

Study of Short Circuit Currents in a Distributed Traction Power Supply System with Renewable Electric Power Sources

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Abstract—The problems of changing short-circuit currents in a distributed traction system for using renewable energy sources were analyzed in the article. Literary sources analysis shows a further tendency for increasing the share of renewable energy sources in the total energy balance of the country and a particular increase in electricity consumption by electric traction. Goal. The main goal of the study is a method development with its practical application to impact estimation of power-boost points that connected to the traction network with energy using from renewable sources on short-circuit currents values. Methodology. The method that has developed in this study is based on well-known approaches for equivalent circuits of electrical equipment definition, but elements pair like «solar panel – inverter» it reproduces as EMF with equivalent resistance, which significantly simplifies further calculations. Results. The study results show that the application of power-boost points will not lead to a significant increase of short-circuit currents in the traction network even if the

power of photovoltaic sources will be comparable with the power of existing converting units on traction substations. This is because of the physical nature of the photovoltaic panel and its power mode which usually closer to the current source with high internal resistance. Practical value. This also allows us to conclude that in most cases from the point of view of changing the short circuit currents the integration of power-boost points that are powered by solar power plants is quite possible with operating sections of the traction power supply system.

Keywords— solar power plant, short circuit, DC traction power supply system, photovoltaic panels, emergency mode

I. INTRODUCTION

The ongoing deterioration of the environmental situation in the world, partly due to the upward trend in the consumption of electricity generated from traditional sources, forces us to take measures to limit emissions of harmful substances into the environment. Electric transport, in comparison with other vehicles, causes less

REFERENCES

- [1] Li, Yongfei & Li, Kang & Zhang, Li & Li, Yong. (2020). A Novel Double-layer DC/AC Railway Traction Power Supply System with Renewable Integration. *IET Renewable Power Generation*, 14, 10.1049/iet-rpg.2020.0131.
- [2] Kolnichenko, Georgij & Tarlakov, Yakov. (2020). Automation of control of electric generators from renewable energy sources in hybrid power supply systems. *Journal of Physics: Conference Series*, 1515, 042072. 10.1088/1742-6596/1515/4/042072.
- [3] O. Ostapchuk, M. Kuznietsov, V. Kuznetsov, V.Kuznetsov, "Problems of the use of renewable energy sources in the structure of railway power supply" (2020) IOP Conference Series: Materials Science and Engineering, 985 (1), DOI: 10.1088/1757-899X/985/1/012011
- [4] D'Arco S., Piegari L., Tricoli P. Comparative Analysis of Topologies to Integrate Photovoltaic Sources in the Feeder Stations of AC Railways. *IEEE Transactions on Transportation Electrification*, 2018, vol. 4, no. 4, pp. 951-960. doi: 10.1109/TTE.2018.2867279.
- [5] Zhang G., Tian Z., Du H., Liu Z., A Novel Hybrid DC Traction Power Supply System Integrating PV and Reversible Converters. *Energies*, 2018, vol. 11, no. 7, p. 1661. doi: 10.3390/en11071661
- [6] Mingliang W., Weiying W., Wenli D., Huabo C., Chaohua D., Weirong C. Back-to-back PV generation system for electrified railway and its control strategy. 2017 IEEE Transportation Electrification Conference and Expo, Asia-Pacific (ITEC Asia-Pacific), Harbin, 2017, pp. 1-6. doi: 10.1109/ITEC-AP.2017.8080799.
- [7] Sychenko, V. G., Kosariev Ye. M., Pulin M. M. Power Quality of the Traction Substation on 10kv Bus With Parallel Work of the Solar Power Station. *Electrification of Transport*, 2017, №13, pp. 71-78. doi: 10.15802/etr.v0i13.117873.
- [8] Bade, Swapna & Kulkarni, V.A. (2018). Analysis of Railway Traction Power System Using Renewable Energy: A Review. 404-408. 10.1109/ICCPEIC.2018.8525206.
- [9] Prykhoda M. S. Studying of the Breaking Capacity of Switching Equipment of Traction Substation upon Accession Solar Power Station. *Electrification of Transport*, 2015, № 9, pp. 62–70. doi: 10.15802/etr.v0i9.51727.
- [10] Di Noia, L.P. & Rizzo, R.. (2019). Analysis of Integration of PV Power Plant in Railway Power Systems. 1-5. 10.1109/MPS.2019.8759720.
- [11] D. O. Bosiy., E. M. Kosarev. Calculation of the Traction Power Supply Systems Using the Functions of Resistance. *Problemy Kolejnictwa*, 2015, Zeszyt 168, p. 7-14. journal e-ISSN :2544-9451.
- [12] Dmitry Bosiy, Yevhen Kosarev. Modeling of the controlled traction power supply system in the space-time coordinates. *Transport Problems*, 2017, Volume 12, Issue 3, p. 5-19. DOI:10.20858/tp.2017.12.3.1.
- [13] Shi, Yongbin & Li, Teng. (2022). Power Quality Management Strategy for High-Speed Railway Traction Power Supply System. 368-373. 10.1109/AEES54426.2022.9759561.
- [14] Hubskeyi P. V. Energy Channels of Power of Distributed Systems of Type electrical Supply. *Electrification of Transport*, 2018, № 15, pp. 23-30. doi: 10.15802/etr.v0i15.155584.
- [15] Sychenko, V. G., Bosiy D. O., Kosarev E. M. Improving the Quality of Voltage in the System of Traction Power Supply of Direct Current. *Archives of Transport*, 2015, Vol. 35, Iss. 3, pp. 63–70.
- [16] Zhukov V. V. Korotkie замыкания в электростановках посттоианного тока [Short circuits in DC electrical installations]. Moscow, MEI Publ., 2005. 160 p.
- [17] Elisabeta S., Bogdan P., Ion P., Valentin N., Florina P. Use of Renewable Energy Sources to Power Railroad Traffic Safety Installations. 2019 11th International Symposium on Advanced Topics in Electrical Engineering (ATEE), Bucharest, Romania, 2019, pp. 1-4. doi: 10.1109/ATEE.2019.8724999.
- [18] M. Tryputen, V. Kuznetsov, V. Kuznetsov, Y. Kuznetsova , M. Tryputen, A. Kuznetsova, "Laboratory bench to analyze of automatic control system with a fuzzy controller" (2020) *Diagnostyka*, 21 (2), pp. 61-68. DOI. 10.29354/diag/122357
- [19] T.M. Serdiuk, V. Kuznetsov, Y. Kuznetsova, "About electromagnetic compatibility of rail circuits with the traction supply system of railway" (2018) 2018 IEEE 3rd International Conference on Intelligent Energy and Power Systems, IEPS 2018 - Proceedings, 2018-January, pp. 59-63. DOI: 10.1109/IEPS.2018.8559541
- [20] Shen X., Wei H., Wei L. Study of trackside photovoltaic power integration into the traction power system of suburban elevated urban rail transit line. *Applied Energy*, 2020, Vol. 260, p. 114177. doi: 10.1016/j.apenergy.2019.114177.
- [21] Li C., Xu C., Li X. A multi-criteria decision-making framework for site selection of distributed PV power stations along high-speed railway. *Journal of Cleaner Productio*, 2020, Vol. 277, p. 124086. doi: 10.1016/j.seta.2016.05.006.
- [22] Ji L. Yu, Z.; Ma, J.; Jia, L.; Ning, F. The Potential of Photovoltaics to Power the Railway System in China. *Energies*, 2020.Vol. 13, № 15, p. 3844. doi: 10.3390/en13153844.