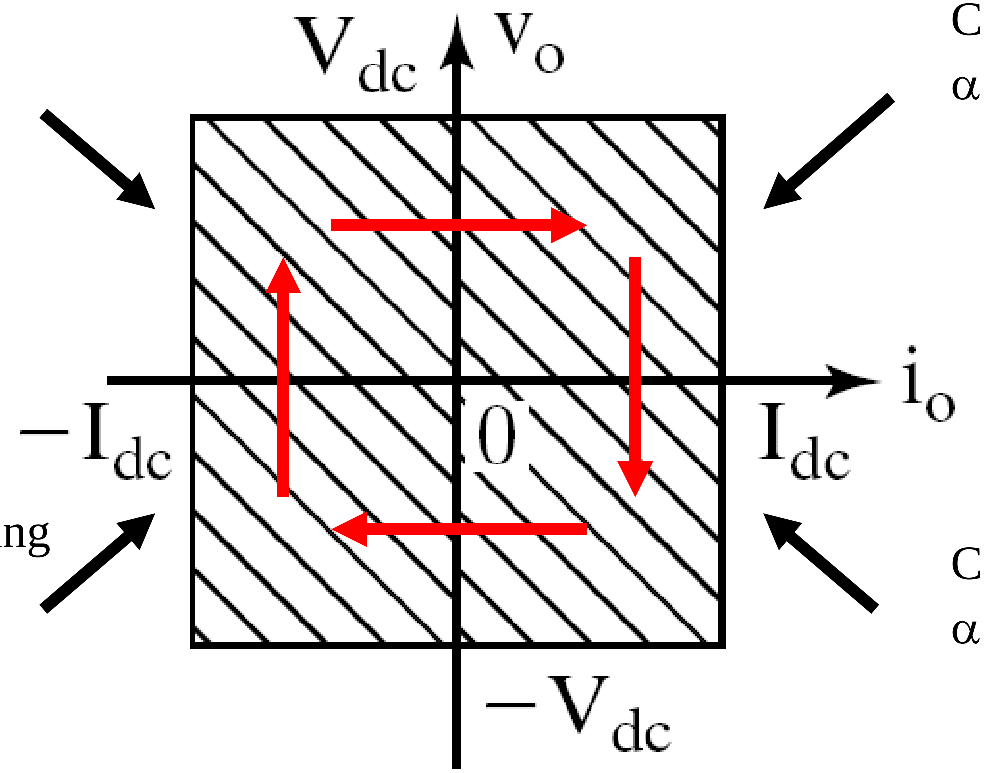
Four Quadrant Operation

Conv. 2 Inverting

$\alpha_2 > 90^0$

Conv. 1 Rectifying

$\alpha_1 < 90^0$



Conv. 2 Rectifying

$\alpha_2 < 90^0$

Conv. 1 Inverting

$\alpha_1 > 90^0$

3-Phase Thyristor Converters

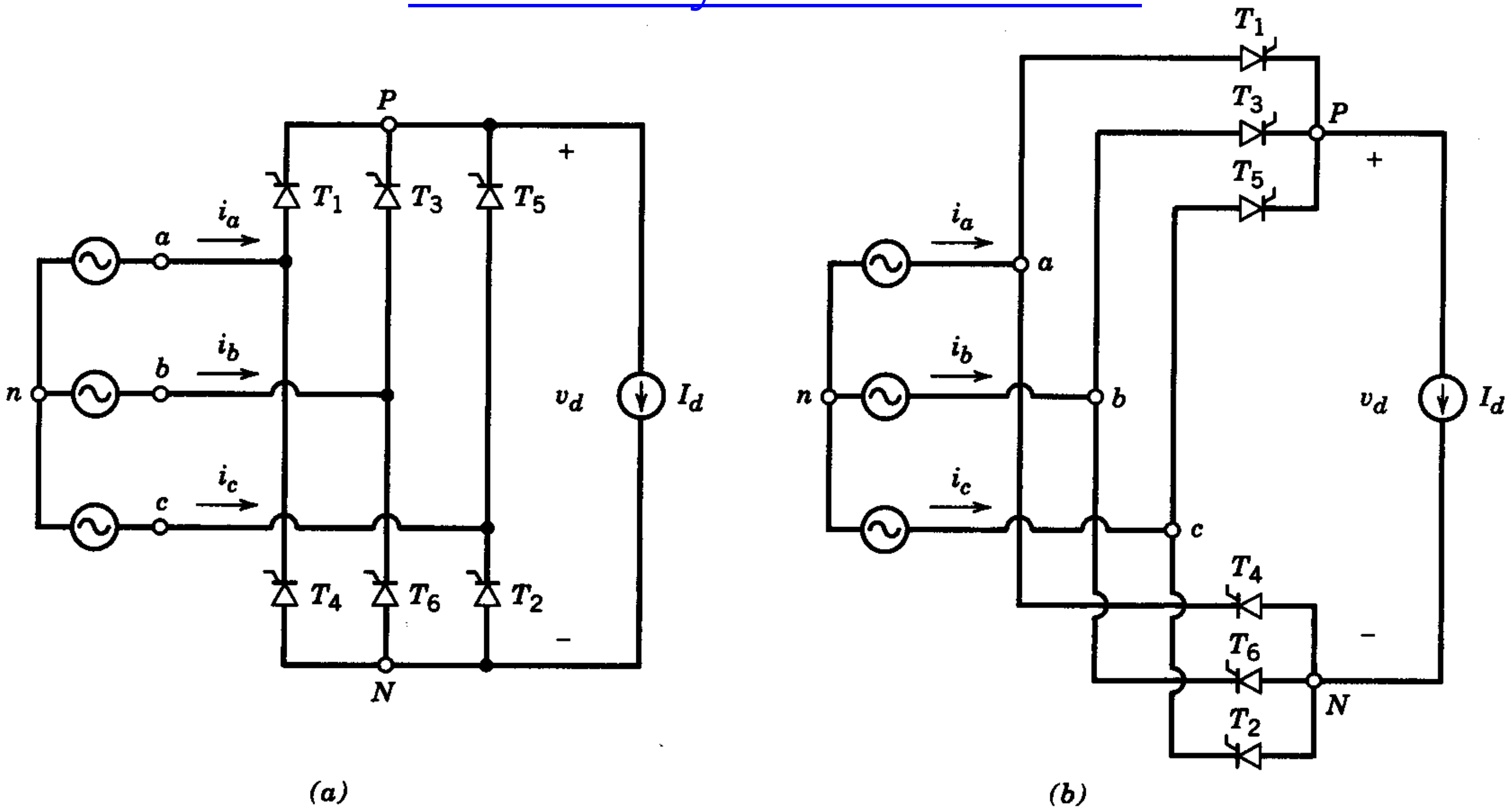


Figure 6-19 Three-phase thyristor converter with $L_s = 0$ and a constant dc current.

- Current I_d flows through the one thyristor of the top group and one of the bottom group
- If a continuous gate pulse is applied then this circuit will act like a three-phase full bridge diode rectifier and, as a result,

$$V_{d0} = 1.35 V_{LL}$$

3-Phase Thyristor Converter Waveforms

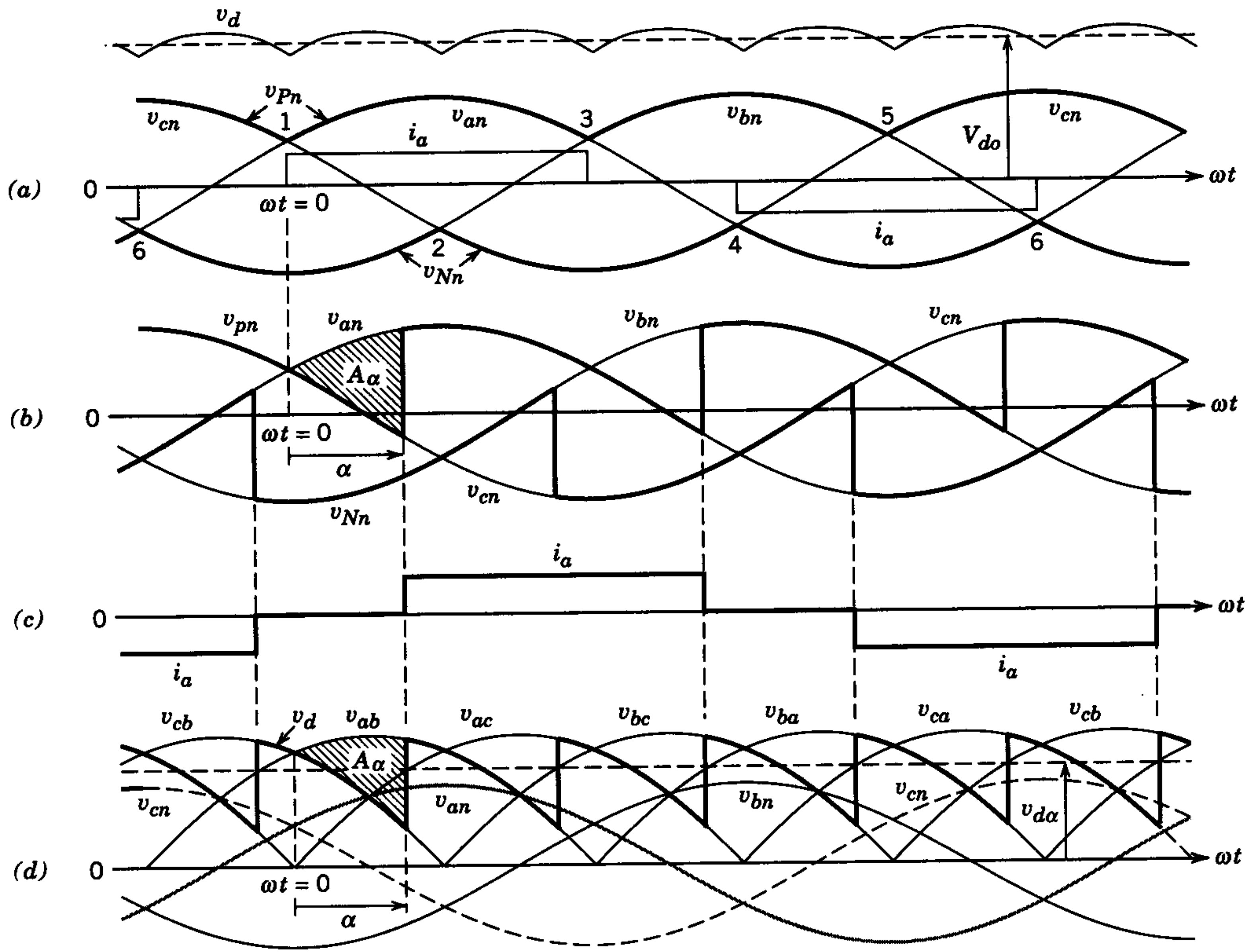


Figure 6-20 Waveforms in the converter of Fig. 6-19.

Average Output DC Voltage

$$V_{d\alpha} = V_{d0} - \frac{A_\mu}{\pi/3}$$

$$V_{ac} = \sqrt{2} V_{LL} \sin(\omega t)$$

The reduction in the average dc voltage due to the delay angle α

$$A_\mu = \int_0^\alpha \sqrt{2} V_{LL} \sin(\omega t) d(\omega t) = \sqrt{2} V_{LL} (1 - \cos\alpha)$$

$$\therefore \quad V_{d\alpha} = V_{d0} - \frac{A\mu}{\pi/3} = 1.35 V_{LL} - \frac{\sqrt{2} V_{LL} (1 - \cos\alpha)}{\pi/3}$$

$$= 1.35 V_{LL} \cos\alpha = 1.35 V_{d0}$$

Average Power

$$P_{d\alpha} = V_{d\alpha} I_d = 1.35 V_{LL} I_d \cos\alpha$$

❖dc-side voltage waveforms as a function of α

❖V_d repeats at six times the line frequency

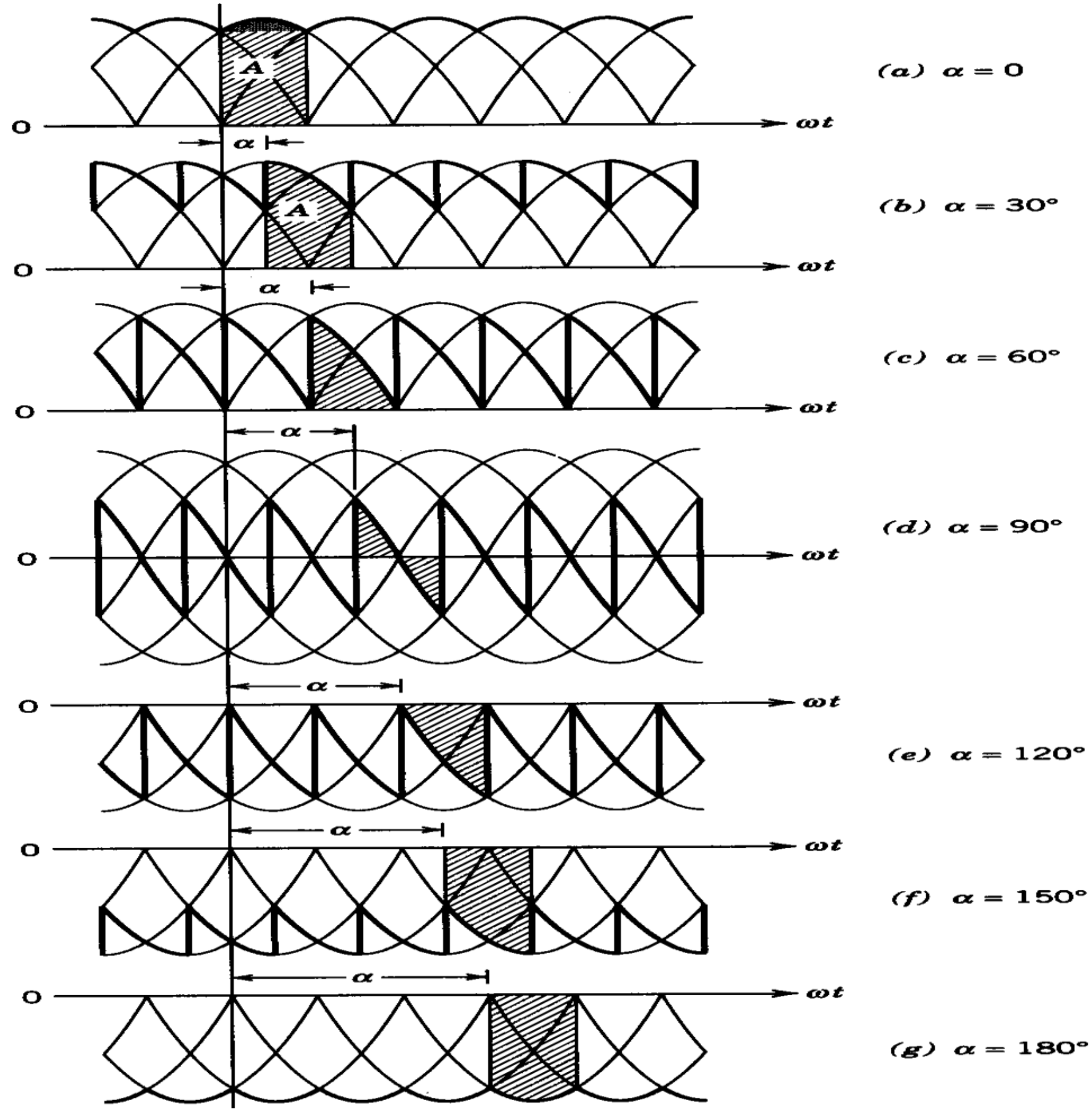


Figure 6–21 The dc-side voltage waveforms as a function of α where $V_{d\alpha} = A/(\pi/3)$. (From ref. 2 with permission.)

Conclusions

- Thyristor converters provides controlled transfer of power between the line frequency ac and adjustable-magnitude dc
- By controlling α, transition from rectifier to inverter mode of operation can be made and vice versa
- Thyristor converters are mostly used at high-power levels
- Thyristor converters inject large harmonics into the utility system