Development of three-level Neutral-Point-Clamped inverter

Agris Treimanis
Riga Technical University
Agris.Treimanis@rtu.lv

TOPIC

Single phase neutral point clamped (NPC) inverters are one of the most perspective types of Photo-Voltaic Inverters for single phase transformerless grid connected application. Source [2] mentions active clamped stacked neutral point inverter (ASNPC), which is one of the most advanced variations of NPC inverters – its power circuit consists of 8 transistors, with 8 antiparallel diodes. For the purpose of getting into a subject an earlier version of NPC inverter was used – active neutral point inverter (ANPC), which consists of 6 transistor-diode switches. ANPC inverter was tested together with control strategy, that gives natural doubling of the apparent commutation frequency. Sigma-delta modulation technique usage is also considered.

DESCRIPTION

Three-level Neutral-point-clamped (3L-NPC) inverter for first time was proposed in source [1]. This circuit was tested using MATLAB-Simulink software. 3L-NPC inverters one of possible control circuit versions together with power circuit is presented in Fig. 1.

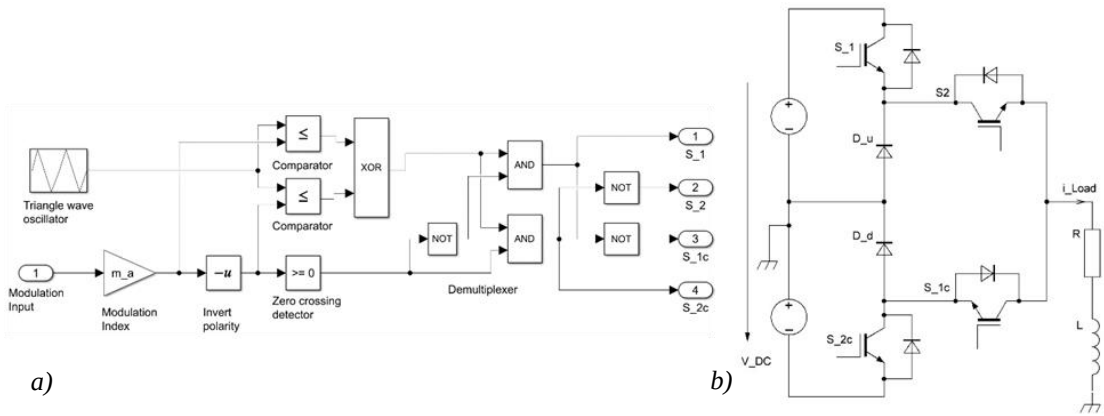

Fig. 1. 3L-NPC inverter: a) control circuit in Simulink; b) power circuit.

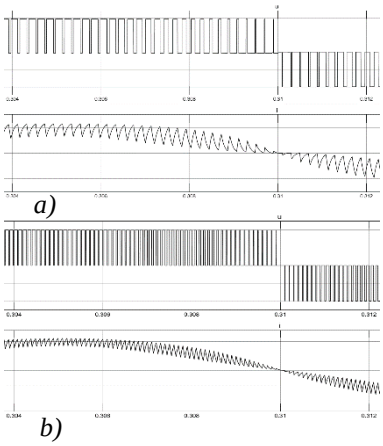

Fig. 2 Inverter output signals: a) 3L-NPC; b) 3L-ANPC.

Simulation results showed, that inner transistors S_2 and S_1c are virtually without commutation losses. Simulation conditions: carrier frequency – 4,95kHz, DC source voltage – ±100V, load resistance – 40Ω, load inductance – 3mH. 3L-NPC inverters output voltage and load current are presented in Fig. 2 a).

Next circuit tested using MATLAB-Simulink was 3L-ANPC inverter together with the control strategy that was proposed in source [3]. According to this source, proposed control strategy gives better distribution of power losses among switching devices and gives natural doubling of apparent switching frequency. Latter statement is obvious from Figure 2 b). 3L-ANPC inverters power circuit together with control circuit, that provides mentioned control strategy is presented in Figure 3.

Figure 4 shows output signal spectrum of two mentioned inverter variations. Second variation allows for much easier output filtering conditions (lesser filter inductance, capacitance).

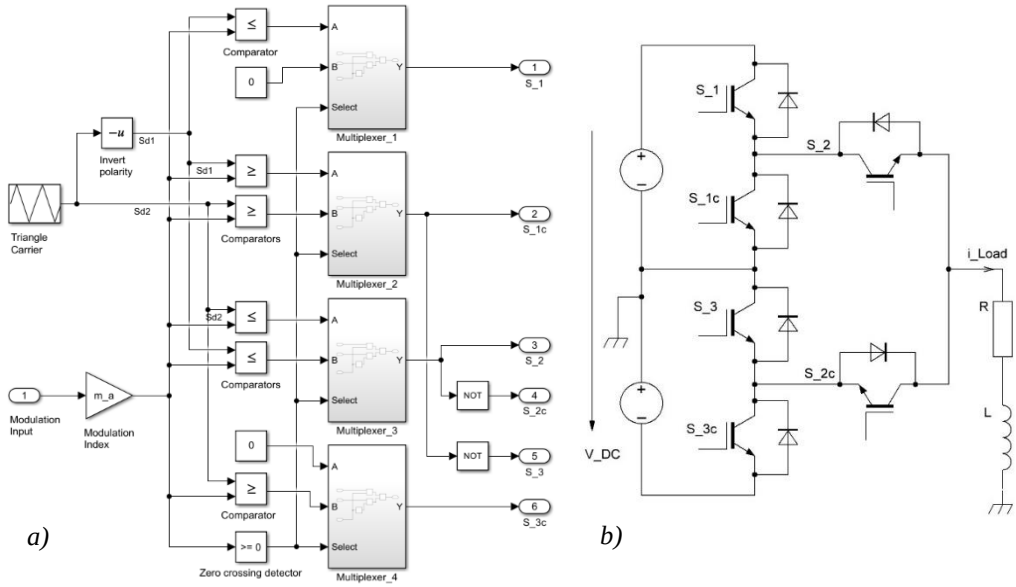

Fig. 3. 3L-ANPC inverter: a) apparent switching frequency doubling control circuit in Simulink; b) power circuit.

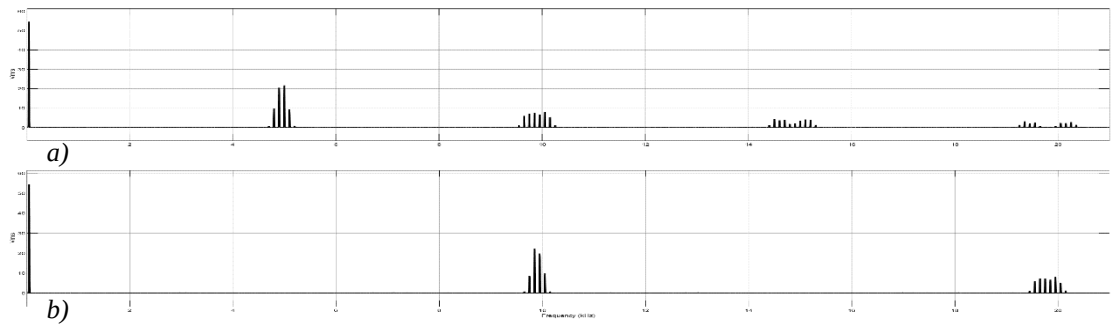

Fig. 4. Output voltage spectrum:
a) 3L-NPC inverter; b) 3L-ANPC inverter with switching frequency doubling control circuit.

Sigma-delta modulation

Sigma-Delta modulation usage in NPC inverter is proposed. Sigma-Delta modulated inverters output voltage spectrum virtually has no expressed frequency peaks, rather ripple energy is distributed along wide frequency band. This is beneficial for filtering process; however, this benefit comes at the cost of significantly increased commutation frequency, which means increased commutation losses in switching devices.

REFERENCES

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