

Noise signals

Modelling and Analyses

The book meticulously details a constructive mathematical model of a stochastic noise process, specifically a linear random process and its characteristics. Theoretical reasoning on the relationship between random processes with independent increments and those with independent values, known as random processes of white noise, is provided. The model of a linear random process serves as a mathematical representation of colored noises in various hues. Characteristics of both non-stationary and stationary linear random processes are elucidated, with emphasis on their ergodic properties, crucial for practical applications. The study also encompasses the vector linear random process, portraying a model of multi-channel noise signals. A novel contribution to the theory of random functions is the development of a constructive model of a conditional linear random process. This involves determining its distribution laws in the form of a characteristic function and relevant statistical characteristics, which can serve as potential indicators for identifying stochastic noise processes. The book revisits research on periodic stochastic models, examining cyclic, rhythmic, natural, and artificial phenomena, processes, and signals. A comprehensive analysis of the linear periodic random process is conducted, and the identification characteristics of periodic models of stochastic noise signals are explored. Significant attention is directed toward employing contour and phase methods as a theoretical foundation for addressing narrow-band noise signal identification challenges.

ISBN 978-3-031-71092-6



9 783031 710926



1	Problems of Noise Signals Research	1
1.1	General Concepts, Models and Measures in Object-Oriented Identification of Stochastic Noise Signals	1
1.2	Subject Areas of Stochastic Noise Signals Application	10
1.2.1	Noise Signals in Nature and Technology	10
1.2.2	Noise Signals in Biomedical Technical Systems	15
1.3	Tasks of Object-Oriented Identification of Noise Signals	19
	References	23
2	Linear Models of Stochastic Noise Signals	27
2.1	Random Processes with Independent Increments and White Noise Models	27
2.1.1	Properties of Random Processes with Independent Increments	28
2.1.2	Gaussian and Poisson Processes with Independent Increments	30
2.1.3	White Noise	32
2.2	Linear Random Processes and Color Noise Models	33
2.2.1	Linear Random Processes with Continuous Time	33
2.2.2	Linear Random Processes with Discete Time	36
2.2.3	Ergodic Properties of Linear Random Processes	39
2.2.4	Color Noises	44
2.3	Linear Models of Multidimensional Stochastic Noise Processes	45
2.3.1	Linear Random Fields	45
2.3.2	Multidimensional Linear Random Processes as Models of Multi-channel Noise Signals	48
2.4	Conditional Linear Random Processes and Their Characteristics	51

2.4.1	Characteristics of Conditional Linear Random Processes Within the Framework of Correlation Theory	54
2.4.2	Characteristic Function of Conditional Linear Random Process	56
2.5	Characteristics of Noise Signal Identification Based on Linear Stochastic Models	60
	References	64
3	Periodic Models of Noise Signals	69
3.1	Linear Periodic Random Processes	72
3.1.1	Linear Periodic Random Processes with Continuous Time	72
3.1.2	Linear Periodic Random Processes with Discrete Time	79
3.2	Conditional Linear Periodic Random Processes	83
3.3	Harmonized Periodic Random Processes	87
3.4	Characteristics of Noise Signal Identification Based on Periodic Models	94
	References	98
4	Method of Envelope and Phase in the Tasks of Identification of Narrowband Noise Signals	101
4.1	Method of Envelope and Phase as Theoretical Basis of Identification of Narrowband Noise Signals	103
4.2	Properties of Hilbert Transform of Signals and Processes and Their Correlation Functions	105
4.3	Random Vector Model with Independent Gaussian Components in Polar Coordinate System	109
4.3.1	Probability Distributions of Modulus and Argument of Random Vector	112
4.3.2	Probability Density of Sum of Two Random Phase Shifts with Mises Distribution	118
4.4	Research of Envelope and Phase of Narrowband Noise Random Processes	119
4.4.1	Probability Densities of Envelope and Phase of Narrowband Process	122
4.4.2	Probability Density of Envelope and Phase of Additive Mixture of Amplitude-Phase Modulated Signal and Gaussian Interference	124
4.5	Determination of Narrowband Processes Characteristics with Hilbert Transform	128
4.6	Sample Circular Statistics and Their Use in Cyclic Signal Identification Tasks	130
4.6.1	Features of Practical Implementation of Hilbert Transform	130

4.6.2	Numerical Characteristics of Signals' Random Phase Shifts	132
4.6.3	Methodology of Phase Characteristics' Using for Identification of Narrowband Noise Processes and Signals	138
	References	140
5	Identification of Vibration Noise Signals of Electric Power Facilities	143
5.1	Features of Vibration Noise Signals' Identification	144
5.2	Linear Stationary Random Processes of Vibration Noise Signals of Electric Machines Bearing Assemblies	149
5.3	Identification of Vibration Noise Signals of Electric Power Facilities Based on Pearson Curve System	156
5.4	Algorithmic-Software Identification of Vibration Noise Signals Based on Pearson Curves System	161
5.5	Models and Characteristics of Vibration Noise Signals Identification	166
	References	168
6	Examples of Stochastic Noise Signals Identification	171
6.1	Experimental Results of Vibration Noise Signals Identification of Electric Machines Bearing Assemblies	172
6.2	Statistical Evaluations of the Identification Characteristics of Noise Electroencephalographic Signals	176
6.2.1	Assessment of Electroencephalographic Signals' Characteristics Based on Autoregression Model	176
6.2.2	Statistical Analysis of Electroencephalographic Signals Based on Autoregression Model with Random Coefficients	179
6.3	Using Phase Characteristics for Identifying of Stochastic Narrowband Signals	186
	References	194
7	Identification of Air Pollution Sources	197
7.1	Introduction	197
7.2	Air Pollution Dispersion	198
7.2.1	Classification of Air Pollution Dispersion Models	198
7.2.2	General Approach	199
7.2.3	Some Common Atmospheric Dispersion Models	200
7.3	Methods of Source Pollution Identification	203
7.3.1	Correlation Analysis	203
7.3.2	PCA Estimation Method	210

7.3.3	PMF Estimation Method	212
7.3.4	Modifications of the Classical Newton Method	216
7.4	Conclusions	218
	References	219