ABSTRACT AND REFERENCES

INFORMATION AND CONTROLLING SYSTEM

DOI: 10.15587/1729-4061.2018.131599

APPLICATION OF INTELLIGENT PROCESSING OF DATA FLOWS UNDER CONDITIONS OF RIVER NAVIGATION (p. 6-18)

Mikhail Aleinikov
State University of Infrastructure and Technologies, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-8084-450X

Vladymyr Doronin
State University of Infrastructure and Technologies, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-8387-2992

Vladyslav Panin
State University of Infrastructure and Technologies, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-7572-3682

Illya Tykhonov
State University of Infrastructure and Technologies, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-7628-3914

Implementation of a context-oriented approach for intelligent processing of navigation data flows in operation of water vehicles was considered. The initial sample of processing data flows in the conditions of the current pilot navigation method does not correspond to the regularities of functioning of a complex object with the modern instrumental method of navigation. Solution to the problem consists in overcoming difficulties by defining complex problems of the processes that differ from a simple sum of parameters of elements with the same type of multilevel connections.

A method for processing flows of navigation data under continuous mode was proposed. In the process of study, combining of information from multiple sources with finding more accurate and reliable data was considered. The method of estimation of problem solutions is the criterion method where each single alternative is estimated by a specific number (criterion, objective function). Comparison of alternatives was reduced to a comparison of the corresponding numbers. Various variants of the choice of alternatives and criteria of optimality were taken into account: the criteria of Bayes, Wald, Jain, Laplace. The method used is characterized by multicriteria conditions. Methods of decision-making in games with environment, normalization, the use of neural networks based on the context were applied. The architecture of an artificial neural network was constructed.

The study was conducted with the aim of obtaining a stable structure of the system with certain classes of input signals based on artificial neural networks. It is interesting from the theoretical point of view to obtain a parametric variation of the parameters within the specified limits of the optimality criteria. The conducted experiments confirmed efficiency of the use of the proposed methods. The most constructive direction of intelligent processing of the navigational data flow is the context-oriented approach. Implementation of this approach guarantees high level of observance of accuracy criteria in the conditions of river navigation.

An applied aspect of using the results obtained in the process of study is the possibility to abandon the pilotage method of navigation and installation of coastal and floating means of navigation equipment. An important result is derivation of a differentiated mapping of the depth array on an electronic chart. The obtained results give grounds to assert the possibility of introducing the proposed context-oriented approach to real navigation.

Keywords: safety of navigation, electronic navigation, traffic criteria, artificial intelligence, neural network.

References

1. Weintrit, A. (2010). Telematic Approach to e-Navigation Architecture. Transport Systems Telematics, 1–10. doi: 10.1007/978-3-642-16472-9_1
2. Subbotin, S. et. al. (2012). Intellectual information technologies for the design of automated systems for diagnosing and recognizing images. Kharkiv, 318.
3. Nosovskyi, A. M., Baranov, H. L., Vasko, S. M., Panin, V. V., Tykhonov, I. V. (2014). Structural modeling and symbolic transformations for controlling the motion of vehicles. Kyiv, 310.
4. Doronin, V. (2015). System technology for the inception of operational tasks for the synthesis of the law of the exploitation of water transport. System of information boxes, 10, 186–191.
5. Brčic, D., Kos, S., ŽuŁkin, S. (2015). Navigation with ECDIS: Choosing the Proper Secondary Positioning Source. TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation, 9 (3), 317–326. doi: 10.12716/1001.09.03.03
6. Kazimierski, W., Zaniewicz, G., Hyla, T. (2017). Implementation of Voyage Assistant Module in Mobile Navigation System for Inland Waters. TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation, 11 (4), 683–689. doi: 10.12716/1001.11.04.15
7. ŽuŁkin, S., Brčic, D., Valčic, S. (2017). ECDIS Possibilities for BWE Adoption. TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation, 11 (3), 477–482. doi: 10.12716/1001.11.03.13
8. Aydogdu, Y. V., Yalcin, E., Yurtorren, C., Aksoy, S. (2014). A Discussion on e-Navigation and Implementation in Turkey. TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation, 8 (1), 81–87. doi: 10.12716/1001.08.01.9
9. Ackalic, T., Maslaric, M. (2012). Navigation conditions and the risk management in inland waterway transport on the middle Danube. Transport Problems, 7 (4), 13–24.
10. Bergmann, M. (2013). Integrated Data as backbone of e-Navigation. TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation, 7 (3), 371–374. doi: 10.12716/1001.07.03.07
11. Koshevyy, V., Shyshkin, O. (2015). ECDIS Modernization for Enhancing Addressed VHF Communication. TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation, 9 (3), 327–331. doi: 10.12716/1001.09.03.04

12. Barabash, O. V. (2012). Functional stability – the property of complex technical systems. Collection of scientific works of NAOU, 40, 225–229.
13. Bertalanfi, L. (1969). General theory of systems: a critical review. Moscow: Publishing house Progress.
14. Watson, H., Bulding, J. (2010). Executive Information Systems and other Decision Support Applications. New York: John Wiley & Sons Inc, 290–301.
15. Yakhyayeva, G. (2012). Fuzzy sets and neural networks. Moscow: Publishing house Intuit, 316.
16. Dli, M. (2013). Fuzzy sets and neural networks. Moscow. Publishing house Fizmatlit, 225.
17. Doronin, V. (2017). Application of evaluation criteria of functional sustainability instrumental method of navigation on Ukraine's Inland waterways. The XIII International Scientific Conference. Zheleznii Port, Ukraine, 178–181.
18. Ning, W., Dan, W., Tieshan, L. (2012). Novel Vessel Maneuvering Model via GEBF Based Fuzzy Neural Networks. Proceedings of the 31st Chinese Control Conference, Hefei, China, 708–726.
19. Ebada, A. (2007). Intelligent techniques-based approach for ship maneuvering simulations and analysis (Artificial Neural Networks Application). Institute of Ship Technology and Transport Systems. Germany, 156–172.
20. Valcic, M., Antonic, R., Tomas, V. (2011). Based Model for Ship Speed Prediction. Brodo Gradnja, 62 (4), 373–382.
21. Buckley, J. J., Hayashi, Y. (1994). Fuzzy neural networks: A survey. Fuzzy Sets and Systems, 66 (1), 1–13. doi: 10.1016/0165-0114(94)90297-6
22. Raymond M., Schell G. Management Information Systems. Prentice Hall, Upper Sadle River. New Jersey, 2013. P. 56–66.
21. Buckley, J. J., Hayashi, Y. (1994). Fuzzy neural networks: A survey. Fuzzy Sets and Systems, 66 (1), 1–13. doi: 10.1016/0165-0114(94)90297-6
22. Raymond, M., Schell, G. (2013). Management Information Systems. Prentice Hall, Upper Sadle River. New Jersey, 56–66.
23. Melin, P., Castillo, O., Ramírez, E. G., Kacprzyk, J., Pedrycz, W. (Eds.) (2007). Analysis and Design of Intelligent Systems using Soft Computing Techniques. Advances in Soft Computing. Springer. doi: 10.1007/978-3-540-72432-2
24. Hopple, G. (2008). The state of the decision support systems. QED Information Sciences, 246.
25. Doronin, V. (2018). Applicdtion of the system analysis of implementation of the instrumental method of navigation on Inland waterways of Ukraine. Radio Electronics, Computer Science, Control, 2 (3), 47–62.

DOI: 10.15587/1729-4061.2018.132210

INVESTIGATION OF THE CHANGE IN THE STRENGTH PROPERTIES OF A SOIL MASS BY MECHANICAL SENSING (p. 19-26)

Stefan Zaichenko
National Technical University of Ukraine
«Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-8446-5408

Oleksandr Frolov
National Technical University of Ukraine
«Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-9833-6236

Stanislav Stovpnik
National Technical University of Ukraine
«Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-5664-8680

Yurii Veremiichuk
National Technical University of Ukraine
«Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-0258-0478

Determination of depth distribution of strength characteristics and comparison with analytically determined values allows obtaining data on the depth of various morphological horizons, the presence of voids and inclusions. The sensing process occurs due to soil strengthening, which was considered in the analysis of changes in the penetration force. The present stage of development of means for determining the soil properties is characterized by the application of mechatronic systems, which allow obtaining data with high accuracy, reliability and performance. In order to develop the experimental sample, the basic approaches to the creation of a geomechatronic complex for surface soil monitoring, which determine the main objectives, application scope, quality criteria were developed. The presence of geotechnical deviations in the soil mass is accompanied by changes in the penetration force, which was proposed to be measured by a strain gauge dynamometer with the recording of the rod penetration depth. The program algorithm used is a cyclic structure in which the data are logically recorded from the force sensor and the step of the rod, which determines its position. The implementation of the developed algorithm allows determining penetration forces and changes in the strength parameters of the soil mass with high accuracy (0.05 %), which makes it possible, by comparing with the analytically determined distribution, to reveal the position of geoanomalies.

Keywords: geomechatonic complex, penetration force, strength characteristics.

References

1. ISO 22476-3:2005. Geotechnical investigation and testing – Field testing – Part: Standard penetration test (2005). 14.
2. Shcherbakov, G. N. (2005). Antenno-kontaktnyy metod obnaruzheniya lokal'nyh ob'ektov v ukryvayushchih sredah. Elektrotekhnika, 33–37.
3. Korobeynikov, L. V., Mingalev, V. V. (2006). Opyty dinamicheskogo zondirovaniya a arheologii. Regulyarnaya i haoticheskaya dinamika. Izhevsk, 60.
4. Denysiuk, C. P., Zaichenko, S. V., Vovk, O. O., Shevchuk, N. A., Danilin, A. V. (2017). Zasady stvorennia mobilnoi systemy heotekhnichnoho monitorynhu ekzemptovanykh terytoriyi. Enerhetyka: ekonomika, tekhnolohiyi, ekolohiya, 2, 7–12.
5. Kokodeev, A. V. Ovchinnikov, I. G. (2014). Obsledovanie, monitoring, vypolnenie remontnyh i vosstanovitel'nyh rabot na podvodnyh chastyah transportnyh sooruzheniy. Naukovedenie, 5 (24), 3–36.
6. Explosive ordnance disposal (2001). IMAS. Geneva, 8.
7. Zaichenko, S., Shalenko, V., Shevchuk, N., Vapnichna, V. (2017). Development of a geomechatronic complex for the geotechnical monitoring of the contour of a mine working. Eastern-European Journal of Enterprise Technologies, 3 (9 (87)), 19–25. doi: 10.15587/1729-4061.2017.102067
8. Siegwart, R. I. (2004). Introduction to autonomous mobile robots. MIT Press, 317.

9. Bares, J. E., Wettergreen, D. S. (1999). Dante II: Technical Description, Results, and Lessons Learned. The International Journal of Robotics Research, 18 (7), 621–649. doi: 10.1177/02783649922066475
10. Durrant-Whyte, H., Majumder, S., Thrun, S., de Battista, M., Scheding, S. (2003). A Bayesian Algorithm for Simultaneous Localisation and Map Building. Robotics Research, 49–60. doi: 10.1007/3-540-36460-9_4
11. Parcheta, C. E., Pavlov, C. A., Wiltsie, N., Carpenter, K. C., Nash, J., Parness, A., Mitchell, K. L. (2016). A robotic approach to mapping post-eruptive volcanic fissure conduits. Journal of Volcanology and Geothermal Research, 320, 19–28. doi: 10.1016/j.jvolgeores.2016.03.006
12. Sedin, V. L., Ul'yanov, V. Yu., Bausk, E. A., Ul'yanov, Ya. V. (2016). Metodika ispytaniy gruntov universal'nym dinamicheskim zondom liate. Visnyk Prydniprovskoi derzhavnoi akademiyi budivnytstva ta arkhitektury, 2 (215), 19–24.
13. Ivanenko, I. (2013). Prystriy dlia vyznachennia tverdosti hruntu. Tekhniko-tekhnolohichni aspekty rozvytku ta vyprobuvannia novoi tekhniky i tekhnolohiy dlia silskoho hospodarstva Ukrainy, 17, 128–136.
14. Hills, D., Nowell, D., Barber, J. R. (2016). KL Johnson and contact mechanics. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 231 (13), 2451–2458. doi: 10.1177/0954406216634121
15. Bazhenov, V. G. (2014). Analiz modeley i metodov rascheta dvizheniya tel vrashcheniya minimal'nogo soprotivleniya v gruntovyh sredah. Materialy XX mezhdunarodnogo simpoziuma «dinamicheskie i tekhnologicheskie problemy mekhaniki konstrukciy i sploshnyh sred» imeni A. G. Gorshkova. 2014. P. 14–16.
16. Kotov, V. L. (2015). The influence of stress distribution on stability of the displacement of conical indenter into the soil medium. Materials Physics and Mechanics, 1, 91–94.
17. Ganneau, F. P., Constantinides, G., Ulm, F.-J. (2006). Dual-indentation technique for the assessment of strength properties of cohesive-frictional materials. International Journal of Solids and Structures, 43 (6), 1727–1745. doi: 10.1016/j.ijsolstr.2005.03.035
18. Ruestes, C. J., Stukowski, A., Tang, Y., Tramontina, D. R., Erhart, P., Remington, B. A. et. al. (2014). Atomistic simulation of tantalum nanoindentation: Effects of indenter diameter, penetration velocity, and interatomic potentials on defect mechanisms and evolution. Materials Science and Engineering: A, 613, 390–403. doi: 10.1016/j.msea.2014.07.001
19. Sun, Z., Li, F., Cao, J., Ma, X., Li, J. (2017). A method for determination of intrinsic material length base on strain gradient study in spherical indentation. International Journal of Mechanical Sciences, 134, 253–262. doi: 10.1016/j.ijmecsci.2017.10.016
20. Chen, J., Bull, S. J. (2009). On the factors affecting the critical indenter penetration for measurement of coating hardness. Vacuum, 83 (6), 911–920. doi: 10.1016/j.vacuum.2008.11.007
21. Bivin, Yu. K. (2010). Mekhanika dinamicheskogo pronikaniya v gruntovuyu sredu. Izvestiya Rossiyskoy akademii nauk. Mekhanika tverdogo tela, 6, 157–191.
22. Kotov, V. L. (2013). Opredelenie parametrov kvadratichnoy modeli lokal'nogo vzaimodeystviya pri vnedrenii sfericheskogo udarnika v myagkiy grunt. Problemy prochnosti i plastichnosti, 1, 47–55.
23. Bazhenov, V. G. (2011). Matematicheskoe modelirovanie nestacionarnyh processov udara i pronikaniya i identifikaciya svoystv myagkih gruntovyh sred. Vestnik Nizhegorodskogo universiteta im. N. I. Lobachevskogo, 4, 139–149.
24. Ben-Dor, G., Dubinsky, A., Elperin, T. (2007). Shape Optimization of Impactors Against a Finite Width Shield Using a Modified Method of Local Variations#. Mechanics Based Design of Structures and Machines, 35 (2), 113–125. doi: 10.1080/15397730701196629
25. Rubin, M. B., Kositski, R., Rosenberg, Z. (2016). Essential physics of target inertia in penetration problems missed by cavity expansion models. International Journal of Impact Engineering, 98, 97–104. doi: 10.1016/j.ijimpeng.2016.09.002
26. Boldyrev, G. G. (2010). Ispytaniya gruntov metodami penetracii. Inzhenernye izyskaniya, 11, 30–42.
27. Boldyrev, G. G. (2014). Interpretaciya rezul'tatov polevyh ispytaniy s cel'yu opredeleniya deformacionnyh harakteristik gruntov. Inzhenernye izyskaniya, 5, 86–97.
28. Kravets, S. V., Posmitiukha, O. P., Suponiev, V. N. (2017). Analitychnyi sposib vyznachennia oporu zanurennia konusnoho nakonechnyka v grunt. Stroitel'stvo. Materialovedenie. Mashinostroenie. Seriya: Pod'emno-transportnye, stroitel'nye i dorozhnye mashiny i oborudovanie, 97, 91–98.
29. Kravets, S. V., Posmitjukha, O. P., Suponyev, V. M. (2017). Determining of the equivalent and optimum diameters of cone-cylinder tip with soil broaching spurs. Science and Transport Progress. Bulletin of Dnipropetrovsk National University of Railway Transport, 4 (70), 89–97. doi: 10.15802/stp2017/109483
30. Rakhmanov, S. R. (2015). Optimization of process dynamics press roll billets firmware. Izvestiya Visshikh Uchebnykh Zavedenii. Chernaya Metallurgiya, 57 (4), 15–20. doi: 10.17073/0368-0797-2014-4-15-20
31. Rahmanov, S. R. (2011). Issledovanie dinamiki processa proshivki trubnoy zagotovki na proshivnom stane. Vibratsii v tekhnitsi ta tekhnolohiyakh, 1, 46–52.
32. Timoshpol'skiy, V. I. (2015) Raschet usiliya proshivki pri izgotovlenii trub. Lit'e i metallurgiya, 4, 50–53.
33. Johnson, K. L. (1987). Contact mechanics. Cambridge university press, 456. doi: 10.1017/cbo9781139171731

DOI: 10.15587/1729-4061.2018.133159

DEVELOPMENT OF THE SYSTEM TO CONTROL MILK ACIDITY IN THE MILK PIPELINE OF A MILKING ROBOT (p. 27-33)

Oleksandr Nanka
Kharkiv Petro Vasylenko National Technical University of Agriculture, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-4079-8822

Viktor Shigimaga
Kharkiv Petro Vasylenko National Technical University of Agriculture, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-2508-8742

Andriy Paliy
Kharkiv Petro Vasylenko National Technical University of Agriculture, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-9525-3462

Vitaliy Sementsov
Kharkiv Petro Vasylenko National Technical University of Agriculture, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-4423-352X

Anatoliy Paliy
National Scientific Center «Institute of Experimental and Clinical Veterinary Medicine», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-9193-3548

Acidity characterizes the suitability of milk for primary processing and is one of the key parameters monitored when accepting it at a dairy plant. Therefore, it is important to timely separate milk with lowered acidity in the process of milking by a robot. However, no technical means for the detection and separation of milk with lowered acidity in a milk pipeline were designed for robotic milking systems.

Based on the results of experimental study, we established a linear correlation dependence of milk acidity, using a traditional Turner method, on pH. We calculated parameters for the main and additional containers, for milk of superior grade and for non-standard milk in terms of acidity. Linear parameters are determined for inserting into the main milk pipeline of a robot the measuring pH-electrode and a tee with electromagnetic valve for the automated discharge of non-standard milk. Based on the experimental study and our calculations, we developed a project of the technical system for the robotic cow milking technology. A standard technology is complemented by a process of automated measurement of milk pH in a flow, which is implemented using a high-speed transistor pH-FT electrode with a measuring unit.

Control over milk pH in a flow during milking makes it possible to operatively solve two tasks at a time – to improve the accuracy of estimating the quality of starting raw materials and to correct the feed of cows in order to standardize the acidity of milk required for its acceptance at a milk processing plant. We thus exclude a labor-intensive laboratory operation for determining the acidity because this indicator has already been measured during robotic milking process. Therefore, our improvement of technology for robotic milking will make it possible to more accurately assess the quality of raw milk using milking robots that are included in the system of machines for precision cattle breeding.

Keywords: milking robot, milk pipeline, milk, semiconductor pH-FT-electrode, acidity, Turner degree.

References

1. Paliy, A. (2014). Perspective directions of development of dairy cattle breeding in Ukraine. Izvestiya Velikolukskoy GSKHA, 2, 10–15.
2. Naumenko, A. A., Chigrin, A. A., Paliy, A. P. (2014). Robotic systems in dairy cattle breeding. Visnyk Kharkivskoho natsionalnoho tekhnichnoho universytetu silskoho hospodarstva imeni Petra Vasylenka, 144, 92–96.
3. Marcussen, D., Laursen, A. K. (2007). The Basics of Dairy Cattle Production. 1st ed. Danish Agricultural Advisory Service, National Centre, Aarhus, Denmark, 234.
4. Lutsenko, M. M., Ivanyshyn, V. V., Smolyar, V. I. (2006). Perspective technologies of milk production. Kyiv: VC "Academy", 191.
5. DSTU 3662-97. ow's milk is not assembled. Requirements for the purchase (1997). Kyiv, 13.
6. Meijering, A., Hogeveen, H., Koning, de C. J. A. M. (Eds.) (2004). Automatic Milking, a better understanding. Book Type: Edited Collection, 544. doi: 10.3920/978-90-8686-525-3
7. Hupfauer, M., Hecht, H., Ruhmann, N. (1966). Bauarten von Melkanlagen. Landtechnik, 11, 402–407.
8. Kitikov, V. O. (2008). Scientific and technological approaches in the development of advanced technologies in dairy cattle breeding on the basis of robotic equipment. Mechanization and electrification of agriculture, 42, 160–165.
9. Hillerton, J. E., Ohnstad, I., Baines, J. R., Leach, K. A. (2002). Performance differences and cow responses in new milking parlours. Journal of Dairy Research, 69 (01). doi: 10.1017/s0022029901005283
10. Bergveld, P. (2003). ISFET Theory and Practice. IEEE Sensor Conference. Toronto, Canada, 1–26.
11. Turner, E. (1992). Biosensors: basic applications. Moscow: Mir, 614.
12. Xueji, Z., Huangxain, Ju., Joseph, W. (2008). Electrochemical sensors, biosensors and their biomedical applications. Elsevier, Academic Press, 616. doi: 10.1016/b978-0-12-373738-0.x5001-6
13. Borstlap, D. (2006). High-k dielectrics as bioelectronic interface for field-effect transistors. Julich, Institut fur Biound Nanosysteme. Bioelectronik, 143.
14. Dzyadevych, S. V., Soldatkin, A. P., El'skaya, A. V., Martelet, C., Jaffrezic-Renault, N. (2006). Enzyme biosensors based on ion-selective field-effect transistors. Analytica Chimica Acta, 568 (1-2), 248–258. doi: 10.1016/j.aca.2005.11.057
15. Kukla, O. L., Pavlyuchenko, O. S., Goltvyankiy, Yu. V. (2008). Sensory massifs based on differential ISTT elements for monitoring of toxic substances of natural and artificial origin. Sensor electronics and microsystem technologies, 2, 58–68.
16. Arkhipova, V. M., Shelyakina, M. K., Kukla, O. L. (2009). Biosensor analysis of potato glycoalkaloids. Magazine Biotechnology, 3, 64–73.
17. Marchenko, S. V., Nazarenko, O. A., Kukla, O. L. (2009). Development of creatinine-sensitive biosensor for medical use. Sensor electronics and microsystem technologies, 4, 55–62.
18. Pavlyuchenko, A. S., Kukla, A. L., Goltvyansky, Yu. V. (2010). Application of ion-selective field-effect transistors for enzymatic analysis of toxic impurities in aqueous solutions. Technology and design in electronic equipment, 3, 35–46.
19. Shigimaga, V. A., Faizullin, R. A. (1998). Method for measuring the pH of meat. Svinovodstvo, 3, 14–15.
20. GOST 3624-92. Milk and dairy products. Titrimetric methods for determining acidity (2009). Moscow, 7.
21. GOST 8.135-2004. State system for ensuring the uniformity of measurements (ICG). Standard-titers for preparation of buffer solutions – working standards of pH of the 2nd and 3rd digits. Technical and metrological characteristics. Methods for their determination (2008). Moscow, 9.
22. Skoryk, O. P., Polupanov, V. M. (Eds.) (2009). Design of technology and equipment for animal husbandry. Kharkiv: KhNTUAS, 429.
23. Paliy, A. P., Paliy, A. P., Naumenko, O. A. (2015). Innovative technologies and technical systems in dairy cattle breeding. Kharkiv: Miskdruk, 324.
24. Laurs, A., Priekulis, J., Purins, M. (2009). Studies of operating parameters in milking robots. 8th International Scientific Conference "Engineering for rural development". Jelgava, 38–42.
25. Paliy, A. P. (2016). Innovative foundations for the production of high-quality milk. Kharkiv: Miskdruk, 270.
26. Koning, de K., Ouweltjs, W. (2000). Maximising the milking capacity of an automatic milking system. In: Proceedings of the International Symposium "Robotic Milking". Lelystad, Netherland, 38–46.
27. Artmann, R. (2005). Ergebnisse aus langjährigem Praxiseinsatz von Melkrobotern. In: Konferenzmaterialen der 7 Internationalen

Tagung “Bau, Technik und Umwelt in der landwirtschaftlichen Nutztierhaltung 2005”. KTBL: Darmstadt, 145–150.

DOI: 10.15587/1729-4061.2018.133127

STUDYING THE RECURRENT DIAGRAMS OF CARBON MONOXIDE CONCENTRATION AT EARLY IGNITIONS IN PREMISES (p. 34-40)

Boris Pospelov
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-0957-3839

Vladimir Andronov
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-7486-482X

Evgeniy Rybka
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-5396-5151

Ruslan Meleshchenko
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-5411-2030

Pavlo Borodych
National University of Civil Defence of Ukraine, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-9933-8498

It was shown that the methods of nonlinear dynamics, surpassing traditional methods of temporal, frequency or frequency-temporal analysis of dangerous ignition factors may be used for early detection of ignitions in premises. The existence of carbon monoxide in gas medium was found to be most dangerous at fires in premises. The theoretical grounds for studying recurrent diagrams of carbon monoxide concentration in gas medium were substantiated. The modification of recurrent distance diagrams, based on power representations was proposed, making it possible to highlight selectively or to smooth structural features of configuration of recurrent points of distance diagrams. Results of research into recurrent diagrams of dynamics of carbon monoxide concentration show that the specified factor of ignition of materials has generally not stochastic, but chaotic dynamics. It was qualitatively determined that dynamics of carbon monoxide concentration in gas medium has non-uniformed distribution of points. In this case, the configuration of clustering of recurrent points of diagrams for various flammable materials varies and can be used for detecting the type and the beginning of early ignition of combustible material. The established fact of chaotic dynamics of carbon monoxide concentration in gas medium at early ignition of materials should be taken into consideration in the development of new technologies for reliable detection of early ignitions in premises. The data, obtained in the research, are important for deeper understanding of dynamics of the process of carbon monoxide formation in gas medium in non-airtight premises at ignition of various materials, because it is related to saving lives of people who are in these premises and their timely evacuation.

Keywords: recurrent diagrams, concentration of carbon monoxide, gas medium, non-airtight premises.

References

1. Poulsen, A., Jomaas, G. (2011). Experimental Study on the Burning Behavior of Pool Fires in Rooms with Different Wall Linings. Fire Technology, 48 (2), 419–439. doi: 10.1007/s10694-011-0230-0
2. Zhang, D., Xue, W. (2010). Effect of heat radiation on combustion heat release rate of larch. Journal of West China Forestry Science, 39, 148.
3. Ji, J., Yang, L., Fan, W. (2003). Experimental study on effects of burning behaviours of materials caused by external heat radiation. Journal of Combustion Science and Technology, 9, 139.
4. Peng, X., Liu, S., Lu, G. (2005). Experimental analysis on heat release rate of materials. Journal of Chongqing University, 28, 122.
5. Andronov, V., Pospelov, B., Rybka, E. (2016). Increase of accuracy of definition of temperature by sensors of fire alarms in real conditions of fire on objects. Eastern-European Journal of Enterprise Technologies, 4 (5 (82)), 38–44. doi: 10.15587/1729-4061.2016.75063
6. Andronov, V., Pospelov, B., Rybka, E. (2017). Development of a method to improve the performance speed of maximal fire detectors. Eastern-European Journal of Enterprise Technologies, 2 (9 (86)), 32–37. doi: 10.15587/1729-4061.2017.96694
7. Pospelov, B., Andronov, V., Rybka, E., Skliarov, S. (2017). Design of fire detectors capable of self-adjusting by ignition. Eastern-European Journal of Enterprise Technologies, 4 (9 (88)), 53–59. doi: 10.15587/1729-4061.2017.108448
8. Pospelov, B., Andronov, V., Rybka, E., Skliarov, S. (2017). Research into dynamics of setting the threshold and a probability of ignition detection by selfadjusting fire detectors. Eastern-European Journal of Enterprise Technologies, 5 (9 (89)), 43–48. doi: 10.15587/1729-4061.2017.110092
9. Pospelov, B., Rybka, E., Meleshchenko, R., Gornostal, S., Shcherbak, S. (2017). Results of experimental research into correlations between hazardous factors of ignition of materials in premises. Eastern-European Journal of Enterprise Technologies, 6 (10 (90)), 50–56. doi: 10.15587/1729-4061.2017.117789
10. Korn, G. A., Korn, T. M. (2000). Mathematical handbook for scientists and engineers: definitions, theorems, and formulas for reference and review. General Publishing Company, 1151.
11. Bendat, J. S., Piersol, A. G. (2010). Random data: analysis and measurement procedures, fourth edition. John Wiley & Sons. doi: 10.1002/9781118032428
12. Shafi, I., Ahmad, J., Shah, S. I., Kashif, F. M. (2009). Techniques to Obtain Good Resolution and Concentrated Time-Frequency Distributions: A Review. EURASIP Journal on Advances in Signal Processing, 2009 (1). doi: 10.1155/2009/673539
13. Singh, P. (2016). Time-frequency analysis via the fourier representation. HAL, 1–7. Available at: https://hal.archives-ouvertes.fr/hal-01303330
14. Bundy, M., Hamins, A., Johnsson, E. L., Kim, S. C., Ko, G. H., Lenhert, D. B. (2007). Measurements of heat and combustion products in reduced-scale ventilation-limited compartment fires. NIST Technical Note 1483, 155. doi: 10.6028/nist.tn.1483
15. Pretrel, H., Querre, P., Forestier, M. (2005). Experimental Study of Burning Rate Behaviour in Confined and Ventilated Fire Compartments. Fire Safety Science, 8, 1217–1228. doi: 10.3801/iafss.fss.8-1217
16. Pospelov, B., Andronov, V., Rybka, E., Popov, V., Romin, A. (2018). Experimental study of the fluctuations of gas medium parameters as

early signs of fire. Eastern-European Journal of Enterprise Technologies, 1 (10 (91)), 50–55. doi: 10.15587/1729-4061.2018.122419
17. Stankovic, L., Dakovic, M., Thayaparan, T. (2014). Time-frequency signal analysis. Kindle edition, Amazon, 655.
18. Avargel, Y., Cohen, I. (2010). Modeling and Identification of Nonlinear Systems in the Short-Time Fourier Transform Domain. IEEE Transactions on Signal Processing, 58 (1), 291–304. doi: 10.1109/tsp.2009.2028978
19. Giv, H. H. (2013). Directional short-time Fourier transform. Journal of Mathematical Analysis and Applications, 399 (1), 100–107. doi: 10.1016/j.jmaa.2012.09.053
20. Pospelov, B., Andronov, V., Rybka, E., Popov, V., Semkiv, O. (2018). Development of the method of frequencytemporal representation of fluctuations of gaseous medium parameters at fire. Eastern-European Journal of Enterprise Technologies, 2 (10 (92)), 44–49. doi: 10.15587/1729-4061.2018.125926
21. Nishikawa, H., Matsumura, K., Okino, S., Watanabe, T., Suda, F. (2015). Detection of the chaotic flow instability in a natural convection loop using the recurrence plot analysis and the nonlinear prediction. Journal of Thermal Science and Technology, 10 (2), JTST0028–JTST0028. doi: 10.1299/jtst.2015jtst0028
22. Marwan, N., Donges, J. F., Zou, Y., Donner, R. V., Kurths, J. (2009). Complex network approach for recurrence analysis of time series. Physics Letters A, 373 (46), 4246–4254. doi: 10.1016/j.physleta.2009.09.042
23. Rusinek, R., Zaleski, K. (2015). Dynamics of thin-walled element milling expressed by recurrence analysis. Meccanica, 51 (6), 1275–1286. doi: 10.1007/s11012-015-0293-y
24. Kabiraj, L., Saurabh, A., Nawroth, H., Paschereit, C. O. (2015). Recurrence Analysis of Combustion Noise. AIAA Journal, 53 (5), 1199–1210. doi: 10.2514/1.j053285
25. Marwan, N., Carmenromano, M., Thiel, M., Kurths, J. (2007). Recurrence plots for the analysis of complex systems. Physics Reports, 438 (5-6), 237–329. doi: 10.1016/j.physrep.2006.11.001
26. Llop, M. F., Gascons, N., Llauró, F. X. (2015). Recurrence plots to characterize gas–solid fluidization regimes. International Journal of Multiphase Flow, 73, 43–56. doi: 10.1016/j.ijmultiphaseflow.2015.03.003
27. Zbilut, J. P., Thomasson, N., Webber, C. L. (2002). Recurrence quantification analysis as a tool for nonlinear exploration of nonstationary cardiac signals. Medical Engineering & Physics, 24 (1), 53–60. doi: 10.1016/s1350-4533(01)00112-6
28. Andronov, V., Pospelov, B., Rybka, E., Skliarov, S. (2017). Examining the learning fire detectors under real conditions of application. Eastern-European Journal of Enterprise Technologies, 3 (9 (87)), 53–59. doi: 10.15587/1729-4061.2017.101985

DOI: 10.15587/1729-4061.2018.131945

THEORETICAL AND EXPERIMENTAL ASSESSMENTS OF ACCURACY OF NONORTHOGONAL MEMS SENSOR ARRAYS (p. 40-49)

Olha Sushchenko
National Aviation University, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-8837-1521

Yurii Bezkorovainyi
National Aviation University, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-5970-5150

Nataliia Novytska
National Aviation University, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-2212-3805

The paper deals with theoretical and practical assessments of nonorthogonal configurations of MEMS sensors based on both the uniaxial gyroscopes and the triaxial inertial measuring units. The main goal of the paper is research of the possibility to use nonorthogonal redundant configurations in navigation applications. Methods of inertial navigation, analytical mechanics, mathematical statistics and simulation were used in the research. Analysis of nonorthogonal redundant configurations of uniaxial MEMS sensor arrays including matrices of directional cosines has been carried out. Description of nonorthogonal redundant MEMS sensor array based on inertial measuring units (MPU-6050) is represented. Tables of directional cosines for nonortogonal redundant MEMS arrays based on inertial measuring units with such constructive elements as triangular and tetragonal pyramids are obtained. The mutual location of measuring axes for these configurations is given. Features of dynamic test including equipment possibilities and technique of random errors determination are described. Using of the three-degree-of-freedom test bench provides the simulation of the developed MEMS sensor arrays in conditions close to the real operation. The theoretical assessment of accuracy of nonorthogonal redundant MEMS sensor arrays based on both the uniaxial gyroscopes and the triaxial inertial measuring units is carried out. The assessment is implemented using correlation matrices of errors. The experimental assessment of the MEMS array based on triaxial inertial measuring units is determined based on the results of the dynamic analysis. The appropriate graphical dependences including graphs of relative variances and histograms of the random errors distribution are presented. Comparative analysis of the obtained assessments is given. The results can be useful for the design of navigation systems, for example, unmanned aerial vehicles or rockets for the launch of satellites into orbit.

Keywords: dynamic analysis, experimental tests, MEMC sensor, nonorthogonal configuration, measuring error, redundant measuring instrument, theoretical assessment.

References

1. Pejsa, A. J. (1974). Optimum Skewed Redundant Inertial Navigators. AIAA Journal, 12 (7), 899–902. doi: 10.2514/3.49378
2. Epifanov, A. D. (1975). Nadezhnost' sistem upravleniya. Moscow: Mashinostroenie, 144.
3. Epifanov, A. D. (1978). Izbytochnye sistemy upravleniya letatel'nymi apparatami. Moscow: Mashinostroenie, 178.
4. Dai, X., Zhao, L., Shi, Z. (2013). Fault Tolerant Control in Redundant Inertial Navigation System. Mathematical Problems in Engineering, 2013, 1–11. doi: 10.1155/2013/782617
5. Rogne, R. H., Bryne, T. H., Fossen, T. I., Johansen, T. A. (2018). Redundant MEMS-Based Inertial Navigation Using Nonlinear Observers. Journal of Dynamic Systems, Measurement, and Control, 140 (7), 071001. doi: 10.1115/1.4038647
6. Song, J. W., Park, C. G. (2016). Optimal Configuration of Redundant Inertial Sensors Considering Lever Arm Effect. IEEE Sensors Journal, 16 (9), 3171–3180. doi: 10.1109/jsen.2015.2510545
7. Jafari, M. (2015). Optimal redundant sensor configuration for accuracy increasing in space inertial navigation system. Aerospace Science and Technology, 47, 467–472. doi: 10.1016/j.ast.2015.09.017

8. Jafari, M., Roshanian, J. (2012). Optimal Redundant Sensor Configuration for Accuracy and Reliability Increasing in Space Inertial Navigation Systems. Journal of Navigation, 66 (02), 199–208. doi: 10.1017/s0373463312000434
9. Sushchenko, O. A., Golitsyn, V. O. (2016). Data processing system for altitude navigation sensor. 2016 4th International Conference on Methods and Systems of Navigation and Motion Control (MSNMC). doi: 10.1109/msnmc.2016.7783112
10. Larin, V. B., Tunik, A. A. (2015). Fault-tolerant strap-down inertial navigation systems with external corrections. Applied and Computational Mathematics, 14 (1), 23–37.
11. Larin, V. B., Tunik, A. A. (2013). On Inertial-Navigation System without Angular-Rate Sensors. International Applied Mechanics, 49 (4), 488–499. doi: 10.1007/s10778-013-0582-x
12. Chikovani, V., Sushchenko, O., Tsiruk, H. (2016). Redundant information processing techniques comparison for differential vibratory gyroscope. Eastern-European Journal of Enterprise Technologies, 4 (7 (82)), 45–52. doi: 10.15587/1729-4061.2016.75206
13. Parshin, A. P., Nemshilov, Y. A. (2016). Development of measurement UAV attitude control unit with non-orthogonal arrangement of sensing elements. Modern technics and technologies, 3. Available at: http://technology.snauka.ru/2016/03/9697
14. Sushchenko, O. A., Bezkorovainyi, Y. N., Novytska, N. D. (2017). Non-orthogonal redundant configurations of inertial sensors. 2017 IEEE 4th International Conference Actual Problems of Unmanned Aerial Vehicles Developments (APUAVD). doi: 10.1109/apuavd.2017.8308780
15. MPU-6000 and MPU-6050 Product Specification. Available at: https://store.invensense.com/datasheets/invensense/MPU-6050_DataSheet_.pdf
16. Lurie, A. I. (2002). Analytical mechanics. Springer, 864. doi: 10.1007/978-3-540-45677-3

DOI: 10.15587/1729-4061.2018.131150

ANALYSIS OF OPERATING MODES OF SINGLE-PHASE CURRENTSOURCE RECTIFIER WITH RECTANGULARSTEPPED PULSEWIDTH MODULATION (p. 50-57)

Oleksii Krasnov
Branch "Design and survey institute of railway transport" of Public Joint-Stock Company "Ukrainian zaliznytsia", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-7538-8965

Borys Liubarskyi
National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-2985-7345

Vladimir Bozhko
Branch "Design and survey institute of railway transport" of Public Joint-Stock Company "Ukrainian zaliznytsia", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-6068-2881

Oleksandr Petrenko
O. M. Beketov National University of Urban Economy in Kharkiv, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-4027-4818

Oksana Dubinina
National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-6928-0325

Ramil Nuriiev
National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-5034-7350

The operating modes of the single-phase active current-source rectifier in the case of rectangular-stepped pulse-width modulation and load in the form of DC traction motor are investigated. The single-phase bridge rectifier circuit with a discharge diode is considered. The mathematical model of the rectifier is developed and the main ratios for pulse-width modulation with rectangular-stepped modulating signal are determined. On the computer model, electromagnetic processes at three modulation frequencies (900, 1,200, 1,800 Hz) are studied. The features of the effect of the modulation depth and frequency on the rectifier power factor and the total harmonic voltage and current distortion in the mains supply are determined.

The DC motor for today remains the main type of the traction motor of the 25 kV, 50 Hz AC mainline electric locomotives in Ukraine and in some other countries. To power such motors, diode or thyristor rectifiers are used. At the same time, it is known that converters on fully controlled semiconductor devices provide higher power efficiency.

The studies allow determining what values of modulation frequency and depth provide a high power factor (more than 0.9) and minimum total harmonic voltage and current distortion distortions in the mains supply. This allows finding rational approaches to the selection of power circuits and control algorithms for active converters in the traction electric drive of electric locomotives. The efficiency of increasing the power factor and reducing the total harmonic voltage and current distortion can be achieved, first of all, by reducing the power consumption for traction of trains.

According to the set of selected comparison criteria, the active current-source rectifier with a modulation frequency of 1,200 Hz is the most suitable for implementation in the traction electric drive of the electric locomotive. Provision of high power characteristics in a wide range of traction loads can be achieved in the multi-zone circuit of such a converter.

Keywords: active current-source rectifier, power factor, pulse-width modulation, mathematical model.

References

1. Buriakovskyi, S., Babaiev, M., Liubarskyi, B., Maslii, A., Karpenko, N., Pomazan, D. et. al. (2018). Quality assessment of control over the traction valve-inductor drive of a hybrid diesel locomotive. Eastern-European Journal of Enterprise Technologies, 1 (2 (91)), 68–75. doi: 10.15587/1729-4061.2018.122422
2. Yeritsyan, B., Liubarskyi, B., Iakunin, D. (2016). Simulation of combined body tilt system of high-speed railway rolling stock. Eastern-European Journal of Enterprise Technologies, 2 (9 (80)), 4–17. doi: 10.15587/1729-4061.2016.66782
3. Liubarskyi, B., Petrenko, *O.*, Iakunin, D., Dubinina, O. (2017). Optimization of thermal modes and cooling systems of the induction traction engines of trams. Eastern-European Journal of Enterprise Technologies, 3 (9 (87)), 59–67. doi: 10.15587/1729-4061.2017.102236
4. Liubarskyi, B., Petrenko, *A.*, Shaida, V., Maslii, A. (2017). Analysis of optimal operating modes of the induction traction drives for establishing a control algorithm over a semiconductor transducer.

Eastern-European Journal of Enterprise Technologies, 4 (8 (88)), 65–72. doi: 10.15587/1729-4061.2017.109179

5. Shreyner, R. T. (2000). Matematicheskoe modelirovanie elektroprivodov peremennogo toka s poluprovodnikovymi preobrazovatelyami chastoty. Ekaterinburg: URO RAN, 654.
6. Pou, J., Wu, B. (2006). High Power Converters: Topologies, Controls and Applications. IEEE IECON. France.
7. Zak, V. V., Zarif'yan, A. A., Kolpahch'yan, P. G. (2011). Uluchshenie energeticheskih pokazateley elektrovozov peremennogo toka s zonno-faznym regulirovaniem napryazheniya. Visnyk Skhidnoukrainskoho natsionalnoho universytetu im. V. I. Dalia, 4 (158), 185–190.
8. Michalík, J., Molnár, J., Peroutka, Z. (2009). Single-Phase Current-Source Active Rectifier: Control Strategy under Distorted Power Supply Voltage. Przegląd Elektrotechniczny, 85 (7), 148–453.
9. Yagovkin, D. A. (2015). Razrabotka matematicheskoy modeli vypryamitel'no-invertornogo preobrazovatelya na IGBT-tranzistorah dlya elektrovoza peremennogo toka i ego bloka upravleniya v rezhime tyagi. Sovremennye tekhnologii. Sistemniy analiz. Modelirovanie, 3 (47), 197–202.
10. Michalík, J., Molnár, J., Peroutka, Z. (2012). Active Elimination of Low-Frequency Harmonics of Traction Current-Source Active Rectifier. Transactions on Electrical Engineering, 1 (1), 30–35.
11. Michalik, J., Molnar, J., Peroutka, Z. (2012). Behavior of active current source rectifier under critical transient conditions in traction. 2012 15th International Power Electronics and Motion Control Conference (EPE/PEMC). doi: 10.1109/epepemc.2012.6397245
12. Michalík, J., Molnár, J., Peroutka, Z. (2011). Single Phase Current-Source Active Rectifier for Traction: Control System Design and Practical Problems. Advances in Electrical and Electronic Engineering, 86–89.
13. Chaudhary, P., Samanta, S., Sensarma, P. (2015). Input-Series–Output-Parallel-Connected Buck Rectifiers for High-Voltage Applications. IEEE Transactions on Industrial Electronics, 62 (1), 193–202. doi: 10.1109/tie.2014.2327556
14. Liu, Y., Su, M., Sun, Y. (2016). Active power compensation method for single-phase current source rectifier without extra active switches. IET Power Electronics, 9 (8), 1719–1726. doi: 10.1049/iet-pel.2015.0899
15. Efimov, A. A., Mel'nikov, S. Yu. (2016). Regulirovochnye harakteristiki aktivnyh odnofaznyh preobrazovateley toka. Zavalishinskie chteniya. Sankt-Peterburg: GUAP, 114–119.
16. Chaplygin, E. E. (2003). Invertory napryazheniya i ih spektral'nye modeli. Moscow: Izdatel'stvo MEI, 64.
17. Get'man, G. K. (20110. Teoriya elektricheskoy tyagi. Vol. 1. Dnepropetrovsk: Izd-vo Makoveckiy, 456.
18. Senko, V. I. et. al.; Senko, V. I. (Ed.) (2012). Elektronika i mikroskhemotekhnika. Vol. 4. Kn. 1. Sylova elektronika. Kyiv: Karavela, 640.
19. Strizhnev, A. G., Lednik, G. V. (2011). Sintez napryazheniy mnogokratnyh ravnomernyh ShIM, sozdannyh po stupenchatym funkciyam postroeniya. Energetika. Izvestiya vysshih uchebnyh zavedeniy i energeticheskih ob'edineniy SNG, 5, 24–30.
20. Shavelkin, A. A. (2012). Aktivniy vypryamitel' toka dlya preobrazovateley chastoty na baze avtonomnogo invertora toka. Nauchniy vestnik DGMA, 2 (10E), 139–147.
21. Kulinich, Yu. M. (2001). Adaptivnaya sistema avtomaticheskogo upravleniya gibridnogo kompensatora reaktivnoy moshchnosti elektrovoza s plavnym regulirovaniem napryazheniya. Habarovsk: DVGUPS, 153.

DOI: 10.15587/1729-4061.2018.132479

DEVELOPMENT OF ALGORITHMS FOR IMPROVING THE ACCURACY AND PERFORMANCE SPEED OF A FUNCTIONAL ANALOG-TO-DIGITAL CONVERTER (p. 58-69)

Lesya Mychuda
Lviv Polytechnic National University, Lviv, Ukraine
ORCID: http://orcid.org/0000-0001-8266-1782

This paper presents results of the study into the functional analog-to-digital conversion with a replaceable logarithm base. In known analog-to-digital converters, an increase in speed leads to a decrease in accuracy and vice versa. In contrast to the known methods, the method developed makes it possible to improve conversion rate without increasing errors. It was implemented in circuits with switched capacitors since it is the use of the phenomenon of redistribution and accumulation of charge in capacitor cells that makes it possible to create converters with a variable logarithm base.

Another advantage of such implementation consists in reliability, low power consumption and high manufacturability. This enables integration of the converters with a variable logarithm base into various automation devices, e.g. both in blocks of evaluators of stationary information and computing systems and miniature or mobile sensors of the object state.

In the course of the study, three algorithms of replacing the logarithm base with a ratio of capacitances have been developed. The conversion step height depends on the logarithm base and varies in each conversion sub-band. Descending sweep takes place in downward steps. It is suitable for large input signals. Ascending sweep in upward steps is better for small input values. Two-sided sweep is universal.

The conducted study had allowed us to estimate errors and conversion time of the proposed device. An optimal number (10) of steps – apportionings in each sub-band and an optimal number (4) of conversion sub-bands have been chosen. An error less than 0.005 % was obtained for these values during conversion time of 100 μs (40 clock cycles).

The results obtained make it possible to manufacture analog-to-digital functional converters with increased accuracy and speed, applicable for various industrial and scientific tasks. A special feature is the possibility of user's choice of the required accuracy and speed, even before the start of conversion.

Keywords: accuracy, speed, algorithm, variable base of the logarithm, functional analog-to-digital conversion, switched capacitors.

References

1. Szcześniak, A., Myczuda, Z. (2010). A method of charge accumulation in the logarithmic analog-to-digital converter with a successive approximation. Przegląd Elektrotechniczny (Electrical Review), 86 (10), 336–340.
2. Bako, N., Baric, A. (2011). A low-power fully differential 9-bit C-2C cyclic ADC. 2011 20th European Conference on Circuit Theory and Design (ECCTD). doi: 10.1109/ecctd.2011.6043599
3. Antoniw, U., Myczuda, Ł., Myczuda, Z., Szczesniak, A. (2013). Logarytmiczne przetworniki analogowo-cyfrowe z nagromadze-

niem ładunku i impulsowym sprzężeniem zwrotnym. Przegląd Elektrotechniczny (Electrical Review), 89 (8), 277–281.

4. Lee, J., Kang, J., Park, S., Seo, J., Anders, J., Guilherme, J., Flynn, M. P. (2009). A 2.5 mW 80 dB DR 36 dB SNDR 22 MS/s Logarithmic Pipeline ADC. IEEE Journal of Solid-State Circuits, 44 (10), 2755–2765. doi: 10.1109/jssc.2009.2028052
5. Sirimasakul, S., Thanachayanont, A., Jeamsaksiri, W. (2009). Low-power current-mode logarithmic pipeline analog-to-digital converter for ISFET based pH sensor. 2009 9th International Symposium on Communications and Information Technology. doi: 10.1109/iscit.2009.5341061
6. Lee, J., Rhew, H.-G., Kipke, D. R., Flynn, M. P. (2010). A 64 Channel Programmable Closed-Loop Neurostimulator With 8 Channel Neural Amplifier and Logarithmic ADC. IEEE Journal of Solid-State Circuits, 45 (9), 1935–1945. doi: 10.1109/vlsic.2008.4585958
7. Thanachayanont, A. (2015). A 1- V 330-n W 6-Bit current-mode logarithmic cyclic ADC for ISFET based pH digital readout system. Circuits System and Signal Processing, 34 (5), 1405–1429. doi: 10.1007/s00034-014-9908-0
8. Pagin, M., Ortmanns, M. (2017). Evaluation of logarithmic vs. linear ADCs for neural signal acquisition and reconstruction. 2017 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC). doi: 10.1109/embc.2017.8037828
9. Pooja Shukla, A., Shah, B. Dr. V. A. (2011). Implementation of logarithmic Analog to Digital Converter. Proceeding of the Multi-Conference 2011: Second International Conference on Signals, Systems & Automation (ICSSA-11), EC Departament, GII Patel College of Engineering & Technology. Gujarat, India, January, 538–542.
10. Qian, W., Cao, D., Cintron-Rivera, J. G., Gebben, M., Wey, D., Peng, F. Z. (2012). A Switched-Capacitor DC–DC Converter With High Voltage Gain and Reduced Component Rating and Count. IEEE Transactions on Industry Applications, 48 (4), 1397–1406. doi: 10.1109/tia.2012.2199731
11. Mychuda, L. (2016). Pat. No. 113138 UA. Loharyfmichniy analoho-tsyfroviy peretvoryuvach [Logarithmic Analog to Digital Converter]. No. *a*201604094, declareted: 14.04.2016; published: 12.12.2016, Bul. No. 23, 9.
12. Mychuda, L. (2016). Pat. No. 114064 UA. Sposib funktsional'noho analoho-tsyfrovoho peretvorennya [Method of Functional Analog to Digital Conversion]. No. a201607039, declareted: 29.06.2016; published: 10.04.2017, Bul. No. 7, 7.