3

AC-AC Conversion

Sándor Halász
Budapest University of Technology and Economics

3.1 Introduction

AC-AC converters as shown in Fig. 3.1 are frequency converters. They produce an AC voltage in which both the frequency and voltage can be varied directly from the AC line voltage, e.g., from a 60- or 50-Hz source.

There are two major classes of AC-AC, or so-called direct static frequency converters, as shown in Fig. 3.1.

1. Cycloconverters, which are constructed using naturally commutated thyristors. The commutation voltage is ensured by the supply voltage. These are so-called line commutated converters.
2. Matrix converters, which are constructed using full-controlled static devices, such as transistors or GTOs (gate turn-off thyristors).

3.2 Cycloconverters

In Figs. 3.2 and 3.3, the two typical types of cycloconverters are presented. In the first case there are two three-phase midpoint controlled rectifiers connected back to back. The second case shows two three-phase bridge rectifier converters connected back to back. Both are used for three-phase to three-phase conversion. In Fig. 3.4 the single-phase output voltage and current waves are presented for the

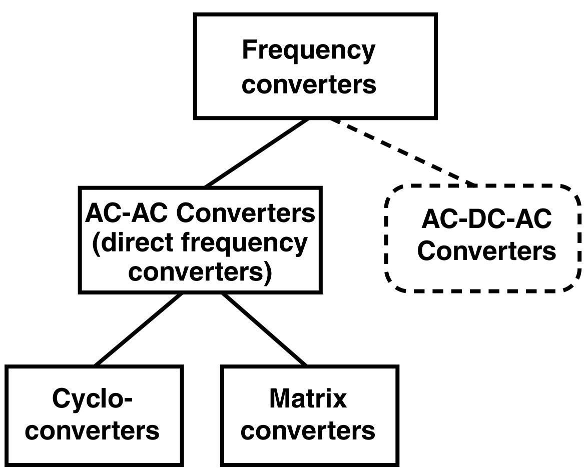

FIGURE 3.1 Classification of frequency converters.

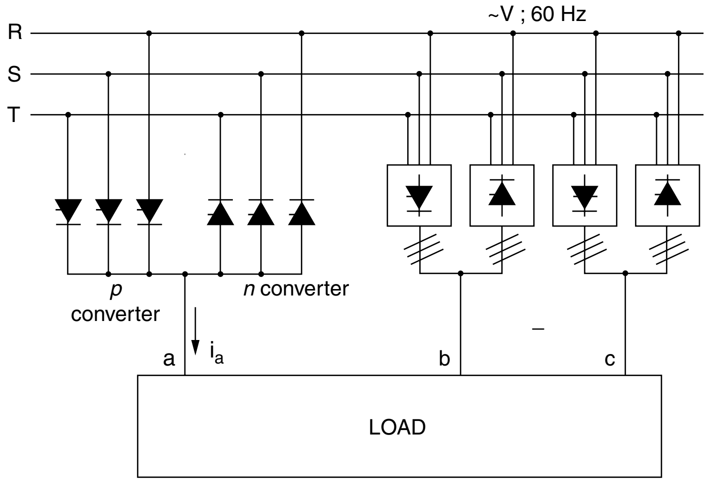

FIGURE 3.2 Cycloconverter scheme with three-phase midpoint controlled rectifier.

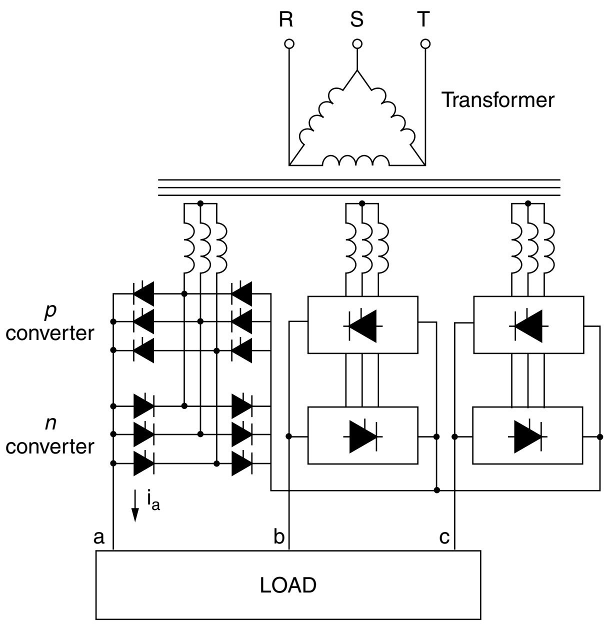

FIGURE 3.3 Cycloconverter scheme with three-phase bridge controlled rectifier.

bridge rectifier circuits. The output voltage V_a and current i_a have V_{a1} and i_{a1} fundamental components with ϕ_1 phase displacement and numerous harmonics. Because of the load inductance, the current harmonics will be significantly lower than the voltage harmonics. The firing angles are α_P and α_N for the p and n converters, respectively. In general, the controls are designed so that only the thyristors of either the p or n converter is firing, which produces a current in the desired direction. During this period the other converter is blocked. When the current changes direction, both converters must be blocked for a short time.

It is possible to operate without blocking the converters. In this case, their average voltage must be the same, and therefore the relation $\alpha_p = 180 - \alpha_n$ is valid. However, additional inductances are necessary to limit the circulating currents between two converters since the instantaneous voltages of the two converters differ from one another.

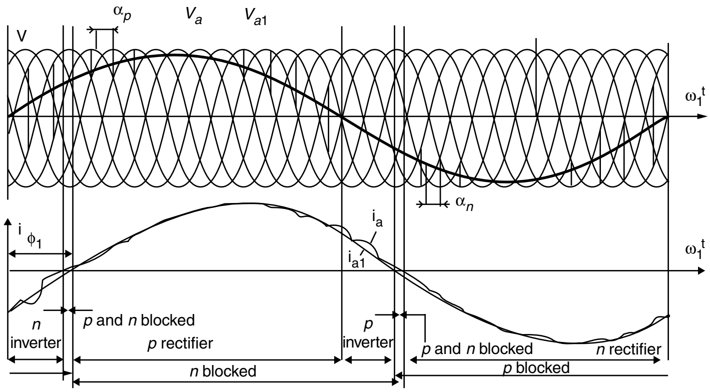

FIGURE 3.4 Voltage and current vs. time for cycloconverter with three-phase bridge converters.

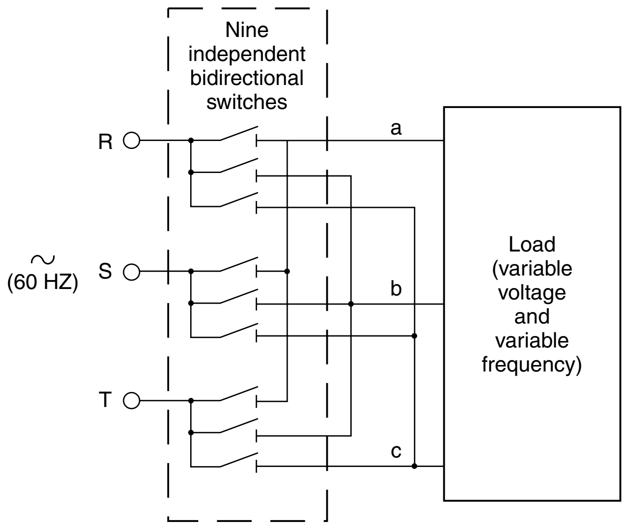

FIGURE 3.5 Three-phase to three-phase matrix converter.

The phase control of the *p* and *n* converters is modulated by a sine or trapezoidal wave. The content of the harmonics for sine modulation is lower; however, the maximum value of the output voltage is lower than that for trapezoidal modulation. During every cycle of the output voltage both of the converters must work as rectifiers and inverters.

The shape of the output voltage goes from bad to worse with an increase in the output voltage and the output frequency. If the frequency reaches the well-defined value the current harmonics become unacceptable. This frequency is usually 33% of supply frequency for three-phase midpoint (Fig. 3.2) and 50% for three-phase bridge (Fig. 3.3) converters.

The cycloconverter is usually used for three-phase, high-power, low-speed synchronous motor drives and rarely employed for induction motor drives.

3.3 Matrix Converters

The three-phase to three-phase matrix converter is presented in Fig. 3.5. Using the bidirectional switches, any phase of the load can be connected to any phase of the input voltage, e.g., the zero value of the load phase voltages is maintained by connecting all the load phases to the same input phase. Using pulse-width

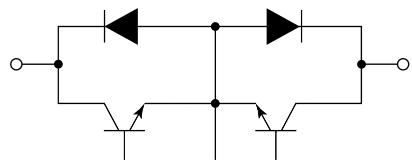

FIGURE 3.6 Bidirectional switch.

modulation techniques, the load voltage and the load frequency are controlled from zero to their maximum values. The maximum voltage is usually close to the input voltage, but the maximum frequency can be several times that of the input frequency and is only limited by practical considerations. The bidirectional switches must be capable of permitting current flow in either direction. In Fig. 3.6 one possible configuration of the bidirectional switch is shown.

Matrix converters require the use of numerous switches and well-established control methods. Some additional elements are necessary for the safe commutation of the bidirectional switches. These disadvantages of matrix converters prevent their use in industrial applications.

References

Guggi, L. and Pelly, B. R. 1976. *Static Power Frequency Changes,* John Wiley & Sons, New York.

Pelly, B. R. 1976. *Thyristor Phase-Controlled Converters,* John Wiley & Sons, New York.