Preface

Dynamic systems, described by definite differential or difference equations, are the universal model for investigation of laws in behavior of different natural processes related to the motion of material objects, information transfer, and the development of social, biological, economic and other structures. Their application in the investigation of control processes in technical and other systems forms the fundamental idea of automatic control theory.

Estimations of dynamic system accuracy greatly depend on the choice of initial models of actions. Those models give input for actuating the right member of appropriate differential equations. Variability and partial knowledge of real action properties trouble the formation of spectral-correlation and other full models of action, described by the analytical functions of nontrivial mode. This is due to the loss of practical efficiency of investigation (due to low validity of such models) which exceeds the possible gain of more accurate system adjustment on the definite operating regime. Therefore it is rational to use for description of action properties the nonparametric classes of functions. Their satisfactory width provides the required validity of description. This approach requires the investigation and development of special methods for analysis and synthesis of dynamic systems with the ensured accuracy characteristics.

Ensuring good protection of results from errors in the initial data is important not only in researching control accuracy. A similar requirement applicable to mathematical statistics problems was clearly formulated by P. Huber [61]. It was indicated as a "robustness" term in the sense of its insensitivity to low deviation from initial suppositions. The robustness in the modern theory of automatic control is often coupled to the ensuring of system stability at the definite scatter of its parameters (V. L. Kharitonov theorem, discovered by J. Z. Tsypkin and his school). Therefore the more widespread explanation of its concept became convenient. If the system or algorithm posses the high efficiency at the nominal operation conditions and good efficiency at the deviation from the nominal conditions in the preset accessible limits [3, 8, 27, 40, 54] then it is considered robust.

These limits can be determined by the accepted classes of external and parametric disturbances. Ensuring control accuracy in this case can be treated as providing the robust accuracy, and then appropriate control systems are called robust.

The robustness concept is actually not new. It is followed by the tendency to give nonadaptive systems the property of holding the preset characteristics in the admissible limits at possible variation of their operating conditions, without demanding the best quality for some fixed conditions. Highly experienced designers have always been working in that way. Their works were based not only upon any mathematical theories but also upon the prudence and good intuition in major cases. The theoretical methods of dynamic systems investigation in their development could not comprise all the features of practical design problems. Some "residual" in theoretical and practical approaches to design process always existed. It stimulated the improvement of theories and created witty stories about the loss of mutual understanding between theorists and empirics. The limited possibilities of theoretical investigations are coupled to excessive formalization and idealization of problem statements. It can also be the fee for the possibility of finding the strict solution. The robust approach is the attempt to smooth the sharpness of exposed problems in the account of the more rough, approximate description of initial information about the conditions of system operation, assuming the possibility of normality in such conditions.

This book does not comprise all known methods for ensuring control accuracy, which are various enough and can hardly be joined with anything to form a single theory, except with the robust concept used in all of them.

The chosen stated methods suppose mostly the investigation in the frequency domain. The main arguments in advantage of such choice are their relative simplicity and high validity of initial conditions being appreciated by all specialists and practitioners. The direct interaction between those methods and classical frequency domain methods for investigation of automatic control systems quality is also very important. It simplifies the understanding of material for a large group of readers, including students. Therefore, a list of questions is given at the end of every chapter. The statement style can satisfy system designers and designers of automatic control devices. The author hopes that specialists in the sphere of control theory will read this book, although many of them suppose the frequency domain to be some kind of trampled out field of knowledge, where it is hard to find something new. But the author was not seeking the new but required in practice, investigation methods, which are improved by the given formulae and examples.

The main list of references contains minimum basic publications that are close to the subject of the book. Additional literature is indicated by particular references in the text.

Most of the ideas shown in this book were formulated by the authors' cooperation with his scientific teacher V. A. Besekerski. He became the co-author when publishing the first book devoted to robust control systems [8] based on Besekerski fundamental treatises [6, 7]. The author gratefully appreciates Prof. Besekerski for an excellent education and support.

Professor A. A. Zinger was the first to confirm the authors' suppositions about the possibility of investigating the accuracy of linear filtration of signals with the limited variances of derivatives on the basis of using the current problem apparatus by Chebyshev-Markov. He also recommended the perfect treatise by M.G. Krein and A.A. Noodelman. By virtue of those treatise the author has discovered the new vision on familiar verity.

Professor I.B. Chelpanov with his opinions on earlier authors' publications, and with his speeches and books during many years has helped the author to keep certainty in the efficiency of chosen investigation methods.

Professor E.N. Rosenwasser gave much useful advice on the material of this book and approved it conceptually. It has improved the authors' resolution to accomplish this book till the end.

Academician J. Z. Tsypkin has always been the best authority and kindest tutor to the author. J.Z. Tsypkin has greatly influenced the statement of given problems

in this book. As an active supporter of the robust approach to dynamic systems investigation he played a great role in spreading these methods in Russia and in the world on IFAC line.

Academician F.L. Chernousko has greatly supported the author at the most difficult period of the book's completion, which predetermined the possibility of publishing this book.

The author had the additional opportunity to check up the efficiency of suggested methods for theoretical investigations in contensive problems of synthesizing precision automatic control complex for the relative motion of aerospace planes at their horizontal start and landing on moving ekranoplanes [86, 89]. The concept for construction of this perspective space transport system is being developed in cooperation with professor N. Tomita and other colleagues from Tokyo. The communication between them provided new ideas for improving the material in the book.

On every stages of this book preparation the author was inspired by support of many other friends and colleagues, who are greatly faithful to science and who give all the strength they have to it. Many thanks to all of them.

St. Petersburg, December 2003 Alexander Nebylov