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ACTIVE THREE-PHASE CURRENT AND VOLTAGE RECTIFIERS FOR CHARGING STATION

Over the last decade, the number of electric vehicles in Europe has increased more than 20 times. This is due to the fact that electric vehicles are an environmentally friendly form of transport, and it is much cheaper to drive 100 km in an electric car than in a car with an internal combustion engine [1, 2].

Charging stations are an important component of electric vehicle infrastructure. Further development and improvement of power converters for charging stations of electric vehicles with lithium-ion, lithium-iron-phosphate and other types of batteries will lead to an increase in the energy efficiency of charging stations, better electromagnetic compatibility between charging stations and the power network, lower emissions of harmonics and components of reactive power [3, 4].

The power circuit with fast charging consists of three stages, namely: an input filter to reduce input harmonics and optimize the power factor, a rectifier for cyclic DC currents, and a DC-DC converter to transfer energy to the battery for fast DC charging from a hybrid electric vehicle [5, 6].

Traditional charging stations for electric vehicles include a two-stage energy conversion and consist of an input AC/DC rectifier and an output DC/DC converter. In this topology, an input rectifier is used to create a DC voltage circuit. Then the DC/DC converter regulates the voltage and charging current of electric vehicles in a certain range. DC/DC converters are also used for galvanic isolation of electric vehicles from the network.

At the same time, the main requirements of charging station systems are regulation and stabilization of charging current and voltage. In addition, it is also important to ensure the requirements for increasing the efficiency of the converter, and to ensure the requirements for electromagnetic compatibility.

Promising topologies that can provide the listed requirements for charge-discharge modes of powerful storage devices are an active three-phase current rectifier and an active three-phase voltage rectifier, the circuits of which are shown in Fig. 5, 6.

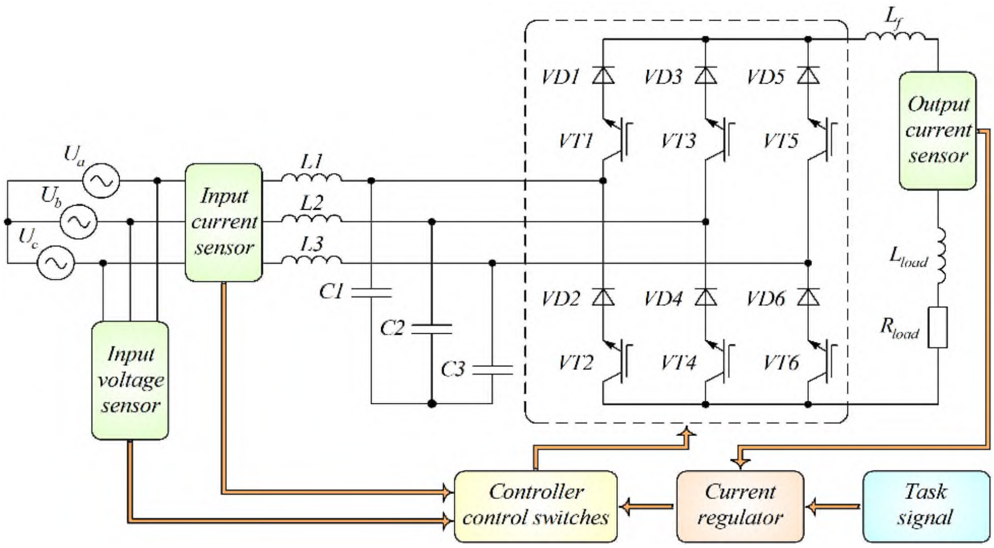

Figure 1 – Topology of an active three-phase current rectifier

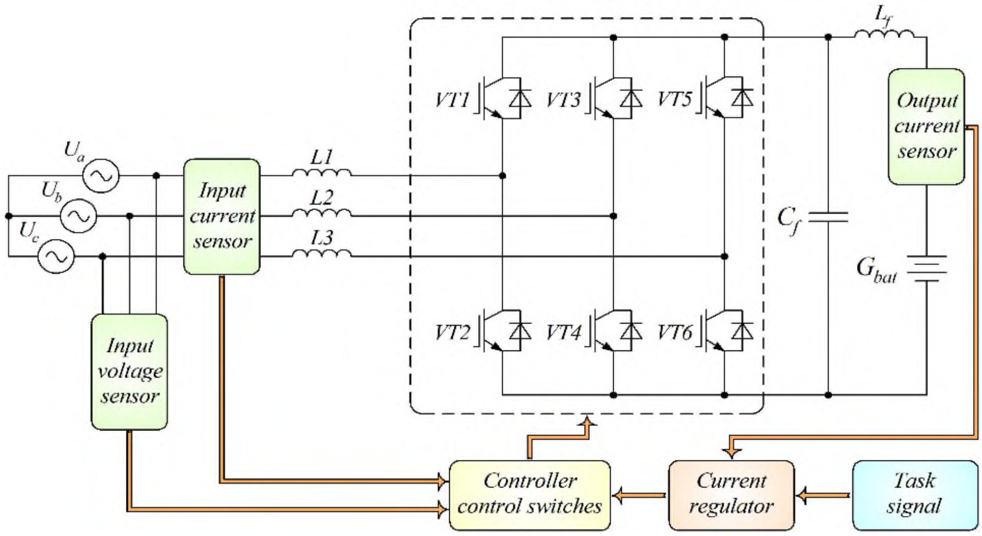

Figure 2 – Topology of an active three-phase voltage rectifier

These topologies have significant advantages over conventional diode and thyristor rectifiers. These advantages are threefold: the ability to operate in near-unity power factor mode, the ability to generate a sinusoidal form of current drawn from the network, and the ability to provide power factor correction.

Based on the recommended charge modes of lithium-ion storage devices, there are requirements for regulation and feedback of the output current and output voltage to the converters implementing the charge. In addition, in the case of power supply from the general industrial electrical network, electromagnetic compatibility requirements are imposed on them, namely the limitation of the harmonic spectrum of higher harmonics of currents that are consumed from the electrical network or generated to it.

Based on the conducted research, it can be seen that the efficiency of the proposed structure of the charging station is quite high. The dynamics of the fact that the higher the charge current, the lower the efficiency is clearly visible. With different parameters of the charge current and switching frequency, the efficiency of the charging station, taking into account the power losses in the battery of the electric vehicle, ranges from 91.3 % to 95.6 %.

Conducted studies of the energy indicators of the charging station based on a three-level active rectifier showed that the power factor of the charging station lies in the range from 0.985 to 0.993. The coefficient of harmonic distortion in the charging process ranges is 2.5…11.8 %.

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