APPLICATION OF CONTROL SYSTEMSACTIVE FOUR-QUADRANT RECTIFIERS ONTRACTIONAL ELECTRIC ROLLING STOCK

Nerubatskyi Volodymyr Pavlovych,
PhD, Associate Professor,
Associate Professor of Department of Electrical Energetics,
Electrical Engineering and Electromechanics,
Ukrainian State University of Railway Transport,

Hordiienko Denys Anatolievych
Postgraduate of Department of Electrical Energetics,

Most traction electric rolling stock in Ukraine is morally and technically obsolete, and therefore needs modernization [1]. In particular, diode and thyristor four-zone rectifiers, which are used on electric rolling stock AC, cause significant emissions of higher current harmonics and realize a fairly low power factor, which is in the range from 0.65 to 0.85, which significantly reduces energy efficiency as the electric rolling stock and the entire traction power supply system. In turn, the presence in the traction network of a significant reactive power component leads to the need to use expensive reactive power compensators, made by passive or active topology [2].

The use of active four-quadrant rectifiers with power factor correction, known as 4QS converters, is promising on electric rolling stock [3]. Unlike traditional thyristor rectifiers, 4QS converters have a number of significant advantages: they provide a form of current consumption close to a sinusoid, realize a power factor close to one, provide a low level of emission of higher harmonics of the current consumed into the power supply, implement two-way transmission of electricity, and also provide voltage regulation and stabilization in the DC circuit [4]. The power circuit of the traction electric drive of the electric rolling stock of alternating current with the 4QS-converter which supplies the independent voltage inverter and the traction asynchronous motor is given in fig. 1.

The active four-quadrant rectifier consists of a choke *L1*, which acts as a buffer reactor to increase the output voltage, IGBT transistors *VT1...VT4*, a capacitive filter *C1*, designed to reduce the amplitude of the output voltage ripple and a notch filter *C2-L2* used for output harmonic voltage of 100 Hz.

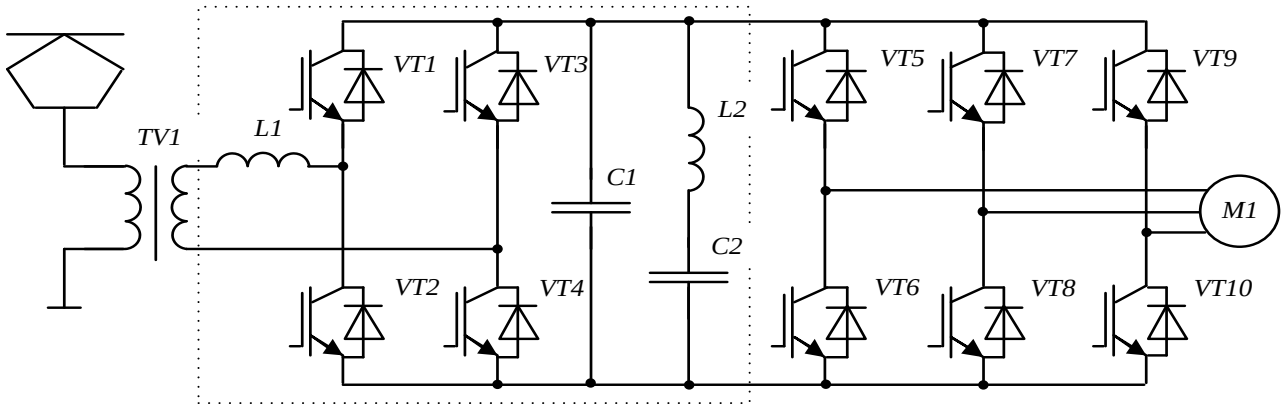

Figure 1. Power scheme of traction electric drive of alternating current rolling stock with 4QS-converter

The most widespread in 4QS-converters are control systems based on pulse-width modulation and hysteresis modulation [5]. Each of these systems has its advantages and disadvantages. The advantage of control systems built on the basis of pulse-width modulation is the ability to set a constant modulation frequency, but there are disadvantages, namely reducing the range of output voltage regulation, and deteriorating power quality. The advantage of hysteresis control systems is their relative simplicity and the ability to implement a fairly high quality of electricity. The disadvantage of existing hysteresis control systems is the presence of a high and at the same time variable frequency switching of power switches, which causes high dynamic losses in the converter. The switching frequency of the 4QS-converter with a hysteresis control system depends on many factors: the value of the input inductance of the converter, the load current and the setpoint of the hysteresis.

References

1. Нерубацький В. П., Гордієнко Д. А. Інтелектуальне багаторівневе управління на залізничному транспорті. *Тези доповідей першої міжнародної науково-технічної конференції «Інтелектуальні транспортні технології*. Трускавець-Харків, 24-30 січня. 2020. С. 90–92.

2. Нерубацький В. П., Гордієнко Д. А. Контроль і планування енерговикористання на залізничному транспорті. *Матеріали VII міжнародної науково-практичної конференції «Людина, суспільство, комунікативні технології»*. 2019. С. 227–230.

3. Plakhtii O. A., Nerubatskyi V. P., Kavun V. Ye., Hordiienko D. A. Active single-phase four-quadrant rectifier with improved hysteresis modulation algorithm. *Scientific Bulletin of National Mining University*. 2019. No. 5 (173). P. 93–98. DOI: 10.29202/nvngu/2019-5/16.

4. Щербак Я. В., Плахтій О. А. Нерубацький В. П. Регулювальні характеристики активного чотириквадрантного перетворювача в режимах випрямлення і рекуперації. *Технічна електродинаміка*. 2017. № 6. С. 26–31.

5. Bohra A., Sajeesh D., Patel C., Saldanha M. Modulation Techniques in Single Phase PWM Rectifier. *IJCA Proceedings on International Conference on Advances in Science and Technology*. 2016. P. 5–7.