

Design of High-Performance Negative-Feedback Amplifiers

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Preface

Amplifier design is very often regarded as making a selection from the large arsenal of known amplifier circuits and then adapting it for a specific purpose, possibly with the aid of computer-aided-design programs. Now and then designers are surprised by the introduction of a new amplifier circuit performing better in some respect than the others.

Each aspiring designer has to find his own way in this jungle. He has to choose from a rather chaotic and scattered collection of amplifier circuits rather than apply a systematic and straightforward design sequence that enables him to design his special-purpose amplifier circuit. A great deal of experience is essential.

This work is an attempt to make a useful contribution to the extensive literature on the subject of amplifier design. It can be justified on the grounds that the approach is believed to be unique in a number of respects. Many works that promise to cover the subject are instead concerned with analysis. Moreover, they frequently deal specifically or separately with particular design aspects, characterised by descriptions such as ‘wide-band’, ‘low-noise’, ‘low-distortion’, etc.

A treatment of the various design aspects and their interconnections, however, is necessary for fruitful amplifier design. At the basis of such a treatment lies the observation — usually easily overlooked — that amplifier design is concerned in the first place with obtaining an adequate quality of information transfer. Amplifiers are more than electronic circuits merely bringing the source power up to a higher level. Quality requirements are imposed on the signal transfer relative to the type of information and to the manner of perception, registration, or processing. The quality of information transfer is determined by a large number of quality aspects such as linearity, accuracy, efficiency, signal-to-noise ratio, etc. Unfortunately, it cannot be expressed as a quantitative figure of merit

Trade-offs between various quality aspects are likely to emerge. Sometimes they will be of a fundamental nature and are imposed by physical and technological limitations, but frequently they will result from the nature of a specific amplifier circuit itself, which — on second thoughts — might not be the most appropriate one to fulfil the desired function.

A systematic, straightforward design approach is presented in this work. It is more or less inspired by the work of Cherry and Hooper¹ which I consider one of the

¹ E.M. Cherry and D.E. Hooper, *Amplifying Devices and Low-Pass Amplifier Design*, John Wiley and Sons, New York, 1968.

finest design treatises. The present work is more concerned with basic design considerations. Preference was given to a qualitative rather than to a quantitative approach.

Finding the proper configurations for the basic amplifier and of the amplifier stages is considered of primary importance and is emphasised here. This book is therefore largely concerned with the design phase preceding the phase in which existing computer aids can be helpful.

The approach is characterised best by describing it as a systematic and consistent arrangement of design considerations regarding various quality aspects of information transfer. Via the classifications of amplifier configurations, a systematic design method for negative-feedback amplifiers is developed.

A short description of the main lines along which the design method has been developed is given below.

In chapter 1, criteria are given for the adaptation of the input and output impedances to the source and the load, respectively (usually transducers). The purpose of these adaptations is the realisation of optimum information transfer from the signal source to the amplifier and from the amplifier to the load. Next, criteria are deduced for optimum information transfer of the amplifier, preserving signal-to-noise ratio and efficiency by the application of feedback. Classifications are given of basic amplifier configurations with up to four negative-feedback loops, providing the designer with the complete set of fundamentally different two-port amplifier types. The characteristic properties and the practical merits of these configurations are discussed.

A similar classification is given in chapter 2 for configurations with a single active device. A uniform description of these single-device configurations will appear to be of great help in finding suitable stage configurations in the active part of an amplifier with overall negative feedback. The balanced versions of these single-device stages are mentioned but not studied in detail.

In chapter 3, design criteria regarding random noise are formulated. These criteria relate mainly to the selection of the most favourable input-stage configuration and the active device to be used in this stage for a given signal source.

In chapter 4, those configurations of amplifier stages that are best suited to realising optimum accuracy and linearity of information transfer are arrived at.

Thereafter, bandwidth and stability considerations are taken into account in chapter 5. The requirements for optimum performance in this respect fortunately appear to be to a large extent compatible with the requirements regarding the other quality aspects.

The design of bias circuitry is considered in chapter 6. It will be shown that this part of the design can be done in such a way that the signal-path performance of the amplifier is scarcely affected.

Finally, an outline of the design method is given in chapter 7. For examples of

amplifiers designed according to the design procedure developed in this book reference is made to the literature.

This book is a revised and reviewed version of my Ph.D. thesis, which was published in June 1980 under the supervision of Prof.Dr.Ir. J. Davidse. The results of the work that he has encouraged me to carry out in the Laboratory of Electronics at the Delft University of Technology, The Netherlands, can be found here.

Writing such a thesis is perhaps even more of a burden to those in an author's environment than to himself. Without the aid of many others, it would not be possible to obtain a Ph.D. degree. As an acknowledgement of their support, this book is dedicated to all who contributed in some way.

Susan Masotty reviewed the text and corrected my numerous linguistic errors. Wim van Nimwegen drew the figures. Josette Verwaal and Hilda Verwest typed the manuscript. They thus contributed to the mere physical existence of this book, which happens to bear my name. This may, however, veil the fact that an author is no more than a person who is lucky enough to be able to write down the ideas he would never have had without a stimulating environment.

It is to this environment — which usually cannot be adequately indicated by names but includes the above — in all its abstraction that I am deeply indebted.

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Ernst Nordholt

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