Special Session in Honor of Dr. Seymour B. Cohn

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A SPECIAL SESSION in honor of Dr. Seymour B. Cohn was held at the 1989 IEEE MTT-S International Microwave Symposium in Long Beach, CA, on the afternoon of Wednesday, June 14.

I. Organization of the Session

The special session to honor Dr. Cohn was proposed by the members of the Technical Committee on Microwave Network Theory (MTT-8), who appointed the writer to be organizer/chairman. The plan met with rapid and enthusiastic approval by the members of AdCom and the Symposium Steering Committee. The session was scheduled for 2:00 P.M. Wednesday, June 14, the day believed to be the most convenient for Dr. Cohn's friends and colleagues (because of the two filter sessions in the morning and the banquet in the evening).

Four of Dr. Cohn's colleagues, whose associations with him span the length of his career, were invited to prepare papers for the *Digest* and to present them at the session:

- Dr. Kiyo Tomiyasu (General Electric Company, Philadelphia, PA) "An Admirable Microwave Engineer."
- Dr. George L. Matthaei (University of California, Santa Barbara) "An Overview of Some Important Contributions to Microwave Engineering."
- William H. Harrison (Loral Microwave—Wavecom, Northridge, CA) "The Rantec Years."
- J. Keith Hunton (GTE Government Systems, Mountain View, CA) "Novel Contributions to Microwave Circuit Design."

As the session began, the meeting room was quickly filled to capacity with an enthusiastic crowd of Dr. Cohn's friends and supporters. The chairman declared that there would be four formal presentations and that comments from the audience were welcome following each one. He added that it would be "all right to embarrass Seymour, but not *too* much." The invited speakers presented their papers, and members of the audience offered relevant testimonials and anecdotes during the periods between.

Manuscript received July 14, 1989.
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IEEE Log Number 8931357.

Seymour B. Cohn was born in Stamford, CT, on October 21, 1920. He received the B.E. degree in electrical engineering from Yale University in 1942 and the M.S. and Ph.D. degrees in engineering sciences and applied physics from Harvard University in 1946 and 1948, respectively.

From 1942 to 1945 he was employed as a Special Research Associate by the Radio Research Laboratory of Harvard University, and also represented that laboratory as a Technical Observer with the U.S. Air Force. From 1948 to 1953 he was with Sperry Gyroscope Company, Great Neck, NY, where he became Head of the Microwave Research Section. From 1953 to 1960 he was with the Stanford Research Institute, Menlo Park, CA, first as Head of the Microwave Group and, from 1957, as Manager of the Electromagnetic Techniques Laboratory. In 1960 he joined the Rantec Corporation, later a division of the Emerson Electric Company, Calabasas, CA, as Vice President and Technical Director. In 1967 he formed S. B. Cohn Associates, Inc., and since that date has practiced as an independent consultant to numerous companies in the microwave industry.

Dr. Cohn is a member of Tau Beta Pi and Sigma Xi. In 1954 he received the Annual Award for the Advancement of Basic and Applied Science given by the Yale Engineering Association. In 1960 he was elected to the grade of Fellow of the IEEE. In 1962–1963 he served as Chairman of the G-MTT Administrative Committee, and later he was made an Honorary Life Member of both the MTT-S Society and AdCom. He was the recipient of the G-MTT 1964 Microwave Prize. He has been awarded the IEEE Lamme Medal (1974), the MTT-S Microwave Career Award (1979), and the IEEE Centennial Award (1984). In addition, Dr. Cohn has served as Associate Editor of the *Microwave Journal* since its inception.

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Time ran short at the end, and several who had planned to offer comments were unfortunately unable to do so.

Dr. Cohn was then introduced by Steering Committee Chairman Chuck Swift, who first revealed some of the *alternative* ways for spelling "Seymour" and "Cohn" (at least two of which appeared in recent publications). Dr. Cohn then came to the podium to address the meeting. He thanked all those present for honoring him, and he introduced the members of his family who were present: his wife Florence, his son William, and his daughter-in-law Margaret. The formal session was then brought to a close and Dr. Cohn was immediately surrounded by well-wishers offering their personal congratulations.

The remarks offered from the floor during the session covered a wide range of subjects, from personal anecdotes

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to technical matters. The following statements paraphrase just a few of them:

> "Seymour Cohn wrote papers that engineers could understand and use directly to design products. Later, when the hardware was built, it actually *worked*."

> "We had a problem making phase measurements. He went home and thought about it, and by the next morning he had worked out a solution which resulted in a new commercial instrument, actually the ancestor of today's vector network analyzers."

> "He is a legend to microwave engineers, not only in the United States but all over the world."

The four formal papers are summarized below, and they can be found in their entirety on pages 743–755 of the *Symposium Digest*. The *Digest* also includes a reference list of Dr. Cohn's published works, and that has been reproduced here in order to make it available to the widest possible readership.

II. Summaries by Speaker

Dr. Kiyo Tomiyasu, "An Admirable Microwave Engineer"

Dr. Tomiyasu told of his first taking notice of Seymour Cohn in 1944, as a quite, unassuming, serious student while both were attending a course in electromagnetics at Harvard University. He later learned that Seymour was a part-time student who was employed at the Radio Research Laboratory (RRL). Four years later, Seymour Cohn received his Ph.D from Harvard with a dissertation on the properties of ridge waveguide, a medium important to RRL because of its capabilities for wide-band countermeasures.

Dr. Cohn then joined the Sperry Gyroscope Company, Great Neck, NY, where he engaged in the research and development of microwave components. Dr. Tomiyasu recalls next meeting Dr. Cohn when he visited Harvard during the spring of 1949, and they discussed the interesting work going on at Sperry and the possibility of Dr. Tomiyasu's employment there. Later that year Dr. Tomiyasu joined Sperry to work under Seymour Cohn, who was then Head of the Microwave Research Section.

During the years when they worked together at Sperry, Dr. Tomiyasu remembers Dr. Cohn's diligence, dedication, thoroughness, confidence, and determination to produce and to excel. At each point of accomplishment, when significant technical progress had been made, Dr. Cohn would generously share his knowledge with the rest of the microwave community by publishing papers in journals and making presentations at conferences.

Dr. Tomiyasu quoted from an editorial, "Breaking Through the Mental Barrier," which Dr. Cohn wrote for the April 1959 issue of this TRANSACTIONS [33]. It reads in part:

> "Any of us whose work requires thinking will realize that the brain was not really meant for scientific effort... the mind tends to form easy paths of thought, with access to new ideas blocked by over-generalized beliefs and over-extended assumptions... In effect, misused principles are barriers to creative thought. To break through these barriers we must completely understand the range of validity of each principle, and realize that outside this range any principle may be as unreliable and treacherous as prejudice and superstition..."

This quotation helps us understand why Seymour Cohn has had such remarkable success in finding innovative and practical solutions to myriad engineering problems. He truly can be called "an admirable microwave engineer."

Dr. George L. Matthaei, "An Overview of Some Important Contributions to Microwave Engineering"

Dr. Matthaei described some of Dr. Cohn's many contributions to microwave engineering while at the Stanford Research Institute (1953–1960), first as Head of the Microwave Group and later as Manager of the Electromagnetic Techniques Laboratory. Dr. Matthaei had the privilege of working in this laboratory during Dr. Cohn's last two years there.

When Dr. Cohn arrived at SRI there was growing interest in stripline as a microwave circuit medium, but little design information was available. He proceeded to fill this void by deriving expressions and publishing design charts for determining the impedance and loss of isolated strips, and the even- and odd-mode impedances of edge-coupled and broadside-coupled pairs of strips [18], [21], [24], [37], [38]. The impedance data are exact for the case of zero strip thickness, with approximate but highly accurate corrections for finite strip thickness. Much of this information was reproduced in the well-known "black book" [60] and is still being used today.

Although Dr. Cohn is a very capable mathematician, his special forte is to seek out the dominant physical mechanisms involved in problems and then to obtain relatively simple approximate design theory, equations, and charts which are invaluable to design engineers.

In no area is Dr. Cohn better known than filter design theory, and the landmark "Direct-Coupled Resonator Filters" [29] is arguably his most influential paper. In it he presents an approximate design technique for band-pass filters which is so general that it can be applied to any all-pole filter consisting of a cascade of similar resonators separated by coupling elements. His approach is to characterize the coupling circuits as impedance or admittance "inverters," which act similarly to quarter-wavelength transmission lines. Admittance inverters, for instance, when placed between *shunt* resonators present the same impedances to each individual resonator as having *series* resonators on either side. Thus a band-pass filter with alternating series and shunt resonators, which can be easily designed by transformation from a low-pass filter prototype (but which is usually impractical to build), can be further transformed to a cascade of the same type of resonator (either series or shunt) separated by the appropriate inverters.

This technique has proved to be incredibly powerful for the design of all sorts of band-pass filters: lumped, distributed, waveguide, and multivariable. Even with today's increasing use of exact synthesis, approximate design using inverters is often the preferred approach. An example can be seen in the paper on miniature hairpin resonators which was presented on the same day as this special session [61]. The full paper (to be published) reveals that inverter theory was used in the design of the test filters.

Dr. Matthaei went on to describe some of the specific filter types for which Dr. Cohn developed design procedures. Best known among these is the edge-coupled half-wave resonator filter [31], easily the most popular type of filter for MIC applications. Other filter designs to which he contributed are the directional filter [27] and the "waffle-iron" waveguide low-pass filter [60]. Additional filter papers by Dr. Cohn during this same period dealt with power handling for waveguide filters [32], dissipation loss in band-pass filters [34], and the phase and time delay of maximally flat and Chebyshev band-pass filters [36].

Also while at Stanford Research Institute, Dr. Cohn published work in the areas of step transformers [23], waveguide impedance measurement [19], a nonreciprocal structure [35], and microwave lens antennas [22], [25], [26]. As can be seen from the foregoing, Seymour Cohn's years at SRI were extremely productive and valuable to the microwave community.

William H. Harrison, "The Rantec Years — Dr. Seymour B. Cohn (1960–1967)"

When Dr. Cohn left Stanford Research Institute to become Vice President and Technical Director of Rantec Corporation, he went from the environment of a dedicated research laboratory with plentiful external funding to a small commercial company with a very limited research budget. Yet he still managed to find the time and the resources to develop new devices and to write papers describing them, furthering his contribution to the microwave community. Bill Harrison had the good fortune to work under his direction during those years.

Mr. Harrison described some of these devices and the circumstances leading to their development, along with showing slides from the Rantec "family album" and relating anecdotes of experiences shared with Dr. Cohn during those times. He paid special tribute to Dr. Cohn's family: his wife Florence and his sons Bill, Ric, and Peter. At one point he asked each member of the audience who had directly used or benefited from Dr. Cohn's work to raise a hand, and more than 90 percent of those present responded.

One of Dr. Cohn's most significant papers during this period, for which he received the G-MTT 1964 Microwave Prize, was "Re-entrant Cross Section and Wide-Band 3-dB Hybrid Couplers" [42]. This described a device which solves the problem of close spacing for tight coupling between two lines by enclosing them both within a common third member, to which each can be tightly coupled without difficulty.

Another innovative device was a waveguide hybrid called the majestic-T. This differs from the well-known magic T four-port hybrid in that its fourth port is terminated internally by a resistive sheet, leaving three ports available to the user. The result is improved performance over very wide bandwidths.

There was considerable interest in dielectric resonator filters during the 1960's, and Dr. Cohn wrote papers dealing with resonator properties and filter design procedures [44], [47], and measurement techniques for high-dielectric-constant materials [45]. Although it was to be 15 years before the development of new materials that would solve the problem of temperature drift and make dielectric resonator filters practical, Dr. Cohn's work provided the foundation upon which others would build later on.

As the sophistication of microwave systems increased, the need to control the phase response of components became more important. Dr. Cohn had designed and built a linear phase filter to very stringent requirements, and the customer required proof that the filter performed according to specification. In response to this need he devised a phase measuring system concept employing many of the components he had already designed. This led to a series of broad-band, precise instruments for direct-reading measurements of phase, amplitude, and impedance [40], [43].

Mr. Harrison emphasized that, in designing a device where several different approaches are possible, Dr. Cohn showed an unusual skill for selecting the "best way," taking into account all factors, such as convenient element values, mechanical tolerances, environment, and cost.

J. Keith Hunton, "Novel Contributions to Microwave Circuit Design"

Mr. Hunton is with GTE Government Systems, a long-time consulting client of Dr. Cohn. His presentation covered two areas in which Dr. Cohn has been active since leaving Rantec to become a consultant. The first was the introduction in 1968 of slot line, a new concept for microwave transmission line [48]. The other was the development of a computer optimization technique for networks which have a response differing from the ideal by an equal-ripple error [55].

Mr. Hunton explained how Dr. Cohn used a resonance method to analyze slot line and compute its wavelength ratio and impedance. This work appeared in a 1969 paper [50], and a set of very useful design graphs was published that same year [51]. Dr. Cohn later wrote two more papers on slot line: a description of sandwich slot line, which contains dielectric on both sides of the slot plane [53], and a complete description of slot line field components [54].

Slot line has found its major use as a balanced transmission line in all kinds of balanced microwave circuits, such as mixers, frequency multipliers and dividers, and push–pull amplifiers. In combination with microstrip and coplanar waveguide, it has been used in various forms of planar hybrid junctions. Mr. Hunton showed slides of several of these applications.

Dr. Cohn's technique for computer optimization of microwave circuits differs substantially from those in commercial analysis/optimization programs. The latter invariably define an error function and seek to minimize its value by varying an arbitrary number of circuit elements, testing the function at as many different frequencies as practical.

In contrast, in Dr. Cohn's approach to equal-ripple optimization, only as many elements are varied as the known degrees of freedom, and the response is tested only at the anticipated ripple peak frequencies and the band edges. The elements are varied until the response at these frequencies is sufficiently close to the predetermined ripple value. During the last few iterations the peak frequencies are tested and adjusted as needed. This procedure is very efficient, because it makes maximum use of information known in advance about the circuit.

Dr. Cohn used this technique in designing a combline filter with half-length capacitive stubs, presented in 1980 [56], and in the design of a broad-band tapered directional coupler, published in 1985 [59]. Equal-ripple optimization, used in conjunction with a good approximate design method, provides an extremely powerful design approach, which often rivals exact synthesis in convenience and accuracy. It has the advantage that it can be applied to multivariable cases (e.g. mixed lumped/distributed), where synthesis fails.

III. Conclusion

The special session in honor of Dr. Cohn was well attended and well received. It was one of the highlights of the 1989 Symposium. The invited speakers are to be commended for all their effort in preparation and presentation. The occasion was an opportunity for Dr. Cohn not only to receive much deserved recognition for his work but also to meet and visit with many of his friends and colleagues from past associations.

Dr. Cohn's work has always epitomized what this writer believes is the essence of engineering: problem solving. No more apt description can be found for Dr. Seymour B. Cohn than that offered by Dr. Tomiyasu: "An Admirable Microwave Engineer."

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