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Development of semiconductor converters for PV applications in industrial power grids

Modern society has an annually growing energy demand that used to be met by fossil fuels for more than two centuries [1]. Due to the imminent depletion of conventional energy sources like oil and gas appeared a need to search for alternative energy sources. There is a common tendency now days to use solar energy to supply the growing demand.

Solar panels can be affectively used mostly as direct current sources [1]. It is sound to use solar generators plugging them into a power grid that contains energy storage units. This will allow compensating daily and even seasonal dissimilarities in the amounts of generated power. But that will require the use of reversible connecting convertors able to operate as inverters on the PV source side and as rectifiers on the grid side [2].

An important aspect of modern converter designs is the search for maximum power density. One of the proven approaches to reach this goal is the use of higher frequency designs, which allows to greatly lessen the sizes of passive elements (capacitors, reactors). But the increase of semiconductor components switching frequency leads to an increase in total switching losses, this often makes the PWM converters less effective on high frequencies. A possible solution to this matter is the use of resonant converters [2]. The operation of the resonant circuit creates conditions for nearly lossless switching of the semiconductor elements at certain time periods.

The power circuit topologies for such converters had been well research by now, while the variety of control systems had been poorly analyzed. During the work on this topic a suggestion was made to research the ability to run a resonant converter by a phase-shifting control system. Taking all the mentioned above to notice a one phased reversible resonant converter topology was designed in [2], it can be seen on figure 1,a. A vector diagram that visualizes the functioning principles of phase control is shown on figure 1,b.

The control systems consists of a current sensor (CS) that allows to compare the load current with a desired referent current signal i_{reff}, a phase shift controller (PSC) and a pulse generator (PG). The PSG forms an output sinusoidal signal phase shifted to a *®/2* angle from the input voltage, this signal is then transformed into control pulses by the pulse generator. The control system of the commuter thus allows deviating vector *U* (switch input voltage) about vector U_n’ (source voltage) to an assigned control angle~. It is clear that the direction of the power flow will change sides, according to the sign of the ~ angle. Thus a phase control algorithm can provide controlled reversible energy transfer between the grid and the storage unit. In addition the use of resonant circuits where inductive reactance overbalances capacitance can cause lagging between the current vector I_n*'* and the voltage vector *U* creating a *®/2* angle, this allows the converter to operate without generating reactive power into the grid under low control angles. It is also possible to stop energy transfer between the grid and the energy storage unit by setting ~=0 [3].

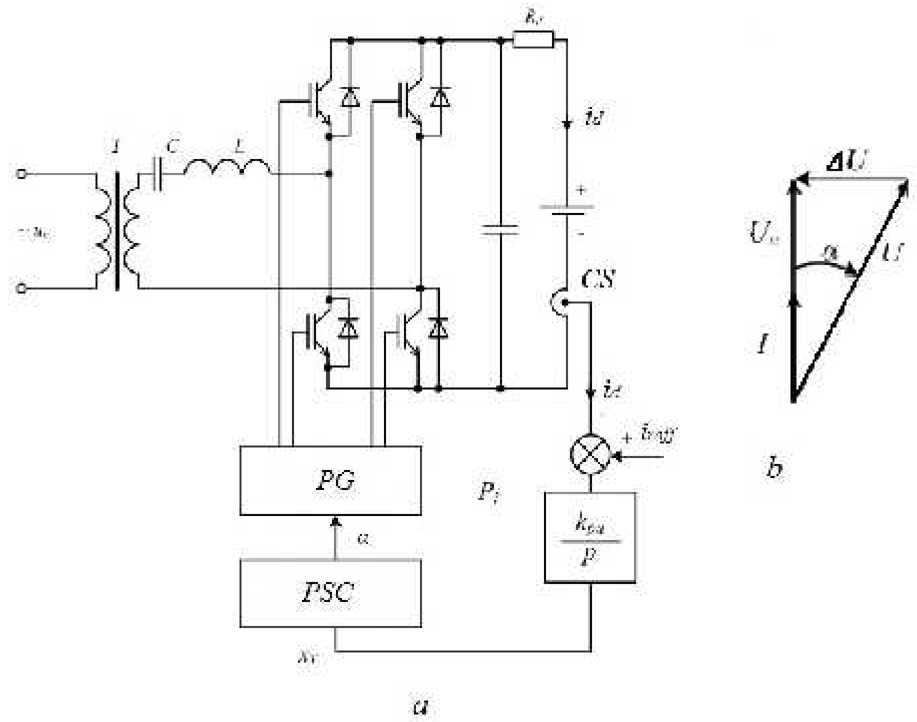

Fig. 1 – Single phased resonant reversive converter: *a* – circuit and controll system configuration; *b* –vector diagram, visualizing the functioning principles of phase control

Due to the convertor's operating features it is possible to use a solely integrating regulator to run it which greatly simplifies the control system structure as seen in fig.1. The system is generating self-oscillations that can be lowered by the increase of the overbalance between the inductor and capacitor, but must still be taken to notice.

References:

1. *Mukund R.* Patel Wind and Solar Power Systems. Design, Analysis, and Operation Second Edition. Taylor & Francis. 2006, 433p.

2. *Sokol E.I., Goncharov Yu.P., Ivahno V.V. et al.* Application of single-phase high frequency AC in low voltage electric power supply distribution grids [Primenenie odnofaznogo peremennogo toka povyishennoy chastotyi v nizkovoltnyih raspredelitelnyih setyah elektrosnabzheniya] // Proceedings of the Institute of Electrodynamics of NAS of Ukraine. Collected papers. Special Issue 2013 - Kyiv Institute of Electrodynamics of NAS of Ukraine, 2013. - 128 - 135 p.

3. *Sokol, E.I., Goncharov, Yu.P., Eresko, A.V., Ivakhno, V.V., Krivosheev, S.Yu., Zamaruiev, V.V., Lobko, A.V., Voytovich, Yu.S.* "Rectifiers with a combined filtration of primary current for high-frequency power systems," Compatibility and Power Electronics (CPE), 2013 8th International Conference on , vol., no., pp.316,319, 5-7 June 2013 doi: 10.1109/CPE.2013.6601176.