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Methods for Prognostic and Diagnostic Assessment of Electromagnetic States of the Pump Drive Stator Based on the Park–Gorev Mathematical Model

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Abstract. This article presents information on the prospects for improving the reliability and efficiency of pumping units used for dewatering in open-pit coal mines. The possibilities for applying the Extended Kalman Filter in diagnostic and control systems for induction-motor-driven pump installations are described. The use of a mathematical model based on the Park–Gorev equations instead of conventional current-based monitoring methods is considered, and the advantages of reconstructing hidden electromagnetic parameters of the stator for predictive assessment of hydraulic load, pipeline operating conditions, and potential integrity violations are analysed. The implementation of model-based estimation techniques is shown to enhance the stability of the electric drive under variable hydraulic conditions, improve fault-detection sensitivity, and increase the overall energy efficiency of dewatering systems compared to traditional control approaches.

INTRODUCTION

Reliable operation of pumping units in coal mines is a key condition for safe and efficient coal mining, requiring high-precision diagnostics of the electric drive and the automation of drainage system control. One promising approach is the use of an extended Kalman filter, which enables predicting the stator current of an asynchronous motor and, based on its dynamics, assessing the water level, pipeline condition, and potential violations of its integrity. Modern research confirms the relevance of intelligent monitoring of pumping installations: works [1], [2] are devoted to the development of telemetric and multiparametric control systems for submersible electric drives; studies [3], [4] emphasize the influence of energy losses and load conditions on the efficiency of pumping complexes; [5] notes the impact of external factors on operational decisions. Thus, a literature review confirms the need to develop adaptive predictive algorithms based on EKFs to improve the reliability, energy efficiency, and stability of pumping units used in the mining industry.

EXPERIMENTAL RESEARCH

The experimental part of the study aims to construct and verify a mathematical model of an asynchronous motor with a short-circuit rotor, and to develop an algorithm for predicting the stator's electromagnetic parameters using an extended Kalman filter. The first stage was the development of a dynamic electric drive model based on the Park–Gorev equations, which allow us to represent electrical and mechanical processes in a rotating dq coordinate system. In accordance with the classical theory of electric machines, the Park–Gorev equations (1) describe the relationship between flow circuits, currents and electromagnetic torque, and also include the transition from a three-phase system to a two-axis orthogonal system, which provides a significant increase in the accuracy of modelling non-stationary modes.

$$\begin{bmatrix} U_s \\ U_r \end{bmatrix} = \begin{bmatrix} R_s & 0 \\ 0 & R_r \end{bmatrix} \begin{bmatrix} I_s \\ I_r \end{bmatrix} + \frac{d}{dt} \begin{bmatrix} \varphi_s \\ \varphi_r \end{bmatrix}, \quad (1)$$

To determine the values of the inductors of the stator and rotor of an asynchronous motor, appropriate matrices are used that take into account the mutual inductors between the stator and rotor windings, as well as the intrinsic inductors of each winding. These inductors can be described using matrices that define the inductive connections in the system.

$$L_0 = \frac{3}{2} L_h \begin{vmatrix} 1+\frac{3}{2}\sigma_s & -\frac{1}{2} & -\frac{1}{2} & \cos(\theta_r) & \cos\left(\theta_r+\frac{2\pi}{3}\right) & \cos\left(\theta_r+\frac{4\pi}{3}\right) \\ -\frac{1}{2} & 1+\frac{3}{2}\sigma_s & -\frac{1}{2} & \cos\left(\theta_r+\frac{4\pi}{3}\right) & \cos(\theta_r) & \cos\left(\theta_r+\frac{2\pi}{3}\right) \\ -\frac{1}{2} & -\frac{1}{2} & 1+\frac{3}{2}\sigma_s & \cos\left(\theta_r+\frac{2\pi}{3}\right) & \cos\left(\theta_r+\frac{4\pi}{3}\right) & \cos(\theta_r) \\ \cos(\theta_r) & \cos\left(\theta_r+\frac{4\pi}{3}\right) & \cos\left(\theta_r+\frac{2\pi}{3}\right) & 1+\frac{3}{2}\sigma_r & -\frac{1}{2} & -\frac{1}{2} \\ \cos\left(\theta_r+\frac{2\pi}{3}\right) & \cos(\theta_r) & \cos\left(\theta_r+\frac{4\pi}{3}\right) & -\frac{1}{2} & 1+\frac{3}{2}\sigma_r & -\frac{1}{2} \\ \cos\left(\theta_r+\frac{4\pi}{3}\right) & \cos\left(\theta_r+\frac{2\pi}{3}\right) & \cos(\theta_r) & -\frac{1}{2} & -\frac{1}{2} & 1+\frac{3}{2}\sigma_r \end{vmatrix} \quad (2)$$

The parameters of an asynchronous motor with a closed rotor, shown in Table 1, were used for modelling. These data include nominal phase resistance, inductors of the longitudinal and transverse axes, nominal frequency, moment of inertia, and damping coefficients. Based on these characteristics, a mathematical model was calibrated and its identification was performed under conditions corresponding to the actual operating modes of the pumping unit. The model was built in the MATLAB Simulink environment using a block-oriented representation of differential equations and specialised modules for modelling electromechanical systems.

TABLE 1. Asynchronous Motor with a Squirrel-Cage Rotor Imitation Model Parameters

Description	Parameter	Value
Rated angular speed	ω_n	314 rad/s
Stator resistance	R_s	0.52 Ohm
Rotor resistance	R_r	0.94 Ohm
Inductive resistance of the rotor	X_{rc}	0.61 Ohm
the total inductive resistance of the closed—circuit mode	X_{sc}	0.67 Ohm
Rated power	P_r	2200 W
Rated voltage	U_r	380 V

After obtaining deterministic dynamic responses of the asynchronous machine, the next stage was carried out: the development and implementation of an algorithm for estimating the stator state using the extended Kalman filter (EKF) (3,4). EKF is used for parametric identification and prediction of stator current under the influence of incomplete measurements, noise, and model nonlinearity. Unlike the standard Kalman filter, the EKF linearises nonlinear models at each iteration by calculating Jacobian matrices, enabling it to model electromagnetic processes in an asynchronous motor correctly.

$$x(t_{k+1}) = \begin{vmatrix} i_{s\alpha}(t_{k+1}) \\ i_{s\beta}(t_{k+1}) \\ \psi_{r\alpha}(t_{k+1}) \\ \psi_{s\beta}(t_{k+1}) \\ \omega_r(t_{k+1}) \end{vmatrix} = \begin{vmatrix} 1-\frac{T}{K_s} & 0 & \frac{L_m}{L_s' L_r'}T & \frac{L_m}{L_s' L_r'}\omega_r(t_k)T & 0 \\ 0 & 1-\frac{T}{K_s} & -\frac{L_m}{L_s' L_r'}\omega_r(t_k)T & \frac{L_m}{L_s' L_r'}T & 0 \\ \frac{L_m}{T_r}T & 0 & 1-\frac{T}{T_r} & -\omega_r(t_k)T & 0 \\ 0 & \frac{L_m}{T_r}T & \omega_r(t_k)T & 1-\frac{T}{T_r} & 0 \\ 0 & 0 & 0 & 0 & 1 \end{vmatrix} \cdot \begin{vmatrix} i_{s\alpha}(t_k) \\ i_{s\beta}(t_k) \\ \psi_{r\alpha}(t_k) \\ \psi_{s\beta}(t_k) \\ \omega_r(t_k) \end{vmatrix} + \begin{vmatrix} \frac{T}{L_s'} & 0 \\ 0 & \frac{T}{L_s'} \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{vmatrix} \cdot \begin{vmatrix} u_{s\alpha}(t_k) \\ u_{s\beta}(t_k) \end{vmatrix} \quad (3)$$

$$P(t_{k+1}) = \begin{vmatrix} 1-\frac{T}{K_s} & 0 & \frac{L_m}{L_s^{'}L_rT_r}T & \frac{L_m}{L_s^{'}L_r}\omega_r(t_k)T & \frac{L_m}{L_s^{'}L_r}T\psi_{r\beta}(t_k) \\ 0 & 1-\frac{T}{K_s} & -\frac{L_m}{L_s^{'}L_r}\omega_r(t_k)T & \frac{L_m}{L_s^{'}L_rT_r}T & -\frac{L_m}{L_s^{'}L_r}T\psi_{r\alpha}(t_k) \\ \frac{L_m}{T_r}T & 0 & 1-\frac{T}{T_r} & -\omega_r(t_k)T & -T\psi_{r\beta}(t_k) \\ 0 & \frac{L_m}{T_r}T & -\omega_r(t_k)T & 1-\frac{T}{T_r} & T\psi_{r\alpha}(t_k) \\ 0 & 0 & 0 & 0 & 1 \end{vmatrix} \times$$

$$\times P(t_k)\cdot \begin{vmatrix} 1-\frac{T}{K_s} & 0 & \frac{L_m}{T_r}T & 0 & 0 \\ 0 & 1-\frac{T}{K_s} & 0 & \frac{L_m}{T_r}T & 0 \\ \frac{L_m}{L_s^{'}L_rT_r}T & -\frac{L_m}{L_s^{'}L_r}\omega_r(t_k)T & 1-\frac{T}{T_r} & \omega_r(t_k)T & 0 \\ \frac{L_m}{L_s^{'}L_r}\omega_r(t_k)T & \frac{L_m}{L_s^{'}L_rT_r}T & -\omega_r(t_k)T & 1-\frac{T}{T_r} & 0 \\ \frac{L_m}{L_s^{'}L_r}T\psi_{r\beta}(t_k) & -\frac{L_m}{L_s^{'}L_r}T\psi_{r\alpha}(t_k) & -T\psi_{r\beta}(t_k) & T\psi_{r\alpha}(t_k) & 1 \end{vmatrix} + Q \qquad (4)$$

The assessment process includes two main stages: prediction and update. At the predict stage, a condition forecast is calculated based on the Park–Gorev model and statistical characteristics of process noise, which is assumed to be Gaussian with mean zero and covariance Q. At the update stage, the forecast is corrected based on the measured stator currents, taking into account Gaussian measurement noise with covariance R. Thus, the EKF minimizes the mathematical expectation of the squares of the estimation errors, providing an optimal approximation of the state of the system in the sense of reducing variance. The EKF model was integrated into the MATLAB/Simulink environment, enabling iterative prediction of the stator current and evaluating changes in electromagnetic parameters under various disturbances, including changes in load and moment of resistance. Comparison of the prediction results with the reference modelled values showed high stability and accuracy of the EKF even with significant parameter jumps.

RESEARCH RESULTS

The study presents a detailed reconstruction of the electromagnetic and electromechanical processes of an induction motor used in a pumping installation. The analysis was performed using the Park–Gorev mathematical model combined with the Extended Kalman Filter (EKF) to estimate hidden states, suppress measurement noise and ensure stable parameter prediction.

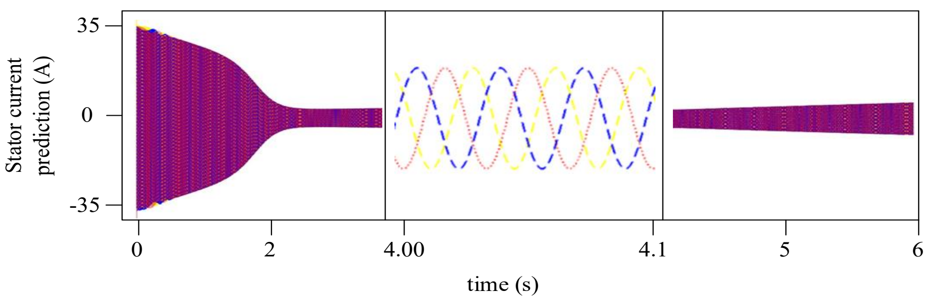

FIGURE 1. Predicted stator phase currents of the induction motor

The predicted three-phase stator currents exhibit significant transient oscillations during the initial stage, with amplitudes reaching ±32–35 A, corresponding to a starting current ratio of approximately 3. Within t = 1.2 s, the amplitude decreases to ±18 A, and by t = 2.0 s, the system reaches a steady sinusoidal regime with an amplitude of approximately 15 A and an RMS value of 10.5–11 A per phase. In the segment t = 4.0–4.1 s, a clear 120° phase shift between the currents is observed, demonstrating the correct reconstruction of the induction motor's electromagnetic behaviour.

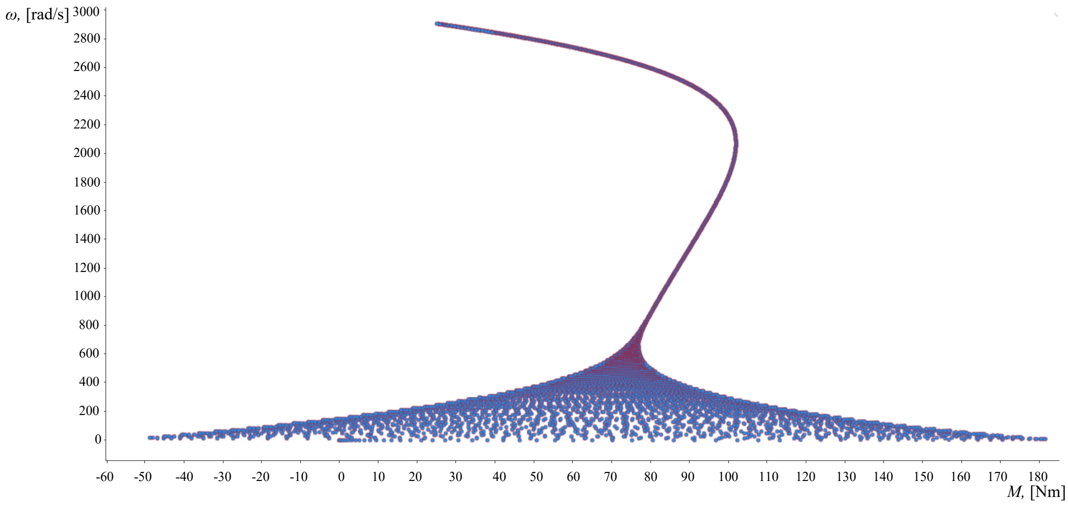

FIGURE 2. Natural mechanical characteristics of the induction motor

The electromagnetic torque reaches 250–270 N·m at start-up, nearly twice the nominal value and typical for an induction motor with a squirrel-cage rotor under a pumping load. Subsequently, the oscillatory component decreases exponentially to 90–110 N·m. The rotor angular velocity increases from 0 to 2800 rad/s (approximately 445 rpm) within 0.8–1.0 s. Afterwards, the speed stabilises at 2600–2700 rad/s, corresponding to the equilibrium between the motor torque and the hydraulic load torque.

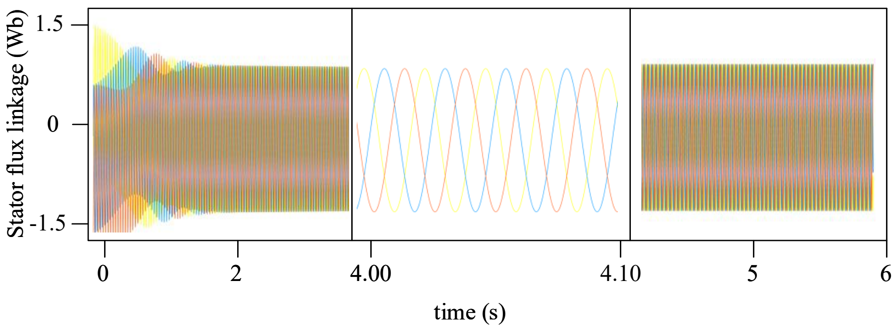

FIGURE 3. Stator flux linkage

The reconstructed flux linkages reach peak values of ±1.4–1.5 Wb during the transient phase. The transient components decay within 1.5–2.0 s, after which the flux linkages settle into a stable sinusoidal pattern with an amplitude of about 1.1 Wb. The symmetry of the trajectories and the low residual oscillation level (no more than 3–

5%) confirm the adequacy of the Park–Gorev model and the effectiveness of the EKF in recovering magnetisation dynamics. Overall, the results (Figs. 1–3) demonstrate that the proposed modelling and estimation approach provides quantitatively accurate predictions of currents, flux linkages, torque, and rotational speed, forming a robust basis for prognostic monitoring and diagnostic evaluation of pump drive systems.

CONCLUSIONS

The conducted research demonstrated that integrating the Extended Kalman Filter with the Park–Gorev mathematical model provides high-accuracy reconstruction of the electromagnetic parameters of an induction motor pump. The average prediction errors were approximately 3% for phase currents, 2% for flux linkages, and 5% for electromagnetic torque, while the rotor-speed estimation error did not exceed 1%. The algorithm remained stable under load disturbances of 6–8% of the nominal value and noise levels of $Q = 10^{-4}$ and $R = 10^{-3}$. The proposed method enhances diagnostic sensitivity and improves the overall energy efficiency of pumping systems.

REFERENCES

1. D. A. De Moura Fonsêca, A. O. Salazar, E. R. L. Villarreal, G. A. E. Espinoza, and A. C. Q. B. Leite, "Downhole teleme try systems to monitor electric submersible pumps parameters in oil well," IEEE Access, vol. 9, pp. 12824–12839, 2021, doi: 10.1109/ACCESS.2020.3049116.
2. J. Han and Q. Gao, "Research on downhole multi-parameters monitoring system," in Proc. 7th Int. Power Electron. Motion Control Conf., vol. 4, Jun. 2012, pp. 2765–2768.
3. F. A. Gizatullin, M. I. Khakimyanov, F. F. Khusainov, and I. N. Shafikov, "Analysis of losses in the cable line of well submersible electric motor," in Proc. Int. Conf. Ind. Eng., Appl. Manuf. (ICIEAM), May 2017, pp. 1–3, doi: 10.1109/ICIEAM.2017.8076285.
4. M. I. Khakimyanov, I. N. Shafikov, and F. F. Khusainov, "Electric submersible pumps in oil production and their efficiency analysis," in Proc. 4th Int. Conf. Appl. Innov. IT Kothen Anhalt Univ. Appl. Sci., 2016, pp. 34–38.
5. H. Atri, S. Kouki, and M. I. Gallali, "The impact of COVID-19 news, panic and media coverage on the oil and gold prices: An ARDL approach," Resour. Policy, vol. 72, Aug. 2021, Art. no. 102061.
6. Umarov, S., Tulyaganov, M., Oripov, S., & Boqijonov, U. (2025). Using a Modified Laplace Transform to Simulate Valve Converters With Periodic Topology. AIP Conference Proceedings. https://doi.org/10.1063/5.0305792
7. Abdullabekov, I., Mirsaidov, M., Umarov, S., Tulyaganov, M., & Oripov, S. (2025). Optimizing Energy Efficiency in Water Pumping Stations: A Case Study of the Chilonzor Water Distribution Facility. AIP Conference Proceedings. https://doi.org/10.1063/5.0305780 Murot Tulyaganov, Shukhrat Umarov, Islombek Abdullabekov, Shakhnoza Adilova. Optimization of modes of an asynchronous electric drive taken into account thermal transient processes. AIP Conf. Proc. 3331, 030084 (2025) https://doi.org/10.1063/5.0305786
8. Makhsud Bobojanov, Furkat Tuychiev, Nuralibek Rashidov, Alim Haqberdiyev, Islombek Abdullabekov. Dynamic simulation of a three-phase induction motor using Matlab Simulink. AIP Conf. Proc. 3331, 040012 (2025) https://doi.org/10.1063/5.0305750
9. M M Mirsadov, B KH Fayzullayev, I A Abdullabekov, A S Kupriyanova, D I Kurbanbayeva and U A Boqijonov. The mutual influence of electromagnetic and mechanical processes in dynamic modes of inertial vibrating electric drives. IOP Conf. Series: Materials Science and Engineering 862 (2020) 062081IOP. https://iopscience.iop.org/article/10.1088/1757-899X/862/6/062081
10. Islombek Abdullabekov, Murakam Mirsaidov, Furkat Tuychiev, Ravshan Dusmatov. AIP Conf. Proc. 3152, 040007 (2024) https://doi.org/10.1063/5.0218880
11. M M Khamudkhanov, I A Abdullabekov, N B Khamudkhanova, R K Dusmatov and B KH Fayzullayev. Controls of the modes of operation of the pumping station with application of frequency-controlled electric drivel. IOP Conf. Series: Materials Science and Engineering 862 (2020) 062048IOP. https://iopscience.iop.org/article/10.1088/1757-899X/862/6/062048
12. Murot Tulyaganov. IOP Publishing Journal of Physics: Conference, 2388, **012099**, (2022), https://doi.org/10.1088/1742-6596/2388/1/012099
13. Alexandr D. Petrushin, Murot Tulyaganov. Optimal Control of the Switched Reluctance Motor of High-Speed Rail Transport with an On-Board Energy Source. 2024 International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM). -2024, https://doi:10.1109/icieam60818.2024.10553741

14. Tulyaganov, M. Optimization of natural gas combustion in furnace of steam boilers E3s Web of Conferences Open source preview, 2020, 216, 01155, https://doi:10.1051/e3sconf/202021601155
15. Liu J.; Chen H.; Wang X.; Gu J.; Shamiyev M.; Pulatov A.O.; Wheeler P.; Torkaman H.; Musolino A.; Gorbounov Y. A Novel Adaptive Force Ripple Suppressing Method for Double-Sided Switched Reluctance Linear Motor. IEEE Transactions on Transportation Electrification, 2025, https://doi.org/10.1109/tte.2025.3609443
16. Hao Chen, Yongqiang Liu, Fan Yang, Wang Xing Xing, Zefu Tan, Li Cai, Antonio Musolino, Qian Huang, Yong Qi, Yokub Tairov, Murat Shamiyev. Research on Temperature Rise and Cooling System Optimization Design of Switched Reluctance Machine. July 2025 Protection and Control of Modern Power Systems 10(4):72-88, https://doi.org/10.23919/PCMP.2024.000092
17. Mirisaev, A., Pulatov, A., Muminov, K. Improving the Energy Efficiency of Power Supply Systems and Electrical Equipment of Induction Plants of Metallurgical Enterprises. Aip Conference ProceedingsOpen source preview, 2024, 3152(1), 030004 https://doi.org/10.1063/5.0218879
18. Mirisaev,A., Pulatov, A., Shamiev, M. The Impact of the Operation of Electric Drives on the Reliability and Energy Efficiency of Power Supply Systems of Industrial Enterprises. Aip Conference ProceedingsOpen source preview, 2024, 3152(1), 030005 https://doi.org/10.1063/5.0218881
19. Abidov Kudrat, Gafurova Mexrnoz. The motion of a particle in a single spatial electromagnetic field. AIP Conf. Proc. 3152, 050018, (2024) https://doi.org/10.1063/5.0219212
20. Abidov Kudrat, Gafurova Mexrnoz. Energy-Saving Modes of Operation of Pump Unit, Machine Water Lift Systems. AIP Conf. Proc. 3152, 030019, (2024) https://doi.org/10.1063/5.0218995
21. Kudrat Abidov. Improving the reliability of the operation of reclamation pumping stations by using self-starting electric motors. E3S Web of Conferences 384, 01055 (2023) Rudenko International Conference “Methodological Problems in Reliability Study of Large Energy Systems” (RSES 2022). https://doi.org/10.1051/e3sconf/202338401055
22. M.Sadullaev, E.Usmanov, R.Karimov, D.Xushvaktov, D.Xalmanov, Y.Shoyimov, D.Khimmataliev. Mathematical Models and Calculation of Elements of Developed Schemes of Contactless Devices. AIP Conference Proceedings, 3331(1), 040043, (2025), https://doi.org/10.1063/5.0305748
23. E.Yuldashev, M.Yuldasheva, A.Togayev, J.Abdullayev, R.Karimov. Energy efficiency research of conveyor transport. AIP Conference Proceedings, 3331(1), 040030, (2025), https://doi.org/10.1063/5.0305742
24. E.Usmanov, M.Bobojanov, R.Karimov, D.Xalmanov, N.Tairova, S.Torayev. Contactless Switching Devices Using Nonlinear Circuits. AIP Conference Proceedings, 3331(1), 040031, (2025), https://doi.org/10.1063/5.0305744
25. Allabergen Bekishev, Nurali Pirmatov, Dilfuza Kurbanbayeva, Najmiddin Kurbanov, Oliyakhon Zaynieva, Obidkhan Yunusov, Utkir Khudoynazarov, Zinatdin Saimbetov.Achievement of maximum power levels at different wind speeds from wind turners with asynchronous double-way feed generator. AIP Conf. Proc. 3331, 030011 (2025).https://doi.org/10.1063/5.0305765
26. Pirmatov, N., Bekishev, A.,Kurbanov, N., Saodullaev, A., Saimbetov , Z. Increasing the efficiency and survivability of synchronous machines with biaxial excitation when operating in transient processes. Proceedings of the AIP conference. Volume 3152, Issue 1, June 17, 2024, https://doi.org/10.1063/5.0218824
27. N. B. Pirmatov, U. T. Berdiyev, and ofters. E3S Web of Conferences, 401, **03021**, (2023) https://doi.org/10.1051/e3sconf/202340103021
28. Jinfu Liu, Hao Chen,Wenju Yan,Ton Duc Do, Murat Shamiev,Yokub Tairov, Miguel Pablo Aguirre. An Adaptive Electromagnetic Force Distribution Method Based on a Double-sided Switched Reluctance Linear Motor, 22nd International Symposium on Power Electronics (Ee), Novi Sad, Serbia, 2023, pp. 1-6, https://doi.org/10.1109/Ee59906.2023.10346203
29. Farrukh Akbarov; Rustam Kabulov; Anvar Alimov; Erkin Abduraimov; Dildora Nasirova. Dependence of output parameters of photovoltaic module based on CIGS solar cells on external temperatures. *AIP Conf. Proc.* 3331, 040046 (2025). https://doi.org/10.1063/5.0305885
30. Anvar Alimov; Kudrat Abidov; Erkin Abduraimov; Farrukh Akbarov; Humoyun Muminov. Generalized model of nonlinear inductance and its parameters. *AIP Conf. Proc.* 3331, 040035 (2025). https://doi.org/10.1063/5.0305883
31. Anvar Alimov, Erkin Abduraimov; Farrukh Akbarov; Dildora Nosirova. Analysis of the Basic Circuit of Ferroresonant Transistor Parametric Dc Voltage Stabilizers with Built - in Functional Converter. *AIP Conf. Proc.* 3152, 050016 (2024). pp. 1-9. https://doi.org/10.1063/5.0218823
32. R.Karimov. AIP Conference Proceedings, 2552, **030014**, (2022). https://doi.org/10.1063/5.0111533
33. A.A.Pulatov, M.F.Shaimiev, U.M.Mirsaidov. E3S Web of Conferences 390, **06039**, (2023), https://doi.org/10.1051/e3sconf/202339006039

34. Nurali Pirmatov, Abdullo Panoev, and ofters. E3S Web of Conferences, 383, **04046** (2023) https://doi.org/10.1051/e3sconf/202338304046
35. Shukhrat Umarov, Murot Tulyaganov. Peculiarities of simulation of steady modes of valve converters with periodic power circuit structure. III International Scientific and Technical Conference "Actual Issues of Power Supply Systems" (ICAIPSS2023). AIP Conf. Proc. 3152, 050004-1–050004-7; https://doi.org/10.1063/5.0218869
36. Ravshan Dusmatov. Proceedings of the 11th International Conference on Applied Innovations in IT. Volume 11, Issue 1, (2023).
37. T.S.Kamalov. Frequency-regulated electric drive of pumping stations of machine irrigation systems. T.: Fan, 2014, 354 p. (in Uzbekistan).