

CONTENTS

PREFACE	v
SPECIAL ABRIDGED NOTATIONS	vii
INTRODUCTION	1

Chapter One. Introductory Treatment of Dimensions One and Two

§1. The Characteristic Function	5
§2. Systems of Dimension Unity. Direct Control	7
§3. System of Dimension Unity. Indirect Control	8
§4. System of Order Two	13

Chapter Two. Indirect Controls

§1. Vectors and Matrices	17
§2. Indirect Control. General Type	18
§3. Comparison with a Recent Result of Yacubovich	22
§4. On the Utilization of Certain Complex Coordinate Systems	23
§5. Special Cases	24

Chapter Three. Indirect Controls (Continued)

§1. Invariance under Change of Coordinates	27
§2. Reduction of the Number of Conditions on the Control Parameters	28
§3. Lurie's Method and a Variant	31
§4. Application to Systems of Order Two	33

Chapter Four. Direct Controls. Linearization Multiple Feedback

§1. Direct Control: General Case	39
§2. Direct Control, Standard Example	41
§3. Reduction of an Indirect Control to a Special Direct Control	42
§4. Linearization of Direct Controls	43
§5. Linearization of Indirect Controls	46
§6. Direct Control with Matrices B or C of Rank $< n$	48
§7. Direct Controls with Matrices B, C , of Rank $n - 1$	50
§8. Direct Control Whose Matrix A Has Zero as a Characteristic Root (Kenneth Meyer)	51
§9. Direct Control Whose Matrix Has a Pair of Conjugate Pure Imaginary Characteristic Roots (Kenneth Meyer)	55
§10. Multiple Feedbacks	56

Chapter Five. Systems Represented by a Set of Equations of Higher Order

§1. Generalities	61
§2. A Digression on Linear Systems	62
§3. Indirect Control	64
§4. Indirect Control: An Example	67
§5. Direct Control	70

Chapter Six. Discontinuous Characteristics

§1. Continuous Approximation of Discontinuous Characteristics	72
§2. Direct Discussion of Discontinuities	73
§3. Some Examples	79
§4. Special Switching Lines	84
§5. Multiple Feedback Switching Line	85
§6. Complementary Remarks	86

Chapter Seven. Some Recent Results of V. M. Popov

§1. Generalities. The Theorems of Popov	87
§2. Preliminary Properties	91
§3. Proof of Popov's First Theorem	93
§4. The Generalized Liapunov Function of Popov	98
§5. Proof of Popov's Second Theorem	100
§6. Comparisons	101
§7. On the Function $G(z)$ as Transfer Function	104
§8. Direct Control	105
§9. Conclusion	105

Chapter Eight. Some Further Recent Contributions

§1. Controllability and Observability	107
§2. Reduction of the System to One with a Completely Controllable Pair (A, b) and Completely Observable Pair (c', A)	109
§3. A Special Form for Systems with Completely Controllable Pair (A, b)	113
§4. Main Lemma (Yacubovich and Kalman)	114
§5. Liapunov-Popov Function and Popov Inequality	118
§6. Fundamental Theorem	119
§7. A Recent Result of Morozan	121
§8. Return to the Standard Example	122
§9. Direct Control	123
§10. Résumé (Indirect Control: $\gamma > 0$)	124
§11. Complement on the Finiteness of the Ratio $\varphi(\sigma)/\sigma$	125

CONTENTS

Chapter Nine. Miscellaneous Complements

§1. The Jordan Normal Form for Real or Complex Matrices	128
§2. On a Determinantal Relation	132
§3. On Liapunov's Matrix Equation	133
§4. Liapunov and Stability	136
Appendix A: An Application of Multiple Feedback Control	139
Appendix B: An Example from the Theory of Nuclear Power Reactors (Kenneth Meyer)	142
BIBLIOGRAPHY	144
INDEX	149