

§27. R&D of Arbitrary Waveform, Arbitrary Power Factor and Fast-response Matrix Converter

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Fast-response power supply is indispensable for feedback stabilization of vertical position instability of spherical tokamak plasma. In the tokamak-type fusion reactor, higher transformation efficiency, less higher harmonics and higher power factor are requested in addition to the high-responsibility, and the candidate for the fast-response power supply is matrix converter (Fig.1).

First, Venturini method¹⁾ and space vector modulation method²⁾ in three-phase to three-phase matrix converter are compared in common alpha-beta-gamma coordinate system, when the switching frequency is much higher than the modulation frequency. The output phase-voltage in Venturini method is described clearly as the product of switching matrix and the input phase-voltage in polar coordinates, and the input phase-current is described similarly from the output phase-current. In case of space vector modulation method, the switching matrix component concerning the phase-voltage and the phase-current is not sinusoidal, though it is sinusoidal concerning the line-to-line voltage. The switching matrix may be reduced to sinusoidal, when modulation shift is made so that the average value becomes 0.5 precisely.

Next, three-phase to single-phase matrix converter is discussed for application to the feedback control of poloidal field coil current (single-phase inductive load). In Venturini method, the output voltage frequency is set to zero, and the voltage gain q is modulated according to the external command (Fig.2). Namely, the arbitrary output voltage and the input power factor of unity are attained (Fig.3). Double star connection, however, is indispensable to avoid asymmetrical magnetization of input transformer. In case of space vector modulation method, only the rectifier stage is adopted in virtual matrix converter and the arbitrary output voltage is obtained by changing the modulation index m . Since the output voltage is symmetrical concerning the ground, the center of the load may be grounded. The input power factor of unity is attained by switching so that the input current is in the same phase with the input voltage.

Though eddy current in the conducting vacuum chamber or stabilizing shell around the tokamak plasma decelerates the growing speed of vertical position instability, it may shield the stabilizing horizontal magnetic field into the chamber or the shell. So, high-voltage power supply is necessary for the forcing in addition to

the above mentioned characteristics. As for the application of the matrix converter, computer and circuit simulations are necessary, since the switching frequency cannot be much higher than the modulation frequency in the real power supply. And the confirmation about the arbitrary output current waveform and the input power factor is necessary, since the output frequency cannot be negligible and the output waveform may be controlled to arbitrary waveform (not DC) according to the external command.

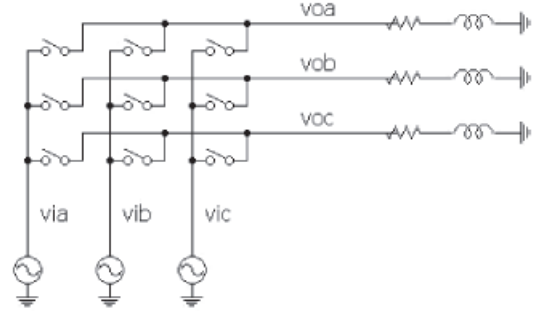


Fig. 1: Three-phase to three-phase direct matrix converter.

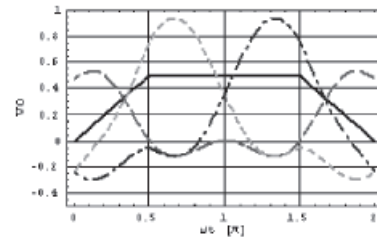


Fig. 2: Contribution from each phase voltage, when the voltage gain is trapezoidal wave.

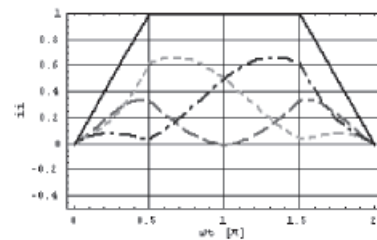


Fig. 3: Contribution from each phase current, when the voltage gain is trapezoidal wave.

- 1) Venturini, M., 1980, A New Sine Wave In, Sine Wave Out Conversion Technique Eliminates Reactive Elements, Proc. POWERCON 7, 1980: pE3-1-E3-15.
- 2) Casadei, D., Serra, G., Tani, A., Zarri, L., 2002, Matrix Converter Modulation Strategies: A New General Approach Based on Space-Vector Representation of the Switch State, IEEE Transactions on Industrial Electronics, Vol. 49, No.2, 2002: p370-381.