Preface

Monographs usually present scholarly summaries of a well-developed field. In keeping with the philosophy of the new series of Research Monographs, however, this monograph was written to present a piece of relatively recent work in a comparatively undeveloped field. Such work might normally be expected to appear in a series of journal articles, and indeed originally the authors followed this method of presentation. As the subject developed, however, a rather general approach to the problem became apparent which both simplified and unified all the prior research. Space limitations in the journals made it impossible to publish in that medium a really suitable picture of the whole development, and this circumstance led the authors to take advantage of the present Technology Press Research Monographs.

The principal motivation for this work arose from the obvious desirability of finding a single quantity, a tag so to speak, to describe the noise performance of a two-terminal-pair amplifier. The possibility of the existence of such a quantity and even the general functional form which it might be expected to take were suggested by previous work of one of the authors on microwave tubes and their noise performance. This work showed that noise parameters of the electron beam set an ultimate limit to the entire noise performance of the amplifier that employed the beam. In the microwave tube case, however, the findings were based heavily upon the physical nature of the electron beam, and it was not immediately clear that a general theory of noise performance for any linear amplifier could be made without referring again to some detailed physical mechanism. In order to detach the study of noise performance from specific physical mechanisms, one had to have recourse to general circuit theory of active networks. Such a theory had grown up around the problems associated with transistor amplifiers, and important parts of it were available to us through the association of one of us with Professor S. J. Mason. This combination of circumstances led to the collaboration of the authors.

Two major guiding principles, or clues, could be drawn from the experience on microwave tubes. One such clue was the general form of the probable appropriate noise parameter. The other was the recognition that matrix algebra and a proper eigenvalue formulation would be required in order to achieve a general theory without becoming hopelessly involved in algebraic detail.

Essentially by trial and error, guided by some power-gain theorems in active circuit theory, we first found a few invariants of noisy networks. Afterward, while we were trying to decide around which quantities we should build a matrix-eigenvalue formulation leading to these same invariants, we were aided by the fact that Mr. D. L. Bobroff recognized a connection between the invariants which we had found and the problem of the available power of a multiterminal-pair network.

Armed with this additional idea, we consulted extensively with Professor L. N. Howard of the Massachusetts Institute of Technology, Department of Mathematics, in search of the appropriate matrix-eigenvalue problem. As a result of his suggestions, we were able to reach substantially the final form of the desired formulation.

Once the proper eigenvalue approach was found, additional results and interpretations followed rapidly. In particular, the idea that the eigenvalue formulation should be associated with a canonical form of the noisy network was suggested in a conversation with Professor Shannon.

One of the principal results of the work is that it furnishes a single number, or tag, which may be said to characterize the amplifier noise performance on the basis of the signal-to-noise-ratio criterion. The novel features of this tag are two in number: First, it clears up questions of the noise performance of low-gain amplifiers or of the effect upon noise performance of degenerative feedback; second, it provides for the first time a systematic treatment of the noise performance of negative-resistance amplifiers. The latter results were not expected in the original motivation for the study but grew from insistent demands upon the internal consistency of the theory. It is interesting that the negative-resistance case will probably turn out to be one of the most important practical results of our work.

Another result worth mentioning here, however, is the canonical form of linear noisy networks. This form summarizes in a clear, almost visual, manner the connection between the internal noise of a network at any particular frequency and its (resistive, positive, or negative) part.

We are hopeful that this second work in the series of Technology Press Research Monographs will meet the standards and aims envisioned by Professor Gordon S. Brown, whose personal inspiration and energetic support brought the present volume into existence.

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