Supplemental Explanation

Three-level inverter technology

Multilevel inverters typified by three-level inverters have a variety of advantages over general two-level inverters. For example, the voltage waveform at the converter output of a two-level inverter is a pulse width modulation (PWM) generating pulses of $\pm E_d$ from the central zero point, whereas that of a three-level inverter is a PWM generating pulses of $\pm E_d/2$ and $\pm E_d$ from the central zero point, as shown in Fig. 1.

As a consequence, the waveform of a three-level inverter is closer to a sinusoidal wave, so that an LC filter for making output waveforms sinusoidal can be rendered compact. What is more, the magnitude of the voltage fluctuation of a three-level inverter per switch operation is half that of a two-level inverter. This brings about an almost 50% reduction in the switching loss of the switching element and a reduction in noise generated by the device. Using a three-level inverter characterized by these features is an effective approach to making systems more compact and more efficient.

Of the many types of three-level inverters, those connected to the neutral point (N) of the direct-current power supply shown in Fig. 1 are called neutral-point-clamped (NPC) inverters. They are called this because the voltage applied to the switching element is kept clamped to a voltage that is half the direct-current voltage E_d.

As opposed to NPC inverters, advanced-NPC (A-NPC) inverters have seldom been put to practical use to date, although they have the advantages of reduced current loss because they have simplified circuits and a small number of current pass elements. This is because the circuit connected to the neutral point requires a bidirectional switching element. Trying to achieve this configuration with a general insulated gate bipolar transistor (IGBT) and diode results in there being two current pass elements for the current passing through the circuit connected to the neutral point. This means that there is not much difference in continuity loss between NPC inverters and A-NPC inverters. In addition, there are some problems with the wiring method and the snubber circuit, such as a high surge voltage resulting from the effect of wiring inductance during switching.

We have successfully resolved the aforementioned problems by applying a reverse-blocking IGBT (RB-IGBT), which is Fuji Electric's original technology, to circuits connected to the neutral point and developing a module designed exclusively for A-NPC inverters. We have thereby made it possible to make practical use of A-NPC inverters.

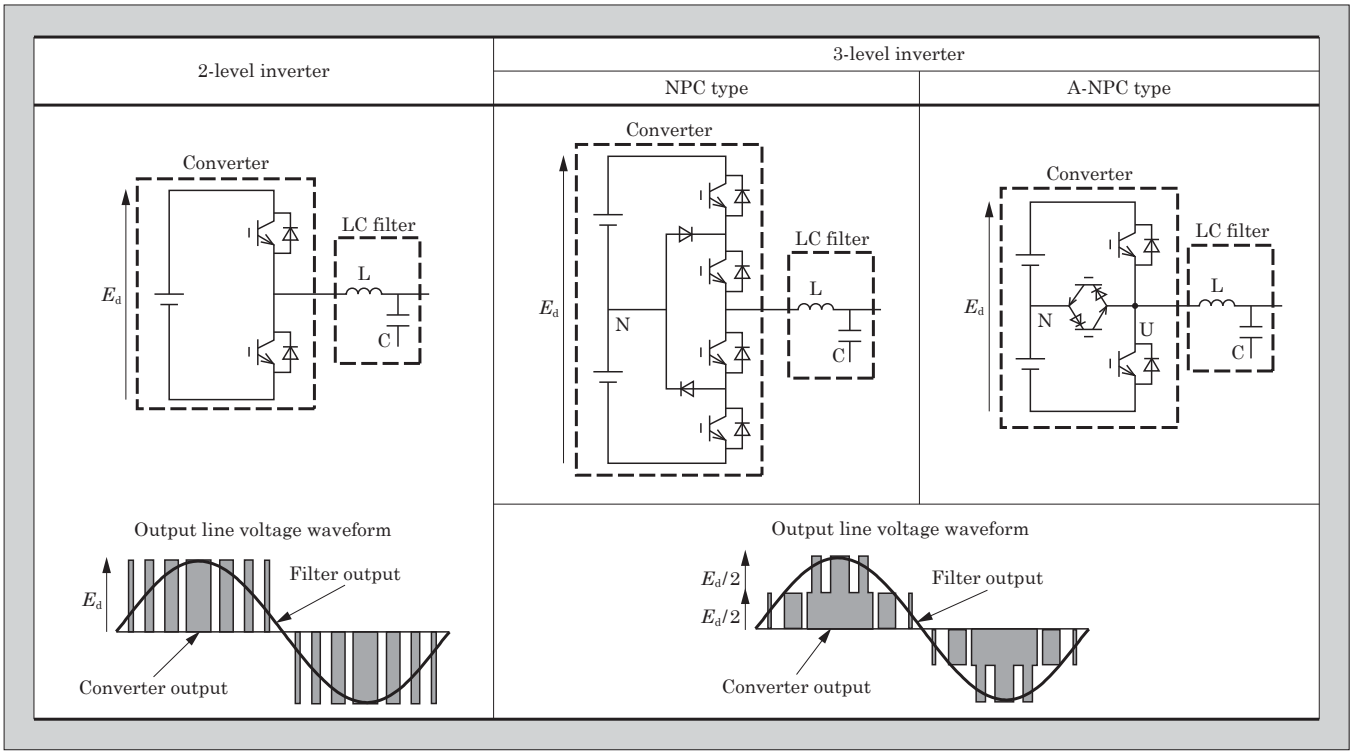

Fig.1 Comparison of voltage waveform between two-level inverter and three-level inverter circuits