Microwave Filters, an Advancing Art

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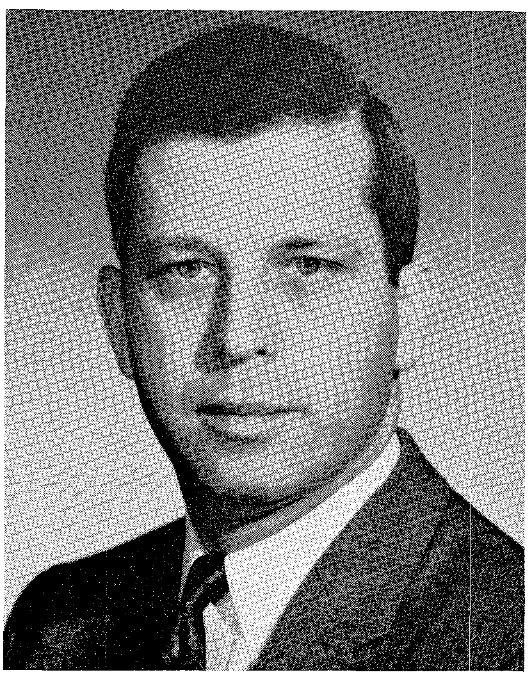
FROM THE beginnings of microwave engineering until today, filter design has been a persistent and fruitful field for investigation. As this issue of the TRANSACTIONS shows, interest in microwave filters remains acute, and probably is greater now than ever before.

In my opinion, there are two very good reasons for the continuing attraction of microwave filters as a subject for applied research. The first is the ever increasing importance of filters to microwave systems, as these systems become more complex and as the spectrum becomes more densely filled with signals. The second reason is a singular appeal of microwave filters for creative study. This appeal results from the amenability of filter circuits to theoretical analysis, the unlimited variety of circuits and structures, and the close experimental agreements that can usually be achieved.

Filters for microwave applications must meet ever tighter specifications on electrical performance, and on size, weight, and reliability. Demands are growing more stringent on reflection and dissipation losses, steepness of cutoff, multiplicity of channels, and linearity of phase shift. New characteristics are being sought, such as electronic tunability. Integrations of filters with couplers, amplifiers, frequency multipliers, and limiters are becoming more essential to system performance. Applications in missiles, satellites, and spacecraft are placing a high premium on miniaturization and reliability, while applications to ground tracking stations emphasize negligible loss in receiver channels, and enormous power handling in transmitter channels.

Advances in filter design fortunately are keeping pace with the growing needs. In early days of microwave work, filters were designed by means of hit-or-miss image-parameter theory and by analogy to single- and double-tuned IF transformers. Rapid progress led to



Seymour B. Cohn (S'41–A'44–M'46–SM'51–F'59) was born in Stamford, Conn., on October 21, 1920. He received the B.E. degree in electrical engineering from Yale University, New Haven, Conn., in 1942, and the M.S. degree in communication engineering in 1946 and the Ph.D. degree in engineering sciences and applied physics in 1948, both from Harvard University, Cambridge, Mass.

From 1942 to 1945 he was employed as a Special Research Associate in the Harvard Radio Research Laboratory, and also represented the laboratory as a Technical Observer with the U. S. Army Air Force in the Mediterranean theater of operations. He worked at Sperry Gyroscope Company, Great Neck, N. Y., from 1948 to 1953, where he held the position of Research Engineer in the Microwave Instruments and Components Department. From 1953 to 1960 he was with the Stanford Research Institute, Menlo Park, Calif., as Head of the Microwave Group and as Manager of the Electromagnetics Laboratory. In July 1960 he joined Rantec Corporation, Calabasas, Calif., as Vice President and Technical Director.

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more sophisticated designs yielding maximally flat and equal-ripple responses. In most practical cases today, filters are designed as distributed-constant approximations to rigorous prototype circuits. Developing formulas, simple to use yet yielding highly accurate approximations has proved to be a fascinating occupation for many engineers, leading to a wealth of design information in our technical literature. Rigorous synthesis of transmission-line filters for prescribed response also has advanced enormously, leading to remarkable results of both theoretical and practical value.

At the same time that filter design theory and formulas have been improving, a number of important practical advances have been made. The first microwave filters were rather cumbersome structures of coaxial-line elements, lumped elements, and waveguide cavities. Today, many ingenious strip-line, slab-line, and waveguide structures combine amazing compactness with remarkable performance. Completely new kinds of circuit elements are coming into use, such as YIG-sphere resonators and high-dielectric-constant disks.

Despite efforts to achieve simplicity in formulas, many refined designs are based on analyses and systems of equations that are too complex for ordinary applications. Use of these designs is feasible only with the aid of an electronic computer. Publication of design tables is justified in such cases, in order to bring these techniques within the range of practical utility. However, the productivity of the electronic computer is so great as to invite abuse. Authors should bear in mind the high expense to technical journals in publishing lengthy tables, including them only when essential, and making them as brief as possible.

Without doubt microwave systems will continue to place increasingly stringent demands on microwave filters. Also, without doubt research will continue to supply the necessary advances to meet these demands.