Experiment Verification of Surge Voltage Reduction by Zero Voltage Switching Indirect Matrix Converter

◎*Toshifumi Hinata, Jun-ichi Itoh*

Department of Electrical Engineering, Nagaoka University of Technology

1. Introduction

Recently, indirect matrix converters (IMC) which uses no large energy storage components have been actively studied because it has a smaller size than conventional converters. Zero current switching method for the rectifier stage[(1)] (R-ZCS) is generally used. R-ZCS often intercepts the DC link current pathway. In high power converters, the wiring in DC link parts contains of large parasitic impedance and therefore large surge voltage will be appeared for the use of R-ZCS.

This paper evaluates a zero voltage switching method for the inverter stage[(2)] (I-ZVS) of suppression for the surge voltage with experimental results.

2. Generation mode of surge voltage

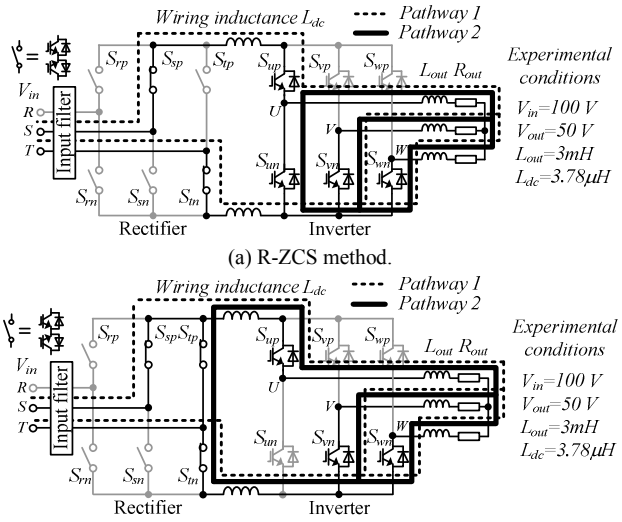
To avoid the surge voltage, the current of the parasitic inductance, i.e. DC link current, should be continuous current. Using R-ZCS operation, the input current of the inverter becomes discontinuous. The DC link current cannot be commutated to other device at the switching point of the inverter. That is, the surge voltage occurs. On the other hands, in the I-ZVS operation, the DC link current keeps continuous state. The DC link current achieves commutation to the other switch in the rectifier. Then, the surge voltage is suppressed.

Figure 1 shows one of example of current path transitions of the IMC. In Fig. 1(a), when the current path-1 changes to the path-2, the DC link current drops to zero because the current path of the DC link wiring is intercepted. Therefore, a large surge voltage occurs at S_{up}. On the other hand, in Fig. 1(b), the DC link current continues flowing in DC link because the DC link current commutates from S_{sp} to S_{tp}. As a result, I-ZVS can suppress a surge voltage. This method can protect the switching devices and is suitable for high power converters and/or multi-drive systems due to large parasitic inductance.

3. Experimental results

Figure 2 shows the experimental results to evaluate the effect of surge voltage reduction by I-ZVS. In this experiment, the output power is adjusted by R_{out}. Low input voltage is applied due to keeping the voltage rating 600 V of power devices. In R-ZCS given in figure 2(a), the large surge voltage occurs at S_{up} when the switch is turned off. The maximum voltage for R-ZCS is 515 V. On the other hand, the maximum voltage for I-ZVS is 322 V and decreased approximately 37 % of surge voltage in comparison with the R-ZCS.

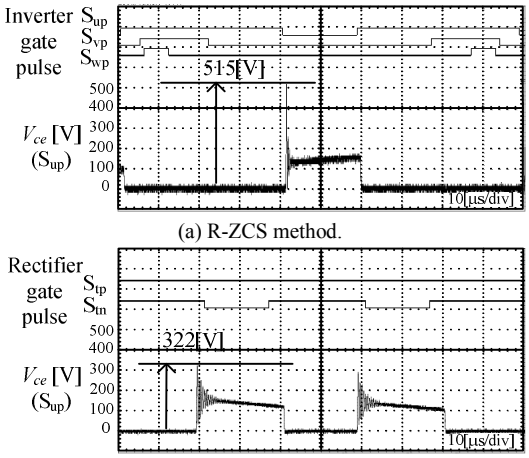
Figure 3 shows the relationship between the maximum voltage and the output power. The surge voltage of the R-ZCS is increased according to the output power increase because inductive energy in the DC link wiring inductance is increased. By applying I-ZVS, a higher power converter can uses a smaller size snubber circuit and achieves high reliability at the same time.



(a) R-ZCS method.

(b) I-ZVS method.

Fig.1. Current pathway transitions of IMC.



(a) R-ZCS method.

(b) I-ZVS method.

Fig.2. Experimental results.

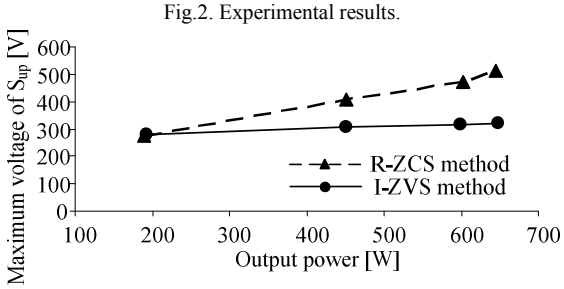


Fig.3. Surge voltage vs. Output power (Experimental result).

References

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(2) J. Itoh, T. Hinata, K. Kato, D. Ichimura: The 35th Annual Conference of the IEEE Industrial Electronics Society, pp.4511-4516 (2009)