Bodo´s Power Systems®

X-Series RFC Diodes for Robust and Reliable Medium-Voltage Drives

The three-level neutral-point-clamped converter is popular and often used in medium-voltage drives for instance. This article explains the popularity of the topology, the semiconductor requirements, and how the new X-Series diode module of MITSUBISHI ELECTRIC can make this converter more robust and more reliable.

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Three-Level Neutral-Point-Clamped Converter

The three-level neutral-point-clamped converter (NPC) is a typical converter topology for high-power medium-voltage applications. The NPC converter is used in various applications: in offshore-wind generators, STATCOMs, rolling mills, conveyor starters or even ship propulsion systems. What is special about this topology?

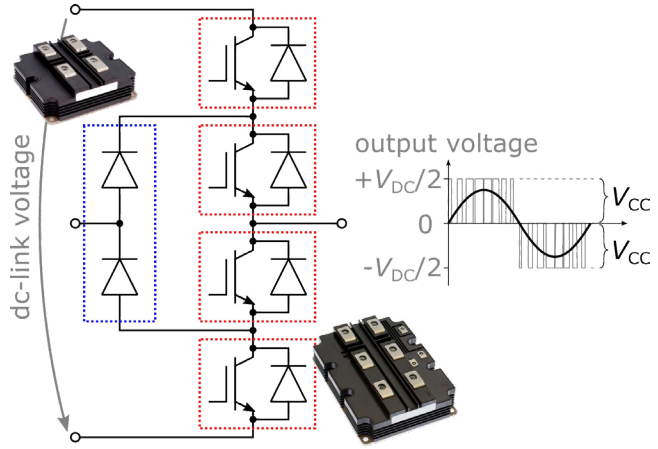

Figure 1: Three-Level Neutral-Point-Clamped (NPC) Converter made of IGBT modules (red) and diode modules (blue)

Figure 1 shows the principle schematic of an NPC converter. It consists of four main IGBTs which are marked in the figure by the red boxes. For one inverter arm, two IGBTs are connected in series. This gives the first advantage of the NPC converter: its dc-link voltage VDC can be twice as high compared to a two-level converter.

Furthermore, the NPC converter utilizes clamping diodes (marked by a blue box). Due to these diodes, the NPC converter is able to output three different voltage levels $(+\frac{V_{DC}}{2}, 0, -\frac{V_{DC}}{2})$. The additional output level allows a lower total harmonic distortion (THD) compared to a two level converter. This results in smaller and more efficient output filters.

As shown in Figure 1, the output voltage makes steps of $\frac{V_{DC}}{2}$. This gives two advantages. Firstly, the switching losses of the semiconductors are lower, due to the lower switching voltage V_{cc}. Secondly, common-mode currents are reduced. These current might cause electromagnetic interference (EMI) and damage of bearing and motors.

In summary, a three-level NPC converter offers the following advantages over a two-level converter:

- Higher achievable dc-link and output voltage
- Smaller, more efficient output filter
- Higher switching frequencies
- Lower common-mode currents

Application Field

The NPC converter is today used in various applications. Looking at three exemplary applications, we will see quiet different technical converter requirements.

The first example is a grid-side converter of an offshore wind turbine injecting power from the wind generator into the grid. Therefore, the grid-side converter mainly operates at a power factor cos(φ) close to 1. It is operated directly at the grid or via a filter. Hence, only small variation of the modulation index *m* are required.

As a second example, the generator-side converter of an offshore wind turbine is regarded. Since power flow is from AC- to DC-side, it is operated with negative power factor. Moreover, the converter's modulation index is varying according to the speed of the wind generator and the generator voltage.

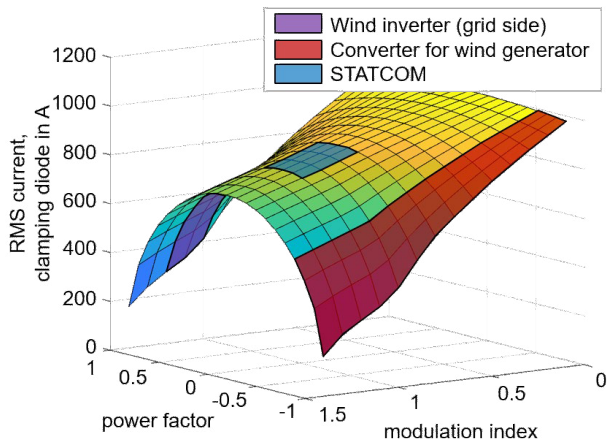

Figure 2: RMS current in the clamping diode for different converter operation conditions