RF Industry Icons Podcast Series

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Ulrich L. Rohde

- **You are a well-known pioneer in the RF and microwave industry with hundreds of publications, numerous patents, awards and professorships – to many to even list here. What first got you interested in RF and microwave technology; did that come from your father or something else?**

  I was born in Germany into a very scientific family. Both of my grandfathers were chemists—one very famous. My mother's father is credited with co-developing the Fischer Tropsch process of chemical reactions (https://en.wikipedia.org/wiki/Fischer%E2%80%93Tropsch_process). My other grandfather also specialized in organic chemistry. Both were friends. My father had a PhD in physics and started, together with a friend Hermann Schwarz from the university, an electrical engineering company later to be known as Rohde & Schwarz in Munich, Germany. After 1952, when Rohde & Schwarz received an order from the US Army to maintain their radios, my father took me to the factory and I experienced the huge distance one can cover with theses radios, I became very curious how such a vehicle-based radio with a whip antenna works.

  Besides my "dominant" father, many professors and scientists impacted on my life, and I think then I developed an ambition to be as educated as they were. At the same time the tube division of AEG Telefunken published annually a fascinating mini handbook of tube applications and so did Siemens about modern semiconductors, now Infineon. I probably kept all their little books. During these times I actually had the opportunity to exchange some ideas about physics with Prof. Heisenberg, known mostly for his uncertainty principle (also known as *Heisenberg's uncertainty principle*) while being on a sailboat with my father and him. During the sailing I asked Prof. Heisenberg: As the tubes have a cathode as a heater and the plate kind of pulls the electrons out of the heater, could I not use a radioactive isotope that provides ample electrons, a beta radiating element. Prof. Heisenberg said, yes but how do you control the amount of electron flow which the negative voltage in a tube circuit via the grid does? Understandably, he was correct, and my understanding at the age about 12 (I don't recollect the exact date) undoubtedly was not well thought out. He just smiled! At that time, I pondered if I would ever comprehend his scientific work.

  It is worth mentioning that during the university days my major mistake was to write a textbook book about microwave transistors (*Transistoren bei hoechsten Frequenzen*, Berlin, 1965). That experience, at the age of 25, provided both impetus as well as impediments. Professors did not like it because it was written by a student and the publishing company did not provide a fair agreement. Also, my girlfriend who typed the whole book got fed up and left after it was complete.

- **Your father Lothar Rohde was a technology pioneer and inventor. He teamed up with Hermann Schwarz to start Rohde & Schwarz which has grown into a multi-billion-dollar company with more than 13 000 employees. You expanded the R&S into the US and launched Compact Software and Synergy Microwave so are a true entrepreneur, which seems to run in the family. What lead you to buy Compact Software and re-launch that company?**

  Prior to escaping a dominant father, everybody asked "are you the son of the famous Rohde" (I really hated that question not because I did not respect my father but rather, I wanted to have my own

identity); I was in charge of the Ulm based Military Radio Division of the then AEG Telefunken company. My pet project was to design, build and sell a fully automated Manpack in competition with the Hughes Aircraft PRC 104. I think we did a good job, and I still have some of the now about 50-year-old radios. The project encompassed all the technologies I always wanted to put together. In those days some of the modern mathematics were missing, there were no microprocessors and versatile integrated circuits had not yet been invented. Most of the interesting things came from the USA, but I was not high enough in the ranks to be allowed to go there. At that time, know-how was not shared as freely as it is today, for an example through IEEE conferences and workshops. Still, I wanted to contribute to worldwide radio technology. So, the solution was to publish innovative things. History demonstrates that technology improves the standard of living, the quality of life and stimulates coordination and engagement. I wanted to be a part of that. When the opportunity came to move to the USA, I took it. In about 1980, overseeing the Radio Division of RCA, our team developed the basic implementation of what today is called the software defined radio (SDR) as a proof of concept. This US Department of Defense (DOD) sponsored effort has had an enormous impact on humanity, in general. Modern affordable A/D converters and algorithms for signal processing have enabled many advanced signal-handling capabilities for applications ranging from communication systems to medical monitors (such as cost-effective monitoring of vital signs). All of this was the result of a dedicated and successful team.

I had a little side company called Communications Consulting which offered RF & Microwave CAD solutions. The product name was CADEC (Computer Aided Design of Electrical Circuits). It was very powerful, and it was offered for the HP computer but was no match to the Compact Software Linear analysis program which could be ported to mainframe computers. We developed the CADEC program for two reasons one being the Compact Software program was not affordable by small companies and the other because of my radio amateur hobby liked to simulate, verify and optimize useful circuits. I actually had the CADEC running at my office at RCA to double check our RF circuits up to 30 MHz at that time.

Comsat was the owner of Compact Software and we were able to negotiate the purchase of the company which had a lot "bad will." In 1985, I bought the company Compact Software, https://en.wikipedia.org/wiki/Compact_Software. The first really useful CAD provider kind of collapsed after its employees on the west coast abandoned it. Founded by Less Besser, it was a very powerful linear circuit simulator, but got stuck in linear circuit analysis. SPICE was nonlinear but not applicable for microwave circuits. (https://en.wikipedia.org/wiki/SPICE.)

Robert Pucel of Raytheon made me aware of the Italian professor, Vittorio Rizzoli, who developed the first useful and efficient piecewise linear harmonic balance method, which became the framework for the new Super compact nonlinear SPICE type program, the first in the world that accurately and without any mathematical compromise predicted correctly the noise performance of oscillators, mixers and frequency doublers. This part, and the introduction of the "noisy" large signal noise contribution, was done well by my team. As others tried to mimic our approach and used mathematical shortcuts, their programs became faster. This resulted in my frequently used statement: "Yes; they come faster to the wrong answer." For a while, speed was more important than accuracy. At that time a CAD program needed to have a 2D, or better 3D, simulator and I was unable to find a team which such knowledge. The bitter consequence was that I had to merge with Ansoft. They lacked a circuit simulator but probably still today have the best 3D simulator. Ansoft later was bought by Ansys, a very successful CAD company. This was a good decision, as Ansys could

make best use of the Circuit simulator to offer complete CAD solutions for RF circuits. At this point I stepped away from software activities but continued to monitor the accuracy and convergence of commercially available CAD tools (ADS, Ansys, AWR/Cadence, and others) and to provide input and feedback from time to time.

- **What lead to the sale of the software to Ansoft which became part of Ansys?**

  Maybe lack of money and attraction for engineers to work in the field of software development. At this time HP with their ADS program was our competitor, they had a proven name, and we had a shaky past. I still remember when an engineering manager at a Hughes Aircraft told me: If your product goofs I may lose my job; if HP goofs, I am safe because it means that no one can do it. That was bitter. My reply at the time was, yes, given that example HP gives the wrong answer faster. The lack of sufficient money did not allow me the fresh development of an HFSS like product and Ansoft did not have a circuit simulator, so this was the perfect match. On the positive side, and very hard mathematical work we implemented the Piecewise Linear Harmonic Balance Method which for the first time in the world enabled us to calculate phase noise and spot noise figure under nonlinear condition. This was validated during the MMIC DARPA program in the TI-Raytheon Compact Software Joint Venture.

- **You have experience in military radios and related technologies, what work did you do in that area (that you can tell us about)?**

  Yes, first at AEG Telefunken, Germany, responsible for all HF communication systems. In 1968, my team and I developed the AEG Telefunken SE6861/12 Military Manpack HF Transceiver which was the German answer to the Hughes Aircraft radio. Some of us were stuck because of a snowstorm while skiing in Madesimo, Italy and we were wondering how to best communicate this message. So, we designed the architecture for a HF radio (battery operated Manpack). The key features were a microprocessor-controlled antenna tuner, RF based speech processor, low IMD power amp, pin diode-based RF attenuator and adaptive dual loop AGC.

  Later at RCA as Business Area Director of Radio Systems, 1983, we introduced the working SDR under several DOD contracts. My personal CAD simulator in my office proved very useful. The SDR is now somewhat mature.

  Much later in the year 2017, I was honored to be recognized with the Wireless Innovation award for contributions in the field of SDR.
  (https://www.businesswire.com/news/home/20171116006330/en/Wireless-Innovation-Forum-Announces-2017-Wireless-Innovation)

- **You have a deep understanding of the physics and science for high frequency oscillators, what motivated you to delve into that area of expertise?**

  In the beginning there were HF and VHF crystal oscillators (sufficient low side band noise) and temperature compensated oscillator with medium power dissipation and narrow tuning range. These systems with many frequencies generated by mixing oscillators could not be locked against a frequency standard and unless channelized could not be brought up to VHF frequencies. Then the need for synthesized signals started. And noise problems became a key issue. Key words are:

Blocking, desensitation and "Adjacent Power Ratio," the ratio between the total power adjacent channels (intermodulation signal) to the main channels power (useful signal). Modern signal generators require very low noise auxiliary frequency sources such as crystal oscillators, SAW oscillators, DRO's, VCO's and Synthesizers. Their design has become black magic, or close to it. This topic fascinates me, especially high frequency signal generation and signal processing electronics for the application in modern communication systems,

- **What lead you to then start Synergy Microwave?**

  Toward my end at RCA, it was taken off the stock market. I had many contacts with the NSA and through my consulting company, I got a contract to develop a high-performance HF receiver for all US embassies. For this project I teamed up with Engelmann Microwave and as the critical parts, we developed a tricky synthesizer and high-level mixer. When the first prototypes were ready for evaluation a suspicious fire burned the company to the ground, I lost the project, and many lost their jobs. So, I felt I was obligated to do something with the techniques and the rescue the people, this was the start of Synergy Microwave finally settling Paterson, NJ. There was an empty building in a bankruptcy case and with money from a bank we bought that building and the company took off.

- **You have been very involved in academia throughout your career, supported a lot of university research, taught at several universities and been awarded many professorships, what has kept you so active in academia?**

  My personal life is fairly uneventful, low-key so to speak. I made my choice to focus on academic, science and technology, including supporting students for research activities in several universities worldwide. Some include UCLA-USA, Drexel University-USA, BTU Cottbus-Germany, Oradea University-Romania, IIT-Delhi, India, IIT-Powai, India, and IIT-Jammu, India. Engaging and motivating next generation students is a positive thing as you learn about their needs and help to educate them in my area of expertise. This is a positive feedback system and connects with different companies like semiconductor houses and research institutions. As far as universities are concerned there are no good or bad universities, at the end it's the professor that is responsible for the quality and the university selects them. Typically, the industry salaries are higher, but life is not all about money. My father told me, he inherited nothing from his parents, why should I? R&S assumes that its owners have a good education and can earn their own money. R&S is set up to protect its workforce and retains most of its earnings for research and independency from banks and other influences. That has worked well for all. We are scandal free.

- **Les Besser expressed grave concern for science and technology expertise in the US; do you share the same concerns?**

  And he is correct! Here, the social and university system is at fault. The education, BS and higher, is simply far too expensive while in other countries the universities get financial support for research, a certain percentage can go to the department members personally and the cost remains affordable. There ratio between foreigners and Americans is disturbing. They get money from their government and legally export technology and then we accuse China of intellectual IP theft when this can be done simply by its student's education. In simple terms the high cost of top universities needs to be examined.

Les Besser and his training company has educated a huge number of engineers and should be accredited as an educational institution in its field.

- **The number of awards and honors you have received are astounding and well-earned with all of the work you have done. The most recent was the Cross of Merit of the Federal Republic of Germany awarded by the President of Germany, recommended by the President of the state of Bavaria which is Germany's top honor – which award are you most proud of receiving**?

  Being born in Germany, Munich (Bavaria) and honorary member of the Bavarian Academy of Science and Humanity (Heisenberg and Einstein were members), this was an astonishing and totally unexpected award.

  I have received several IEEE awards because of my deep involvement in science and technology to address humanitarian challenges. I have learned that humanitarian challenges and ability to apply engineering capability to explore the low-cost solution for improving the quality of life in the underserved regions of the world is rewarding. During natural disasters, I offered help to establish emergency communications system by supporting HAM radios activities in Region 10 and the Blind community in Germany. It is important to share "I like solving problems in my field of expertise where others have failed." Most people lack the drive or staying power to see things through, this complements my thirst for serving humanity. And the gratification resulting from this immense. I am very grateful for each award and do not have a favorite as they all mean recognition of my work. Award nomination process is very rigorous and time-consuming efforts especially for the nominator and in modern time award nomination process is very competitive.

- **You have invented and patented many technologies, which one was the most exciting to work on and which has the most potential to change the industry going forward?**

  Dr. Ajay Poddar, Chief Scientist of Synergy and I have worked on my favorite topic, voltage-controlled oscillators with wide tuning range and low phase noise which is needed as we talk about 6G up to 60 GHz and more. The patented oscillator design using Metamaterial to obtain high Q resonators and the use of the Moebius Loop as a way to tone the frequency has proven to be very effective as the frequency increases. More recently, my contributions on "Metamaterial Inspired Mobius Resonator loop, MIMO Antenna, RF-MEMS Electronics, Opto-Electronics and Casimir force of interactions" are a consequence of past conversation with Prof. Heisenberg and other leading scientists. Dr. Poddar and I worked on these new technologies for the applications in current and later generation electronics and communication systems. These state-of-the-art technologies are developed with the collaboration from IIT-Delhi, India; Drexel University, USA, and UCLA (University of California, Los Angles), USA; and patented for securing the IP rights in favor of Synergy Microwave. Dr. Ajay Poddar and I have together co-authored 200 plus technical publications for sharing the know-how and engineering expertise related to humanitarian technology that includes over two dozen papers in Microwaves Journal.

- **What technologies are you most excited about for the next few years in our industry?**

  I expect the future technology will be driven by 5G and 6G, will drive the technological innovation and affordable engineering solutions to attain the connectivity. I am enthusiastic about some technologies (high frequency signal generation and signal processing electronics, network operating

at the THz band with broader spectrum resources, artificial intelligence, Internet of things, CubeSats, sensors, quantum communication and MIMO networks), which will accelerate the current and later generations of communication networks and systems. I am working on these technologies to fulfill the commercial viable solutions, also filed the patent applications: (1) Optoelectronic oscillator using monolithically integrated multi-quantum well Laser and Phase Modulator, (2) Conformal Antenna Module With 3D-Printed Radome, (3) Broadband Metamaterial Enabled Electromagnetic Absorbers and Polarization Converters, (4) Tunable Bandpass Filter For Millimeter-Wave Signals, (5) Planar Multiband Frequency Selective Surfaces With Stable Filter Response, (6) 5G MIMO Antenna Array With Reduced Mutual Coupling, and (7) Microelectromechanical Switch With Metamaterial Contacts. I am excited to see the evolution GaAs technology to be followed by GaN and now the beginning of AlN. In parallel we expect further advances in the CMOS design. The GaN based transistor can easily operate at 50 V compared to 5-10 V for the GaAs FET and has better thermal conductivity. Metamaterial Mobius inspire Graphene holds promise for electronic circuit's applications, especially in sensors for medical applications.