my teaching at George Washington University. The graphics are the biggest problems for me, since I don't have the proper tools for creating schematic diagrams for these books. Nowadays, book publishers want you to provide camera-ready pages, and I simply don't have the means to properly generate the types of schematic diagrams and graphic files they would like.

MRF: Synergy Microwave Corp. is well known for low-phase-noise oscillators and frequency synthesizers. Are there challenges in trying to measure such low levels of noise, as in having test equipment that is noisier than the sources you are trying to measure?

UR: This is a political question. Around 1982, when I worked at RCA Laboratories, I developed an algorithm for signals that can find the carrier in the noise. Using correlation, I was able to regenerate a carrier from the noise. But this is a calculation, and not a measurement. Modern phase-noise equipment has been developed for this purpose, but it is important to separate what is measured from what is calculated. If you can show –190-dBc/Hz phase noise on an instrument display at 0-dBm input, this is not measured, this is calculated.

Mathematically, you can predict certain behavior, and you can calculate low levels of noise. You cannot measure below kTB. The Nyquist-Johnson noise power sets the limit that you can measure. That is your lower limit on noise measurement, where kT is –174 dBm. If it is a single sideband measurement, it is 3-dB less, or –177 dBm. This is the best you can measure, with another 3 dB, to reach a noise floor of –180 dBm. Mathematically, you can get an additional 10 dB by means of calculation to reach a noise floor of –190 dBm. But any levels shown by test equipment to be that low are not measured, they are calculated.

One of the problems with such calculated results is that crystal-oscillator manufacturers will claim to have oscillators that are capable of these incredibly low phase-noise numbers, but they are not real, they are not measured, and the oscillator cannot achieve those low levels. The best number you can measure is –177 dBm, which is single sideband. And that's really –174 dBm for double-sideband noise, plus another minimum of 3 dB noise figure, typically up to 10 dB of the transistor in the crystal oscillator, to reach a limit dictated by physics of –180 dBm for single-sideband noise. These are the limits of physics, but no one has ever published this in these terms.

MRF: Has today's test equipment reached an upper limit on performance, or is there room for improvement?

UR: It depends on what you want to measure. As far as cellular telephones, which are the largest market for high-frequency test equipment, some companies test everything, while some only test about 10% of their products.

Many people are now talking about the fifth generation (5G) of cellular radio, but the standard is not defined yet. So how can you build test equipment for a standard that is not yet defined? The way out of this is to take a vector signal generator and an arbitrary waveform generator and mix them together with in-phase (I) and quadrature (Q) signal-generation capability. Therefore, with these three techniques, you can essentially generate each and every waveform that you want and whatever will eventually be part of the 5G standards.

In terms of phase-noise measurements, there is a lot of "hocus pocus" in the industry regarding the way that different instruments measure phase noise. These instruments have a lot of intelligence and it can get tricky to use them when you program them incorrectly. You can get almost any number, although it may not be the correct answer. Ajay has a paper that we published where there is a fair comparison about the results of who does what in the market for phase-noise measurements.

We have phase-noise measurement equipment from a number of manufacturers. So if someone wants to compare measurements they made, for example, on an instrument from one particular manufacturer, whether it be from, say, Keysight Technologies or Rohde & Schwarz, we have the same equipment in-house and can compare measurements. I think this is politically and practically important to some customers to show that I am not playing any games.

Currently, I am supervising several PhD dissertations. One of them is on crystal oscillators. As of today, Wenzel has the world-leading crystal oscillators, and they may believe that we are in volume production of crystal oscillators, but we are not. We don't have the facilities or the capabilities for that. Rumor has it that they are more irritated than fearful of us.

We built some systems in-house where we needed specific crystal-oscillator requirements. For the few pieces we needed, they would charge too much. So, it is better we develop these things ourselves. We indicate that we have them if someone wants them, but we are not in the business of making and selling crystal oscillators. That is an important message to the industry. If you do it right, you have to make a few hundred pieces per week or something like that. We don't have the facility or the number of people or the burn-in ovens and other equipment needed to do this. I am not a threat to anyone in the crystal-oscillator marketplace.

MRF: You work at Synergy with, a very talented Chief Scientist, Ajay Kumar Poddar. When a customer brings a new problem, do you consider it separately or do you look at it as a team?

UR: Ajay's educational background in mathematics is better than mine. He is much better educated in advanced mathematics than I have had the opportunity during my university time decades ago. In some areas, I have more practical experience. So, we pool our knowledge.

We look the business side of things at Synergy, and it comes into play because the customer is also concerned with cost. A customer may need an oscillator with a certain set of requirements, so it is necessary to take a parts count and see what needs to be in the design to make this possible.

Let's assume that the parts count comes to a total of $200 for the bill of materials (BOM). You have to assemble it, test it, sell it to a distributor—you have all kinds of costs associated with it. You need a factor of three to four above the BOM and then, if you are lucky, you might make 20% profit after everything is said and done. There is a market price and there is a production price, and there are certain designs where even for a small company, it is not possible to produce something for any kind of reasonable margin. What is fascinating is that the customer may then lower their specifications. Then, our advantage of having a superior product is gone because with 10-dB worse performance compared to the original specifications, everyone can do it. So it is not always a blessing to be the best at something. Sometimes you lose in spite of better performance.

As a team we and the people who manufacture these things in house have an equal say in what we do. Ajay and I can define the architecture, and what is in it and what is possible, but this is not necessarily the part that earns the business. The winning part is not to leave money on the table. Some of my competitors are so eager to get a particular order that they are selling below cost. We do not do this here. I would rather not have the order.

We have had this company since the 1980s. We have had good years, excellent years, and difficult years. But the important thing is that we have no liabilities. This company doesn’t owe any money to any bank; everything is paid for. We have a stable war chest and don’t need to report to anybody. There are no quarterly pressures. We have about $10 million worth of test equipment. We are not pressured by shareholders. If you buy something from us, it’s good. It has been tested and we know that it works.

MRF: Synergy is in many different markets. Can the stability of the company be attributed to this market diversity?

UR: We also help some other companies. There have been cases where some well-known companies couldn't measure something. We had defense companies and these other customers come to us. As you can see, we are well-equipped with test equipment, and we have our own Faraday cage for particularly sensitive and difficult measurements.

We have been able to measure some things that other people could not because they couldn't afford some of this equipment. As a result, these defense companies now come to us, noting that we are so well-equipped and so capable. This actually helped us by helping other companies, getting business by helping these companies. There is very little that we cannot measure. We are equipped to measure up to 120 GHz. Not everybody can do this.

MRF: Our industry likes to switch technologies and "falls in love" with the latest great thing, like gallium nitride (GaN). Does this switching of technologies, such as from silicon bipolar to GaAs to GaN, pose a problem for you, whereby something might become obsolete?

UR: Gallium nitride is for power transistors. GaN has excellent thermal conductivity, so it can get rid of the heat better than some other semiconductor materials. And it can run at higher voltages. By itself, it can make a nice device. The flicker corner frequency of these things is fairly high.

If you take smallest device you can find, and use it as a low-noise preamplifier, the nice thing about it is that it can withstand high pulses. A typical radar system of conventional design needs a limiter, so you have to have a few diodes up front. Therefore, if you have a strong signal in your antenna, it can burn out your preamplifier. But by using a GaN preamplifier, it is almost indestructible. With GaN, you can eliminate these limiters, and the circuit design becomes easier.

I am not in this area, but I wish someone would make a low-noise GaN preamplifier for 10-mW or maybe 100-mW output power to help simplify the radar design. I don't think low-power GaN devices will be going anywhere anytime soon, and there will not be any immediate successors to GaN. So I would like to see someone come up with a really low-noise preamplifier based on GaN.

MRF: Synergy is well known for "pushing the limits" in terms of technology advances, certainly in phase noise. Are you involved in any other development projects that you are willing to share with our readers?

UR: We are well aware of the need for conservation of energy, and are involved in next-generation energy-saving electronic circuits and systems based on energy-harvesting techniques. We are exploring Möbius technology for sensor applications, too, as well as negative-index Möbius technology for use in 5G wireless systems and for Internet of Things (IoT) applications. In connection with expected requirements for 5G and IoT, we are also investigating RF microelectromechanical-systems (MEMS) components incorporating repulsive Casimir effect approaches for improved switching performance. In addition, we are studying anti-gravity technology based on negative-index material and thermally stable, tunable, optoelectronic oscillator circuits to 500 GHz for terahertz and other applications.

A Look at the Books

Students of RF/microwave engineering will be familiar with the excellent textbooks authored or co-authored by Ulrich Rohde and published by longtime technical publisher John Wiley & Sons. Drawing from a deep background in computer-aided-engineering (CAE) software, which included recovering and running the CAE software firm Compact Software prior to Synergy Microwave Corp., Rohde co-authored “Microwave Circuit Design Using Linear and Nonlinear Techniques” with George D. Vendelin and Anthony M. Pavio. The book includes analysis of semiconductor devices, such as diodes and transistors, as well as active and passive components like amplifiers, filters, mixers, and oscillators, and is an excellent companion to a commercial CAE program.

Several of the texts address wireless component and circuit design, including “Microwave and Wireless Synthesizers: Theory and Design,” by Ulrich Rohde and “RF/Microwave Circuit Design for Wireless Applications,” co-authored with Matthias Rudolph. Both books provide excellent mathematical backgrounds on the way that high-frequency components function, with the former text focusing on signal sources, including frequency synthesizers and many different types of oscillators. Each book offers a close look at the physics involved with high-frequency circuits and components, and helps to better understand the behavior of various RF/microwave components under different operating conditions.