

# **2025 Wave Electronics and its Application in Information and Telecommunication Systems (WECONF 2025)**

**St. Petersburg, Russia  
12-16 May 2025**



**IEEE Catalog Number: CFP25S10-POD  
ISBN: 978-1-6654-6569-4**

**Copyright © 2025 by the Institute of Electrical and Electronics Engineers, Inc.  
All Rights Reserved**

*Copyright and Reprint Permissions:* Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

**\*\*\* *This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP25S10-POD
ISBN (Print-On-Demand):	978-1-6654-6569-4
ISBN (Online):	978-1-6654-6568-7
ISSN:	2769-352X

**Additional Copies of This Publication Are Available From:**

Curran Associates, Inc  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: (845) 758-0400  
Fax: (845) 758-2633  
E-mail: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

## Table of Contents

*A.V. Afanasieva, D.A. Dubrovina, E.S. Markovskiy*  
EXPERIMENTAL ANALYSIS OF THE EFFECTIVENESS OF OBJECT DETECTION  
METHODS...1

*N.V. Afonin, E.A. Skorodumova*  
TIME SERIES ANALYSIS FOR COINTEGRATION...5

*Ulyan Belkin, Andrey Prihodskiy, Sergey Serikov*  
HYBRID SWARM CONTROL BASED ON COMBINING VISUAL AND  
COMMUNICATION NAVIGATION IN UNCERTAIN ENVIRONMENTS...9

*N.V. Belov, A.G. Vovik, L.I. Voronova, M.V. Khokhlova, V.I. Voronov* DEVELOPMENT  
OF A METHOD FOR GRIPPING FRAGILE OBJECTS  
WITH A ROBOT MANIPULATOR...14

*O.S. Belova, D.V. Bolotov, O.V. Kolesnikov, S.S. Zhulikov, T.K. Kivshar*  
QUANTUM KEY DISTRIBUTION THROUGH ALL-DIELECTRIC CABLE UNDER  
CLOSE LIGHTNING STRIKE...19

*V.N. Belyi, N.A. Khilo, P.I. Ropot, V.I. Kazakov, O.V. Shakin, S.V. Akimov* ACOUSTO-  
OPTIC SPATIAL SCANNING OF BESSEL-LIKE BEAMS  
IN FAR ZONE USING PARATELLURITE CRYSTALS...24

*Olesya Bolkhovskaya, Maxim Katkov, Victor Sergeev, Alexander Maltsev*  
ZONES OF ANTENNA ARRAY PARAMETERS FOR EFFICIENT SIGNAL ANGLE-  
OF-ARRIVAL ESTIMATION...29

*Artem Burkov, Roman Rachugin, Andrey Turlikov*  
THROUGHPUT TWO-STEP RANDOM MULTIPLE ACCESS BASED ON ALOHA  
WITH EARLY-FEEDBACK...34

*E.V. Burlakov*  
APPLICATION OF A QUANTUM ANNEALER FOR PATTERN RECOGNITION...39

*M.A. Burnasheva, E.A. Skorodumova*  
KOLMOGOROV-ARNOLD NEURAL NETWORKS FOR ANTI-FRAUD PROBLEMS  
SOLVING...44

*E.Y. Bushuev, S.Y. Kazantsev, E.P. Stroganova, S.E. Grychkin, S.N. Kuznetsov*  
EXTERNAL FACTORS INFLUENCE ON QUANTUM CRYPTOGRAPHIC  
COMMUNICATION SYSTEM WITH ATMOSPHERIC LINE...48

*Aleksandr Chabanenko, Victor Kurlov, Maria Rassykhaeva, Victoria Puzyreva, Casadio Daniele*

USING NEURAL NETWORK ALGORITHMS AND MACHINE VISION  
TO ANALYZE THE DYNAMICS OF PRODUCT QUALITY CHANGES...53

*R.I. Chembarisova, V.A. Nenashev, M.Y. Grigorov, K.Y. Ryzhov, A.R. Bestugin*  
STUDY OF PULSE-WIDTH AND AMPLITUDE-PHASE MODULATION  
INFLUENCE ON THE M-SEQUENCES CORRELATION  
CHARACTERISTICS...61

*N.A. Chirikov, T.N. Ulaeva, N.M. Zhilin*  
INFLUENCE OF INPUT POWER ON THE ELECTRICAL PARAMETERS  
OF SOLIDLY MOUNTED RESONATORS BASED ON ALN, AL, MO  
AND TI THIN FILMS...66

*Darya Denisenko, Dmitry Kuznetsov, Yuri Ivanov, Nikolay Butyrlagin*  
THE SECOND-ORDER DISCRETE-ANALOG FILTER ON SWITCHED  
CAPACITORS WITH THREE-PHASE CONTROL...70

*E.A. Dobrovolskiy, A.A. Silina*  
DEVELOPMENT OF AN ALGORITHM FOR ASSESSING THE CONDITION OF  
THE PAVEMENT SURFACE USING DATA FROM UNMANNED AIRCRAFT  
SYSTEMS...74

*Anton Dyudin, Grigoriy Fokin*  
SIMPLE WAY FOR BASE STATION MONITORING.  
PART 1 SOFTWARE EMULATION...78

*Grigoriy Fokin, Vladimir Starikov, Vladimir Sevidov*  
RADIO COVERAGE ESTIMATION AND RAY TRACING WITH DIGITAL  
TERRAIN MODELS IN THE MATLAB ENVIRONMENT...82

*S.G. Fomicheva, G.A. Zhemelev*  
SECURE SELECTIVE DISTRIBUTED LEARNING OF AUTOENCODERS  
IN AUTOML APPLICATIONS...88

*Ilya Grishin, Grigoriy Fokin, Alla Kalinkina, Alexander Sinilnikov, Vladimir Sevidov*  
ANALYSIS OF THE SPECTRAL EFFICIENCY OF A MIMO-NOMA SYSTEM  
WITH SPATIAL MULTIPLEXING...95

*V.N. Gromorushkin, O.V. Varlamov*  
DYNAMIC OPERATION MODES OF OUTPHASING TRANSMITTERS  
WITH SWITCHING GENERATORS DIRECT SUMMATION...101

*S.E. Grychkin, E.Y. Bushuev, D.V. Bolotov, S.Y. Kazantsev, E.P. Stroganova*  
FIBER-OPTIC COMMUNICATION SYSTEM OPERATION UNDER  
ELECTROMAGNETIC FIELDS INFLUENCE...108

*B.G. Ibrahimov, Z.A. Ismaylov*  
RESEARCH ON THE EFFICIENCY OF TELECOMMUNICATION NETWORKS  
USING WIRELESS COMMUNICATION TECHNOLOGY...113

*L.N. Isaeva, D.D. Borisova*  
KUBERNETES-BASED MONITORING METHODS...118

*M.N. Isaeva*  
A METHODOLOGY FOR CONSTRUCTING A SET OF INFORMATION SETS  
FOR CORRECTING DOUBLE ERROR BURSTS...123

*T.V. Kazieva, J. Rabenandrasana, S.Yu. Kazantsev, D.V. Shkrabin, N.V. Pchelkina*  
EDUCATIONAL LABORATORY COMPLEXES FOR TRAINING SPECIALISTS  
AND CONDUCTING SCIENTIFIC RESEARCH IN THE FIELD OF QUANTUM  
COMMUNICATIONS...128

*A.N. Khairullin, I.M. Lerner, Ya.F. Ziatdinova, D.V. Shuspanov, V.I. Il'in*  
ON THE ISSUE OF LOWER BOUND CAPACITY ESTIMATION OF BASEBAND  
BROADBAND COMMUNICATION SYSTEMS IN THE PRESENCE OF  
CROSSTALK...133

*S.A. Kiselev, A.A. Podberezkin, A.M. Borzenkov, A.V. Ostroukh, C.B. Pronin*  
DYNAMIC PRICING IN AIR CARGO: MACHINE LEARNING AND GENETIC  
ALGORITHM-BASED OPTIMIZATION...143

*D.V. Kleimenkin, I.V. Frolov, V.E. Chumakov, A.V. Bugakova*  
GAAS OP-AMPLIFIER WITH CLASS AB OUTPUT STAGE ON P-N-P BIPOLAR  
AND NJFETS...148

*S.S. Kogan, L.N. Isaeva, A.V. Lobzov, A.A. Nemykin*  
FIBER OPTIC TRANSMISSION SYSTEM PERFORMANCE TESTING...153

*A.S. Kostin, A.I. Bolotova, E.A. Voznesenski*  
FEATURES OF NAVIGATION OF UNMANNED SYSTEMS IN A CLOSED  
WAREHOUSE TO SOLUTION THE MONITORING PROBLEM...158

*E.S. Kostin, A.S. Kostin*  
METHODS AND APPROACHES FOR DETERMINING AND MODELING THE  
MOVEMENT OF AN UNMANNED SYSTEM BASED ON A SIMULATION  
ENVIRONMENT...162

*V.N. Kovregin, A.S. Murzaev*

ANALYTICAL PSEUDO-MEASUREMENTS OF THE VELOCITY  
OF THE RADAR PHASE CENTRE FROM EARTH SURFACE ECHOES  
AT QUASI-CONTINUOUS RADIATION...167

*A.Y. Kudriashova, S.S. Galizdra, N.V. Toutova*

DESIGNING IMPLEMENTATION OF ADDITIONAL MODULES TO INCREASE  
THE SECURITY AND STABILITY OF THE BIOMETRIC IDENTIFICATION  
SYSTEM...171

*G.V. Kulak, P.I. Ropot, V.I. Kazakov, S.V. Kulakov*

COLLINEAR ACOUSTO-OPTIC FILTERING OF POLYCHROMATIC BESSEL  
LIGHT BEAMS IN CALCIUM MOLYBDATE CRYSTALS...176

*M.I. Kupreychik, S.N. Mantsevich, V.I. Balakshy*

APPLICATIONS OF ACHROMATIC LOW-SELECTIVE ACOUSTO-OPTIC  
DIFFRACTION IN ALPHA-IODIC ACID BIAXIAL CRYSTAL FOR TUNABLE  
OPTICAL FREQUENCY COMB GENERATION...180

*S.N. Kurilkina, V.I. Kazakov*

FORMATION OF ACOUSTIC BOTTLE AND BESSEL TYPE BEAMS...185

*Elizar Kustov*

A LATTICE-BASED THRESHOLD SIGNATURE SCHEME FOR IOT  
APPLICATIONS...189

*V.E. Kutepov, I.V. Peshkov*

MODELING AND ANALYSIS OF DEFECTIVE GROUND STRUCTURES BASED  
ON A COMBINATION OF UNIT CELLS OF SIMPLER STRUCTURES...194

*Denis Kutuzov, Alexey Osovsky, Nataliya Maltseva, Dmitriy Starov, Vladimir  
Esaulenko*

CONGESTION DETECTION IN NETWORK-ON-CHIP SYSTEMS BASED  
ON FUZZY LOGIC...200

*D.V. Kuznetsov, N.N. Prokopenko, M.A. Sergeenko, N.A. Dmitrienko*

DESIGN OF HIGH-TEMPERATURE OPERATIONAL AMPLIFIERS USING  
LARGE LANGUAGE MODELS...207

*Yuri Leokhin, Timur Fatkhulin, Konstantin Boitsov*

COMPUTER VISION METHODS IN APPLIED PROBLEMS OF CLASSIFYING  
OBJECTS IN IMAGES...211

*D.A. Luzhaitsev, A.O. Turov, Yu.A. Miller, D.S. Shimanovskiy, P.E. Troyan*  
DESIGN COMPARING OF A MONOLITHIC INTEGRATED CIRCUIT  
OF A BUFFER AMPLIFIER USING GALLIUM NITRIDE TECHNOLOGY...221

*N.N. Maiorov, M.R. Yazvenko*  
DEVELOPMENT OF SIMULATION MODEL FOR SIMULTANEOUS SERVICE  
OF SCHEDULED AND RANDOM VESSELS AT SEA PASSENGER PORT...225

*Tatyana Malygina, Alexander Slobodchikov*  
DEVELOPMENT AND RESEARCH OF A DEVICE FOR STUDYING  
THUNDERSTORMS...229

*M.I. Malyshev, A.A. Poberezkin, A.V. Ostroukh, C.B. Pronin, E.B. Khabarova*  
RESEARCH OF CHATBOT SCRIPT CREATING PROCESS FOR DIGITAL  
TRANSPORT LOGISTICS...233

*V.A. Manakova, N.N. Maiorov, A.S. Kostin*  
ROUTING MODELS OF AUTONOMOUS UNMANNED SYSTEM FOR SOLVING  
PROBLEMS IN OBJECT IDENTIFICATION AT THE WAREHOUSE...239

*S.A. Manenkov, D.V. Krysanov*  
THE PROBLEM OF PLANE WAVE DIFFRACTION BY AN INHOMOGENEOUS  
COMPACT BODY...243

*S.N. Mantsevich, V.I. Balakshy*  
PHASE BALANCE CONDITION IN ACOUSTO-OPTIC GENERATOR...250

*N.D. Muraviev, V.P. Kulagin, D.O. Zhukov*  
SOFTWARE TOOL FOR THE SYNTHESIS OF PETRI NET MODELS OF  
PARALLEL COMPUTING SYSTEMS...255

*S.A. Nenashev, V.A. Nenashev, I.A. Kirshina, K.Y. Ryzhov, M.Y. Grigorov*  
ANALYSIS OF HARDWARE-COMPUTING MODULES AND NEURAL  
NETWORKS FOR AVIATION SURVEILLANCE SYSTEMS WITH COMPUTER  
VISION...260

*Ivan Nitkin*  
MEMORY-OPTIMIZED STERN-BASED DIGITAL SIGNATURE...264

*Yu.A. Novikova, M.B. Ryzhikov, A.A. Kazaev*  
OPTICAL SENSOR FOR DETECTING FE, CU AND CO<sub>2</sub> PARTICLES  
FOR ANALYZING THE SERVICEABILITY OR ENVIRONMENTAL  
FRIENDLINESS OF AN AIRCRAFT ENGINE...268

*O.V. Opalikhina, M.A. Zhelavskiy*

MARKOV EVALUATION OF INFORMATION SIGNAL...273

*K.N. Pankov, M.M. Glukhov-jr.*

ENSURING THE SECURITY OF NEW INFORMATION TECHNOLOGIES  
OF THE FOURTH INDUSTRIAL REVOLUTION IN THE CONTEXT OF THE  
QUANTUM THREAT...278

*N.V. Pchelkina, A.K. Nanidzhanyan, A.V. Bahus, M.A. Yarygin*

EXPERIMENTAL MODELING OF THE ATMOSPHERIC DISTURBANCES  
INFLUENCE ON THE WIRELESS QUANTUM CHANNEL  
CHARACTERISTICS...284

*I.A. Pestova*

METHOD OF INDUCTION CONDUCTOMETER SENSORS CALIBRATION...289

*N.V. Polikarpova, E.A. Djakonov*

ACOUSTIC WAVE PROPAGATION IN ORIENTED ACOUSTO-OPTIC  
CRYSTALS AND NEW DEVICE APPLICATIONS...293

*V.E. Pozhar*

SPECTRAL INDICES. DETERMINATION AND INTERPRETATION  
PROBLEMS...300

*Quoc Fung Ngo, O.V. Varlamov*

OUTPHASING TRANSMITTER CIRCUIT WITH SWITCHING GENERATORS  
DIRECT SUMMATION: STATIC MODE ANALYSIS...304

*I.V. Ryabov, T.S. Bukanova, N.V. Degtyarev, E.S. Klyuzhev*

DIRECT DIGITAL SYNTHESIZERS OF FREQUENCY-MODULATED  
SIGNALS...313

*M.V. Sapozhnikov, D.N. Terekhin, S.Y. Kazantsev*

CALCULATION PARAMETERS OF SATELLITE OPTICAL COMMUNICATION  
CHANNEL WITH QUANTUM KEY DISTRIBUTION...318

*Vladimir Sayenko*

EVALUATING THE EFFICIENCY OF SERVER SYSTEM CLUSTERS...324

*Dmitry Semenov, Alexander Bugrov, Olesya Bolkhovskaya, Alexander Maltsev*

EXPERIMENTAL STUDY OF MILLIMETER-WAVE (E-BAND) RADIO RELAY  
LINK CHARACTERISTICS...331

*Roman Shakhovoy*

PASSIVE STATE PREPARATION FOR QUANTUM KEY DISTRIBUTION WITH  
PHASE ENCODING...335

*A.A. Shihotov, T.M. Tatarnikova*  
METHODS FOR PREPROCESSING IMAGES OF HANDWRITTEN DOCUMENTS  
IN COMPUTER VISION TASKS...340

*Yu. A. Silin, A.A. Silina*  
ACHIEVING OPTIMAL FLIGHT CHARACTERISTICS FOR COAXIAL-TYPE  
UNMANNED AIRCRAFT SYSTEMS BY ADJUSTING THE PID-  
CONTROLLER...344

*Anastasiia Solodkova, Andrey Pudeev, Alexander Maltsev*  
SIGNAL DETECTION AND INITIAL ESTIMATION OF CARRIER FREQUENCY  
OFFSET USING THE SWIVELED CORRELATOR FOR SATELLITE  
COMMUNICATIONS...349

*E.P. Stroganova, E.Y. Bushuev, S.E. Grychkin, N.V. Pchelkina*  
INFLUENCE OF ATMOSPHERIC TURBULENCE ON OPTICAL LINE  
OF COMMUNICATION SYSTEM WITH QUANTUM CRYPTOGRAPHIC  
EQUIPMENT...354

*Elena Suvorova, Vadim Polyakov*  
ADAPTIVE DATA FLOW MANAGEMENT IN SPACEFIBRE VIRTUAL  
NETWORKS BASED ON SELF-LEARNING TIMED AUTOMATA...359

*V.E. Taratun, A.A. Silina, E.A. Gaiduk*  
RESEARCH AND DEVELOPMENT OF A DIGITAL TWIN  
OF ST. PETERSBURG'S PUBLIC WATER TRANSPORT...367

*T.M. Tatarnikova, A.S. Raskopina*  
OPTIMIZATION OF NEURAL NETWORKS THROUGH SEMI-STRUCTURED  
ACTIVATION PRUNING...372

*N.V. Toutova, A.Y. Kudriashova, S.S. Galizdra*  
IMPLEMENTATION OF ADDITIONAL MODULES TO INCREASE THE  
SECURITY AND STABILITY OF THE BIOMETRIC IDENTIFICATION  
SYSTEM...377

*T.N. Ulaeva, N.M. Zhilin, N.A. Chirikov*  
INVESTIGATION OF TEMPERATURE EFFECTS ON THE CHARACTERISTICS  
OF A LADDER FILTER BASED ON A SINGLE SOLIDLY MOUNTED  
RESONATOR...382

*Vardges Vardanyan, Anatolij Sychuk*  
TRANSMISSION OF 32X125GBIT/S 16-QAM SIGNALS USING OPTICAL OFDM  
TECHNOLOGY OVER A FIBER-OPTIC PATH. SIMULATION RESULTS...386

*O.V. Varlamov, V.N. Gromorushkin*

MISMATCHED LOAD OPERATION OF OUTPHASING TRANSMITTERS  
WITH SWITCHING GENERATORS DIRECT SUMMATION...391

*Anton Vasin, Vasiliy Elagin*

ASSESSMENT OF THE TRAFFIC PROCESSING IN 5G-NTN...396

*A.M. Veresova, A.A. Ovchinnikov*

BURST CORRECTING CAPABILITY OF BLOCK-PERMUTATION LDPC  
CODES...404

*Alexey Vinogradov, Elena Suvorova*

ARCHITECTURE OF BRIDGES BETWEEN INDUSTRIAL DATA  
TRANSMISSION STANDARDS AND THE SPACEFIBRE...408

*V.Yu. Volkov*

MODELING OF SAR IMAGES FOR REFLECTIONS FROM AN  
INHOMOGENEOUS SURFACE...417

*Xiaoyang Hu, A.Y. Fedorinov, Xiaoyi Liu, V.V. Perliuk*

RESEARCH OF THE TIME SYNCHRONIZATION ALGORITHM  
FOR A LOW-ORBIT GROUPING OF MICROSATELLITES...424

*V.N. Yershov, V.N. Tolstykh*

STUDY OF ORBITAL DYNAMICS IN A SPHERICAL CAVITY...429

*N.M. Zhilin, T.N. Ulaeva, N.A. Chirikov, A.N. Kuznetsov*

INVESTIGATION OF SENSING LAYER IMMOBILIZATION EFFECTS  
ON THE SOLIDLY MOUNTED RESONATOR'S ELECTRICAL  
CHARACTERISTICS FOR GAS SENSOR APPLICATIONS...433