Mykola LUKIANOV[1], Ievgen VERBYTSKYI[2], Natalia STRZELECKA[3], Ryszard STRZELECKI[1]

Gdańsk University of Technology, Faculty of Electrical and Control Engineering (1)
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Dept. of Electronic Devices and Systems (2)
Gdynia Maritime University, Faculty of Electrical Engineering (3)

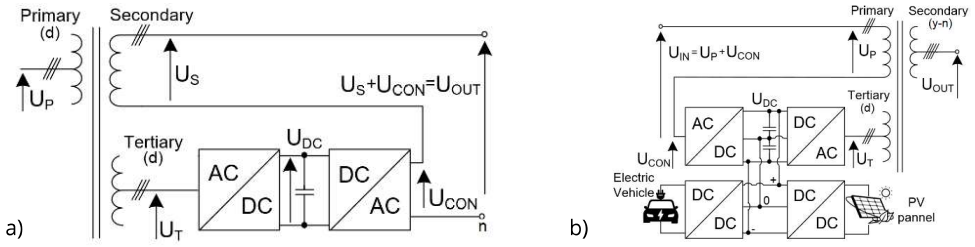
Hybrid distribution transformer with MV side control and DC bus for connecting an EV charger

Abstract. *This paper discusses a hybrid distribution transformer (HDT) with MV (medium voltage) side control as an alternative to typical LV (low voltage) side control. The HDT system consists of a grid transformer and a converter that regulates the voltage to ensure output voltage stability. The use of a three-level "back-to-back" NPC converter with a DC link is under consideration, allowing the connection of additional DC loads/ sources (e.g., V2G chargers). The parameters of the 630kVA 15/0.4kV HDT were estimated, the settings of the basic control system were selected, and the most important simulation results were presented.*

Keywords: hybrid distribution transformer, power transformer, NPC converter.

Considered DTH topology

HDT has many different topologies, the most common of which is the one with LV regulation (Fig. 1(a)). However, there are also solutions with the MV side converter connection (Fig. 1(b)) [1]. MV connection can provide such advantages as lower currents through the switches, the absence of a neutral wire, as well as protection of the main transformer from voltage fluctuations on the primary side, which cannot be achieved with the LV side regulation. At the same time, the main disadvantage of such a solution - higher voltages at the switches - can be solved by appropriate converter design. Additionally, HDT topology takes into account an increasing share of DC loads and sources by simplifying their connection to dedicated DC link. As a result, it is reasonable to choose an HDT with as a hybrid solution for AC and DC distribution networks. In this way, the need for an AC/DC power interface can be eliminated, and only a DC/DC converter can be used to connect DC loads/sources. Renewable sources, battery energy systems (BES) and EV charging stations with bidirectional power transmission can also be connected to the DC link, enhancing HDT's ability to provide various ancillary services [2]. As a result, the use of the HDT topology shown in Figure 1(b) can bring additional benefits to stimulate the development of EVs, renewables and small smart DC grids.



Rys.1. HDT structure with LV side regulation (a) and MV side regulation with the DC-bus connections (b).

Conclusion

In today's distribution networks, HDT appears to be a competitive alternative to other small-scale voltage regulation and control technologies. Analyzing existing HDT solutions, it was found that regulation on the MV side may be more advantageous, making it possible to create a DC link with a voltage of about ±1kV. This makes HDT a universal solution with two buses - DC and AC, which facilitates the connection of different loads and sources, and fits into the trend of developing modern hybrid smart grids. This research is part of an EU project.

Acknowledgment

This research was funded by the EU Horizon 2020 FP Project: 955614— SMARTGYsum—H2020-MSCA-ITN-2020.

References

1. Ryszard Strzelecki, et al. “Transformator rozdzielczy o wielostrefowej regulacji napięcia”, *Poland patent* # PL 234345, 28.02.2020 WUP 02/20
2. L. Zheng *et al*., “Solid-State Transformer and Hybrid Transformer With Integrated Energy Storage in Active Distribution Grids: Technical and Economic Comparison, Dispatch, and Control,” in *IEEE Journal of Emerging and Selected Topics in Power Electronics*, vol. 10, no. 4, pp. 3771-3787, Aug. 2022, doi: 10.1109/JESTPE.2022.3144361.

***Authors**: Mykola Lukianov, Gdańsk University of Technology, Poland, mykola.lukianov@pg.edu.pl; Ievgen Verbytskyi, National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”, Ukraine,verbytskyi.ievgen@gmail.com; Natalia Strzelecka, Gdynia Maritime University, Poland, natalia.strzelecka@we.umg.edu.pl; Ryszard Strzelecki, Gdańsk University of Technology Gdańsk, Poland, ryszard.strzelecki@pg.edu.pl;*