DOI: 10.37102/1992-4429_2025_52_02_02

AUTONOMOUS VOLTAGE INVERTERS IN THE ELECTRICAL SUPPLY SYSTEMS OF UNDERWATER OBJECTS

V.A. Gerasimov, A.V. Komlev, A.Yu. Filozhenko

Reducing energy losses in autonomous voltage inverters and reducing thermal loads on power switches is becoming particularly relevant in electrical supply systems for underwater facilities. This is due to the difficulty of removing heat from the power elements located in the robust housings of the device and having a number of layout limitations. The use of resonant circuits with constant tuning is limited, since the process of contactless energy transfer is accompanied by a wide range of changes in the load of the inverter, which is associated with possible axial displacements of the primary and secondary parts of the transformer, as well as a change in the gap between these parts when the device is automatically moored to the bottom mooring device. A significant reduction in switching losses in the inverter can be achieved by combining the soft switching mode with minimizing the current of the opposing diodes with a corresponding change in the switching frequency. This property is implemented in the proposed control method. The research of an autonomous voltage inverter on a computer model confirmed the high efficiency of the proposed method for generating inverter control signals. Switching losses in the inverter have been reduced tenfold compared to both conventional control with hard switches and soft switches with constant tuning of the resonant circuit. This property is maintained over a wide range of load variations of the inverter. Solutions to reduce switching losses in contactless energy transmission systems will be useful in power supply systems via a ROV cable line or other tethered underwater facilities as ways to increase the overall efficiency of underwater robotics systems.

Keywords: energy supply, contactless charge, cable, autonomous voltage inverter, switching losses, conduction intervals, switching frequency.

References

1. Gerasimov V.A., Kuvshinov G.E., Filozhenko A.Yu., Chepurin P.I. The investigation of modes power system supply for autonomous unmanned underwater vehicle with a contactless power transmission // Underwater research and robotics, No 2, 2013, pp. 24 -32 (in Russian).

2. Independent voltage inverter to supply load through transformer with low coupling coefficient between its windings. Patent 2558681 of the Russian Federation / Kuvshinov G.E., Naumov L.A., Sebto Ju.G., Gerasimov V.A., Filozhenko A.Ju., Chepurin P.I., Kraskovskij M.V. No. 2014111547/07; application on 25.03.2014; published on 10.08.2015. Bull. 22 (in Russian).

3. Gerasimov V.A., Kraskovskiy M.V., Filozhenko A.Yu. Autonomous voltage inverter with series resonant circuit // Izvestiya SFedU. Engineering sciences. 2016. No 4, pp. 147 – 158 (in Russian).

4. Gerasimov V.A., Kraskovskiy M.V., Kuvshinov G.E. Unloading transistors of the inverter in the system contactless transmission on autonomous underwater vehicle // Izvestiya SFedU. Engineering sciences. 2016. No 4, pp. 133 – 147 (in Russian).

5. Gerasimov V.A., Kraskovskiy M.V., Filozhenko A.Yu. Increasing the effectiveness of the contactless charge batteries autonomous unmanned underwater vehicle // Izvestiya SFedU. Engineering sciences. 2017. No 1 (186), pp. 108 – 120 (in Russian).

6. Choi, Wonsuk & Young, Sung-mo & Kim, Dong-wook. (2009). Analysis of MOSFET failure modes in LLC resonant converter. Proc. Int. Telecommun. Energy Conf.. 1. 1 - 6. 10.1109/INTLEC.2009.5351877.

7. Gerasimov V.A., Filozhenko A.Yu. The resonance use to increase the efficiency of the non-contact power transmission system on the underwater vehicle // Izvestiya SFedU. Engineering sciences. 2018. No 1 (195), pp. 168 – 178 (in Russian).

8. Method of autonomous matched resonant inverter control. Patent 2558681 of the Russian Federation / E.M. Silkin. No. 2007123511/09; application on 22.06.07; published on 10.12.08. Bull. 34 (in Russian).

9. Control method for stand-alone inverter with resonance switching. Patent 2453977 of the Russian Federation / E.M. Silkin. No. 2009128714/07; application on 24.07.09; published on 20.06.12. Bull. 17 (in Russian).

10. Wireless charger for the underwater unmanned vehicle / A.A. Martynov, V.K. Samsygin, D.V. Sokolov [et al.] // Transactions of the Krylov State Research Centre. 2017. Vol. 2(380). P. 92–100. DOI: 10.24937/2542-2324-2017-2-380-92-100 (in Russian).

11. Independent voltage inverter to supply load through transformer with low coupling coefficient between its windings. Patent № RU 2637112 C1 of the Russian Federation / Gerasimov V.A., Filozhenko A.Yu., Kuvshinov G.E., Chepurin P.I., Kraskovskij M.V. No 2016147592, application on 05.12.16; published on 30.11.17. Bull. 34 (in Russian).

12. Autonomous voltage inverter control method. Application for an invention 2024135834 of the Russian Federation / Gerasimov V.A., Filozhenko A.Ju. Application on 27.11.2024 (in Russian).

About the authors

GERASIMOV Vladimir Alexandrovich, Head of the Laboratory of Power Engineering of Underwater Robotic Complexes
Institute for Marine Technology Problems, Russian Academy of Sciences, Far Eastern Branch
Address: 5a, Sukhanova Str., Vladivostok, 690091
Research interests: power engineering of underwater vehicles, contactless transmission of electricity, power converter equipment
Phone: +79025223824
E-mail: gerasimov@marine.febras.ru, fobos_v@mail.ru
ORCID: 0000-0003-0246-475X

KOMLEV Anton Vladimirovich, Senior Researcher at the Laboratory of Power Engineering of Underwater Robotic Complexes
Institute for Marine Technology Problems, Russian Academy of Sciences, Far Eastern Branch
Address: 5a, Sukhanova Str., Vladivostok, 690091
Research interests: power engineering of underwater vehicles, contactless transmission of electricity, power converter equipment
Phone: +79502884801
E-mail: kom86@bk.ru
ORCID: 0000-0001-8862-8676

FILOZHENKO Alexey Yuryevich, Leading Researcher at the Laboratory of Power Engineering of Underwater Robotic Complexes
Institute for Marine Technology Problems, Russian Academy of Sciences, Far Eastern Branch
Address: 5a, Sukhanova Str., Vladivostok, 690091
Research interests: power engineering of underwater vehicles, contactless transmission of electricity, power converter equipment
Phone: +79140678041
E-mail: filozhenko_a@mail.ru
ORCID: 0000-0003-1684-3849