Investigation of Line-Commutated Three-Phase Converters under Voltage Unbalance

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Background:

Unsymmetrical loads, transmission lines and faults in three-phase electrical power systems can cause the mains voltage at the point of coupling to be unbalanced. Power converters operating in such unbalanced electrical systems will generally work asymmetrically, which introduces well-known disadvantages for the system's operation such as higher distortion levels and the appearance of non-characteristic harmonics.

Challenge:

In the case of controllable power converters, such as thyristor converters, it is possible to operate the converter with asymmetrical firing angles. This offers the opportunity to react on the system's unbalance optimizing the asymmetrical operation of the converter to lower the mentioned disadvantages; e.g. to reduce the amplitudes of non-characteristic harmonics and therefore the distortion level.

Approach:

For the aspired optimization of the converter's asymmetrical operation it is necessary to calculate the converter's operation. In this work this is done with differential equations in the range of space-phasors. Thereby according to the conducting thyristors several space-phasor networks have to be derived and solution statements for the differential equations have to be stated.

Results:

With the presented method it is possible to calculate optimized firing angles for the asymmetrical operation of a given system and a desired operation mode. With these optimized firing angles it is possible to eliminate non-characteristic harmonics that are introduced by the unbalance and to minimize the distortion level of the AC-line currents and the DC-current.
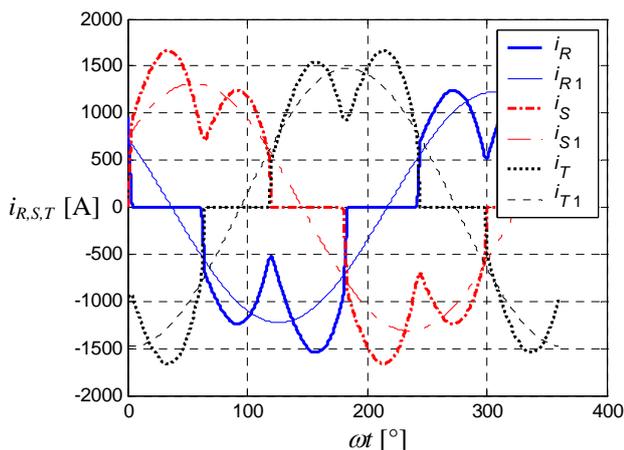

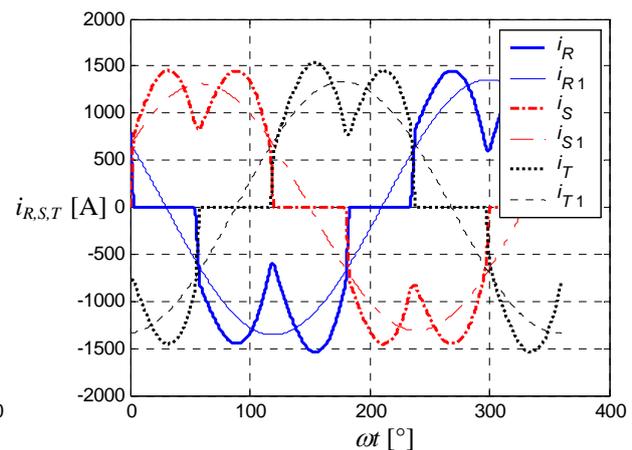Fig. 1: AC-line currents and fundamental component for the voltage-zero-crossing firing method

Fig. 2: AC-line currents and fundamental component for an AC-lines THD optimized firing strategy

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