GUILLEMIN (E. A.)

Introductory Circuit Theory
Theory of Linear Physical Systems
Communication Networks, Volumes 1 and 2
Synthesis of Passive Networks

To Otto Brune

who laid the mathematical foundation for modern realization theory

SYNTHESIS of PASSIVE NETWORKS

Theory and Methods Appropriate to the Realization and Approximation Problems

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matical and the introductory circuit theory background along with topics in network synthesis, for the inevitable limitations upon size must then lead to a superficial result, quite apart from other disadvantages arising out of an attempt to cope with such an extensive array of material within the confines of a single volume (or even two). In the present book, the other two (referred to as *MCA* and *ICT*) are regarded as an integral part of the work, and results given there are drawn upon freely, mostly without further comment and with the expectation that the reader has reached a state of familiarity with this essential background, just as any writer would naturally not feel called upon to rediscuss the results of Chapter 1 in Chapter 2, and so forth.

Even so, the job is not finished with the appearance of this volume. When it initially became evident that the material planned for the synthesis book would more likely require two volumes for its accommodation, the whole of it was tentatively divided at a point where the discussion of the *RLC* driving-point impedance was finished and that dealing with the realization of transfer functions began, this division yielding two parts of approximately equal size.

I soon concluded, however, that this "logical" division was not good at all, for it would delay the most interesting and "waited-for" part of the treatment for another two years or more. I therefore separated out all topics having to do with further applications of synthesis methods (such as the broadbanding problem, optimum input and output networks, more detailed material on the design of filters as well as more general types of filter groups, and so on) and decided to include in the present volume all fundamental theory and methods with just sufficient examples to make their presentation clear and meaningful. The rest will appear later on under a title such as "Special Problems in Network Synthesis." Although this separation of the total material does not represent a division into equal parts, since the present volume carries a lion's share, it is one which I feel makes pretty good sense from a practical standpoint.

The job is furthermore not finished because there exists a gap between the *ICT* book and the present volume that needs to be filled. For obvious reasons I decided to skip this intermediate book and bend all efforts to the present task even though some topics (principally those having to do with Fourier theory) had to be presented more fully here for the time being. There are times when one cannot proceed with one's plans in a completely logical manner. For one thing, some of my former students were threatening to "beat me to the draw" in the production of a book on network synthesis, and I just could not let that happen. As it is, the race is a close one.

It is not out of place here to call attention to some of the early work in network synthesis following the initial contributions of O. J. Zobel, G. A. Campbell, and R. M. Foster. It was through the interest and encouragement of Vannevar Bush and Norbert Wiener that the necessary climate for a deeper study of network analysis and synthesis was established and fostered among our group in those early days. The outstanding member of that younger group, and in my opinion the one primarily responsible for establishing a very broad and mathematically rigorous basis for realization theory generally, was Otto Brune, to whose clear and penetrating insight we owe much more than is generally credited to him by those who know of his work only through his very meager publications.

Everyone who studies network synthesis knows about Brune's contributions to the *RLC* driving-point impedance problem, but only those who have listened to my lectures know that it was his creative thinking that also laid the rigorous mathematical foundations for all realization theory. It is for this reason that I enthusiastically dedicate this volume to him.

Regarding the subject with which this book is concerned, it is significant to recognize at the outset that synthesis differs from analysis in two major respects: (*a*) a solution to a stated problem does not necessarily exist, and (*b*) when it does exist it is not unique, there being theoretically an infinite number of circuits all having the same response function or functions at specified points of access. For these reasons the approach to a synthesis problem must begin by establishing necessary conditions for the existence of a solution and effective means for determining whether these conditions are met in a given situation. The nonuniqueness aspect leads us into the byways of equivalent network determination, a subsidiary problem whose solution is far from satisfactory at present.

The approach to a synthesis problem is further complicated by the fact that the specified data regarding excitation and response can be presented in a variety of forms First of all, we recognize that these data may be specified either in terms of time functions or frequency functions; and secondly, that in either of these situations the required network performance may be described graphically or analytically or piecewise analytically or in various combinations of these terms.

Known realization methods for lumped finite networks can accommodate specified performance requirements only when these are expressed in the form of rational functions of the complex frequency variable such as driving-point and/or transfer impedances. Hence it