Preface

The circuit regime analysis is one of the main problems for electric circuit theory. The finding of the actual (absolute) value of regime parameters (voltage, current, power, and transformation ratio for different parts of a circuit) is the simplest analysis task. If a circuit has variable elements (loads and voltage regulators), additional analysis tasks appear.

The interest in such circuits is defined, in particular, by the state and tendencies of development of power electronics, modular power supply, or distributed power supply systems with renewable power sources. Similar devices, in general, represent the complex multiple inputs and multiple outputs systems and their loads can change from the short circuit to open circuit and further give energy. In turn, the loads can be subdivided into high priority and additional (ballast) loads. For definiteness, it is possible to accept that such systems, for circuit theory, present linear mesh circuits of a direct current or multi-port networks.

We will consider some of the arising additional tasks of analysis. For example, it is important to confront operating regime parameters with characteristic values; that is, to represent these parameters in the normalized or relative form. In this case, the informational content of these parameters is increasing; it is possible to appreciate qualitative characteristics of an operating regime or its effectiveness, to compare regimes of different circuits, and to set a necessary regime.

The other task of analysis is the determination of the dependence of the regime parameter changes on the respective change of element's parameters (for example, the problem of the recalculation of load currents). Thus, it is necessary to set the form of these changes reasonably; that is, to determine whether these changes are increments or any other expressions.

Another task of analysis is the definition of the view or character of such an active circuit with a changeable element (as a power source concerning load); that is, this circuit shows more property of a voltage source or current source.

In the electric circuit theory, a range of circuit's properties, theorems, and methods is well known, and their use simplifies the decision of these problems.

However, the known approaches do not completely disclose the properties of such circuits, which reduces the effectiveness of analysis.

The method of analysis for a circuit with variable element parameters is developed by the author. For interpretation of changes or “kinematics” of circuit regimes, projective geometry is used. For example, the known expression has the typical fractionally linear view for functional dependence of current (or voltage) via resistance. It gives the grounds for considering this expression as a projective transformation. The projective transformations preserve an invariant; there is a cross ratio of four points (a ratio of two proportions) or four values of current and resistance. The value of this invariant is preserved for all the variables (as a current, voltage, and resistance) and for parts or sections of a circuit. Thus, this invariant is accepted as the determination of the regime in the relative form. Therefore, obvious changes in regime parameters in the form of increments are formal and do not reflect the substantial aspect of the mutual influences: resistance → current.

In general, this geometrical approach grounds the introduction and determination of required concepts.

The book has an introduction (Chap. 1) and four parts. The disadvantages of known methods are considered in Chap. 1.

Part I (Chaps. 2–5) considers electrical circuits with one load. The application of projective geometry to analysis of an active two-pole is shown in Chap. 2. The concept of generalized equivalent circuits is introduced in Chap. 3. The invariant relationships of cascaded two-ports are considered in Chap. 4. In Chap. 5, the paralleling voltage sources are presented.

Part II (Chaps. 6–9) considers multi-port circuits. The application of projective geometry to analysis of an active two-port and three-port is shown in Chap. 6. The concept of generalized equivalent circuits of multi-port is introduced in Chap. 7. The recalculation formulas of load currents are obtained in Chap. 8. The invariant relationships of cascaded four-ports are considered in Chap. 9.

Part III (Chaps. 10–12) considers circuits with nonlinear regulation curves. The voltage regulator regimes are studied in Chap. 10. The load voltage stabilization is shown in Chap. 11. The pulse-width modulation converters are considered in Chap. 12.

Part IV (Chaps. 13 and 14) discusses circuits with nonlinear load characteristics. The concepts of power-source and power-load elements with two-valued characteristics are shown in Chap. 13. Quasi-resonant voltage converters with self-limitation of current are considered in Chap. 14. The attention to similarity of characteristics of this converter and some electronic devices is paid.

The book may be useful to those who are interested in the foundations of the electric circuit theory and also for a professional circle of experts in various areas of electrical engineering and radio electronics.

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Contents

Part II Multi-port Circuits. Projective Coordinates of a Point on the Plane and Space