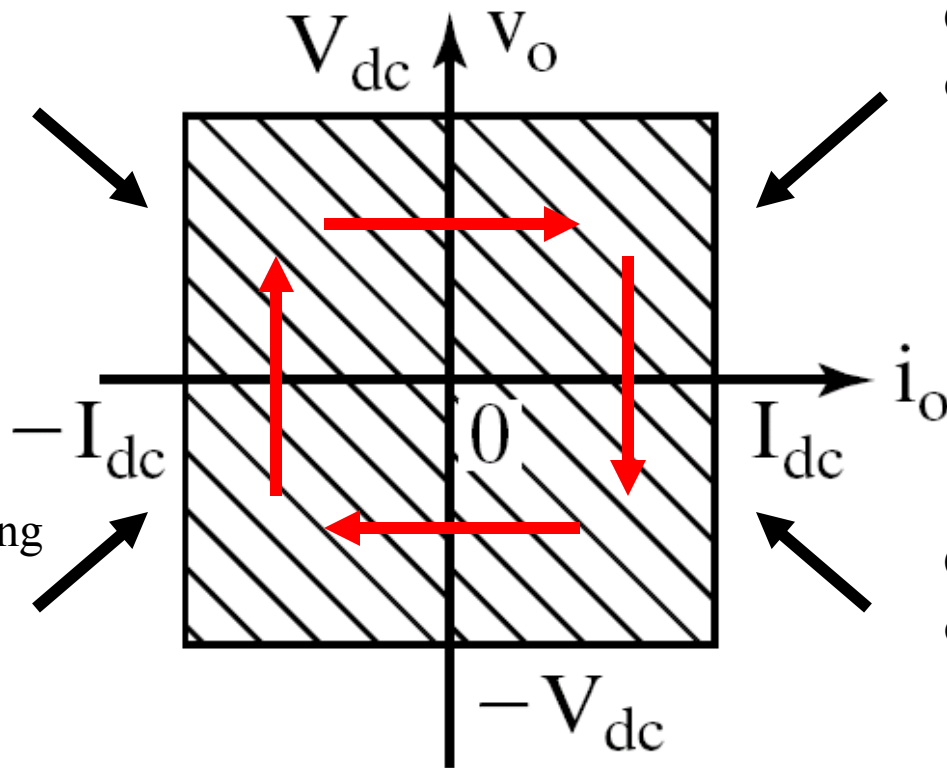


Four Quadrant Operation

Conv. 2
Inverting
 $\alpha_2 > 90^\circ$

Conv. 2 Rectifying
 $\alpha_2 < 90^\circ$



Conv. 1 Rectifying
 $\alpha_1 < 90^\circ$

Conv. 1 Inverting
 $\alpha_1 > 90^\circ$

3-Phase Thyristor Converters

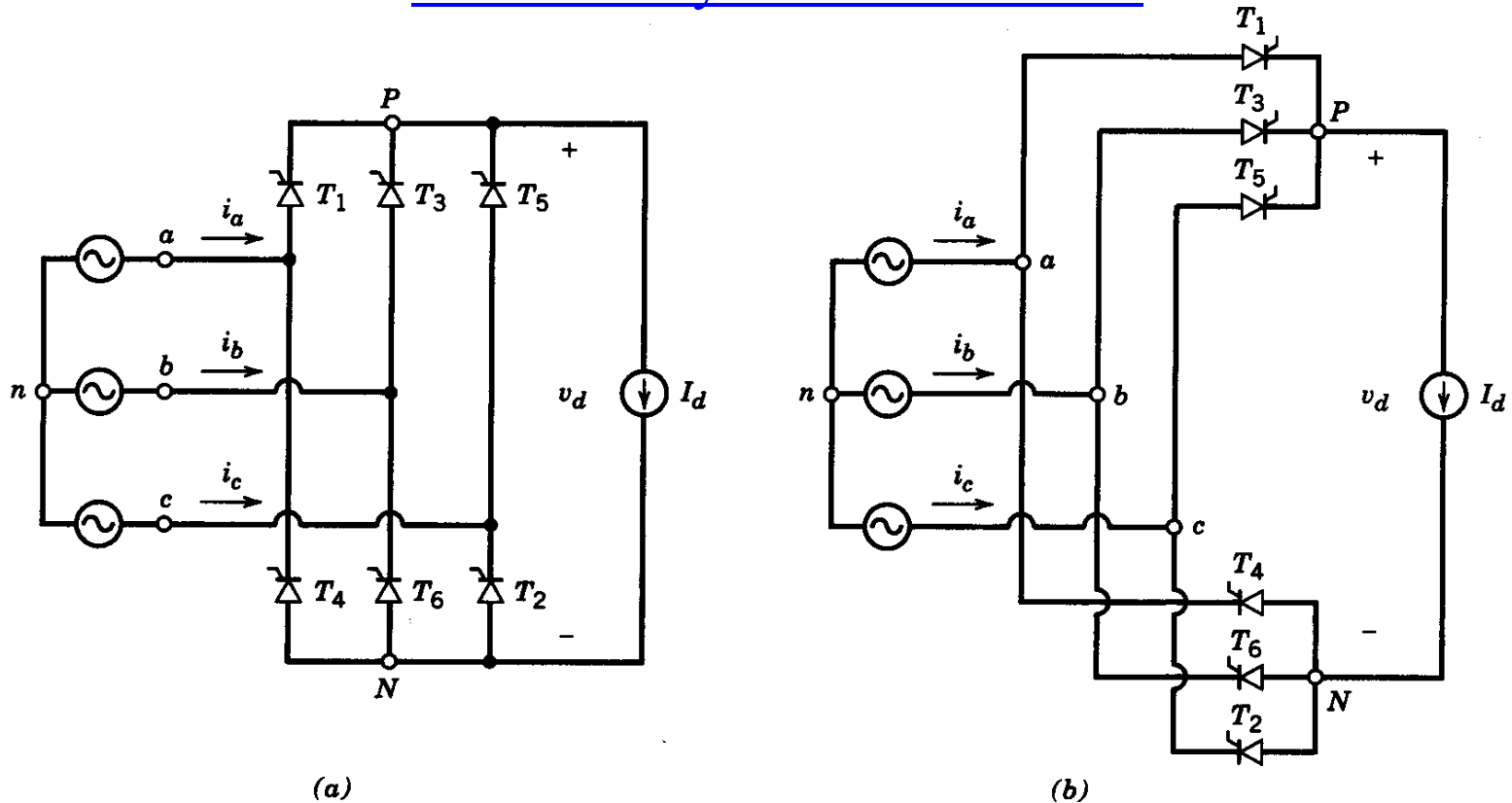


Figure 6-19 Three-phase thyristor converter with $L_s = 0$ and a constant dc current.

- 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

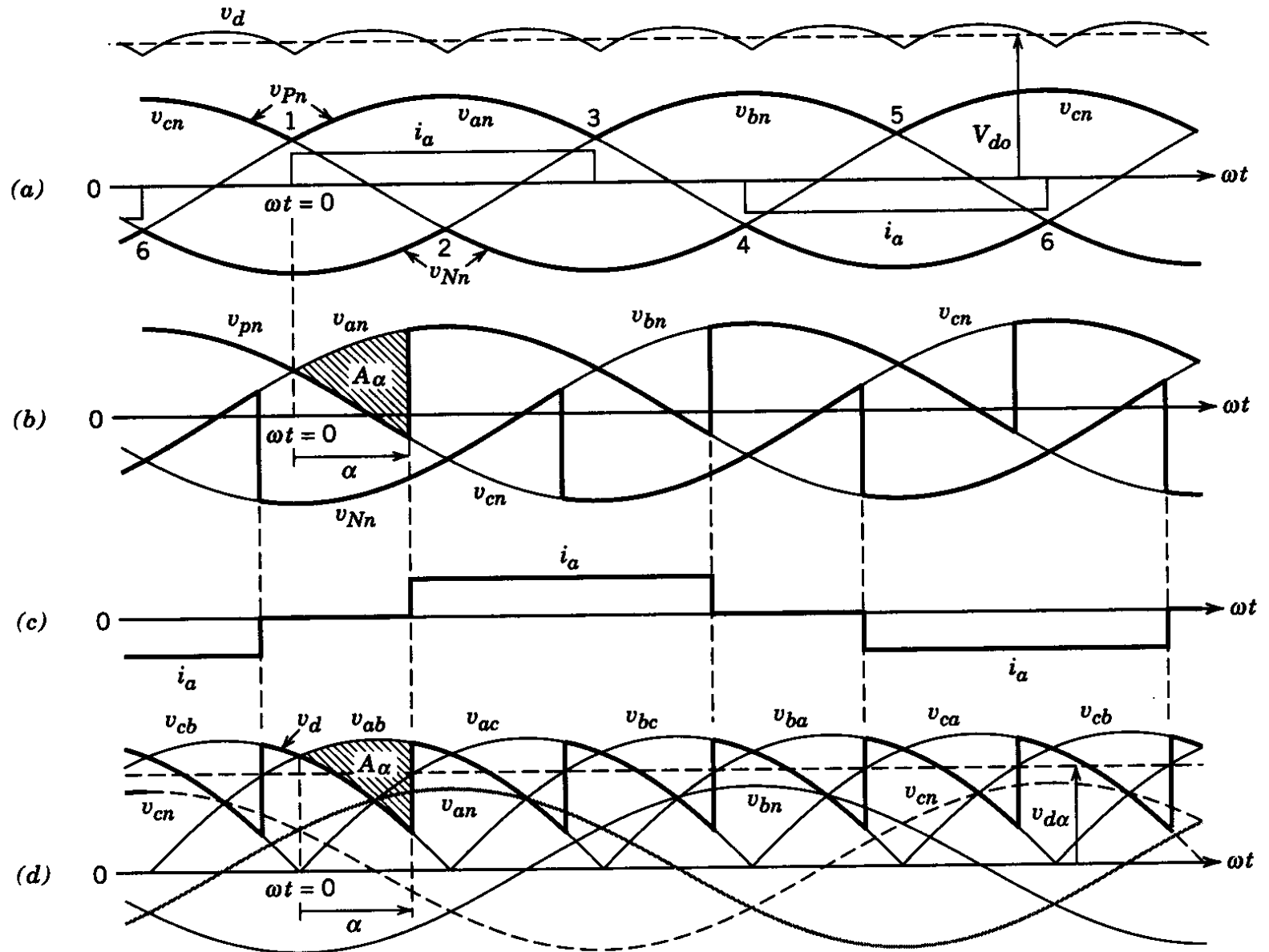


Figure 6-20 Waveforms in the converter of Fig. 6-19.

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

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

$$\begin{aligned} \therefore V_{d\alpha} &= V_{d0} - \frac{A_{\mu}}{\pi/3} = 1.35V_{LL} - \frac{\sqrt{2}V_{LL} (1 - \cos \alpha)}{\pi/3} \\ &= 1.35V_{LL} \cos \alpha = 1.35V_{d0} \end{aligned}$$

Average Power

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

❖ dc-side voltage waveforms as a function of α

❖ V_d repeats at six times the line frequency

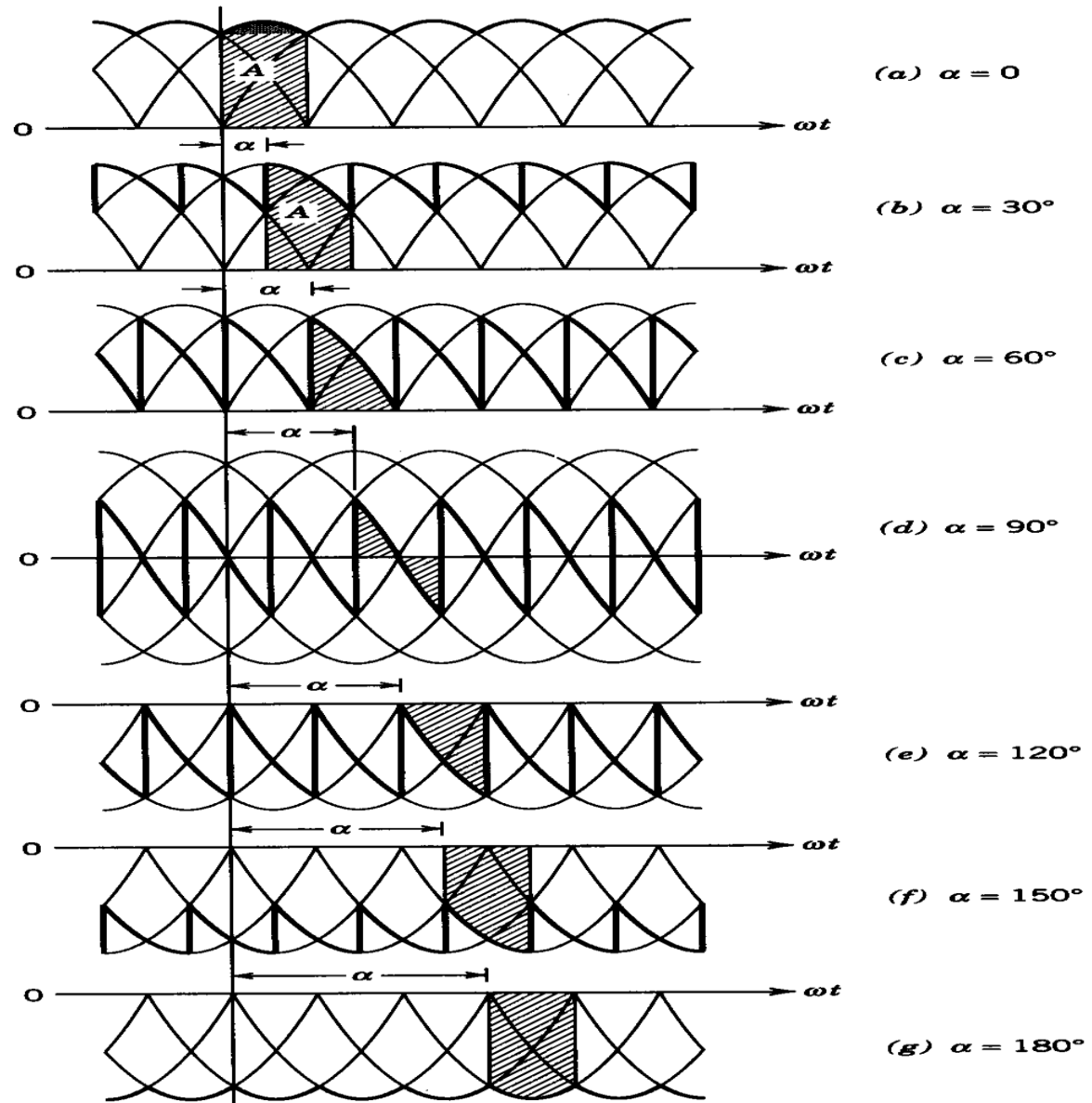


Figure 6-21 The dc-side voltage waveforms as a function of α where $V_{d\alpha} = A/(\pi/3)$. (From ref. 2 with permission.)

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

Effect of source inductance on phase controlled AC-DC converters

Overlap in single-phase, CT fully controlled converter

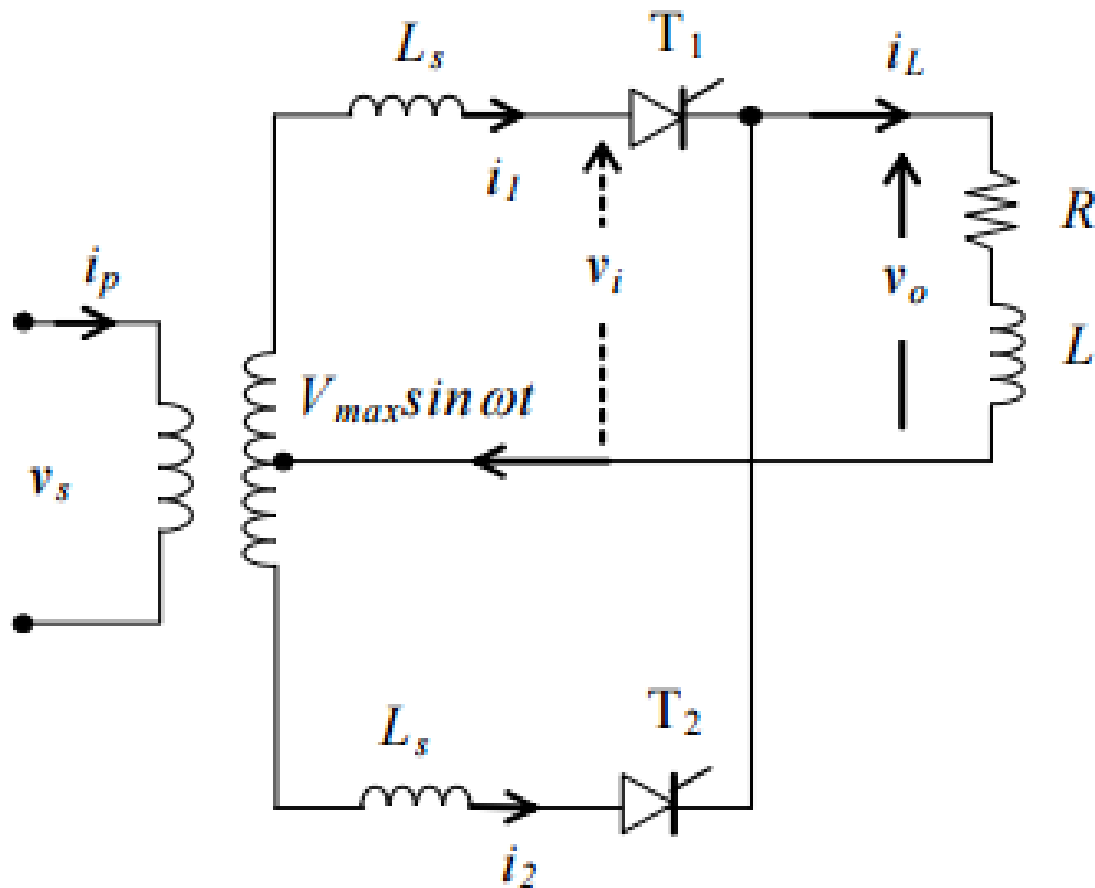
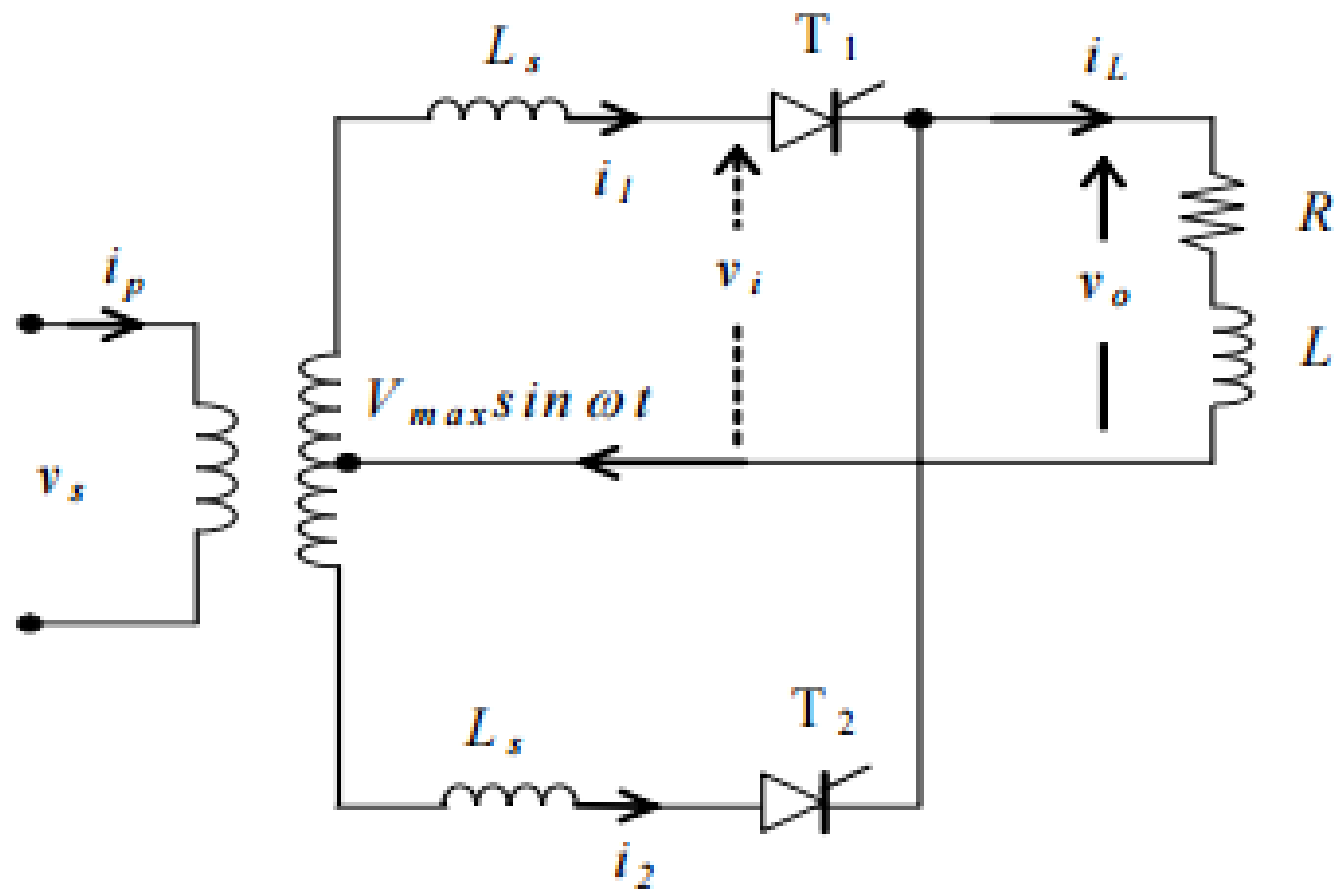
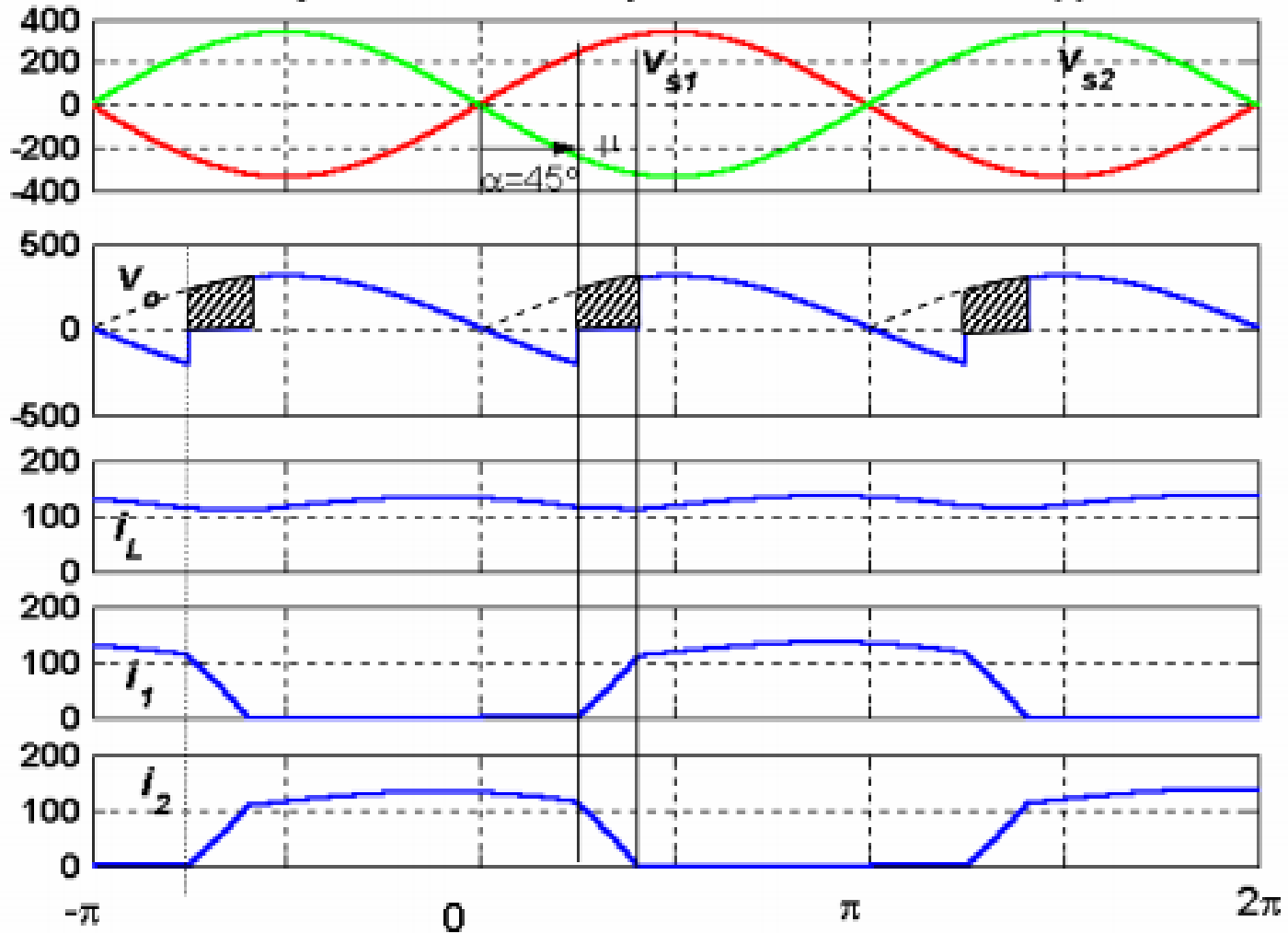


Figure Single-phase C-T converter with source inductance

The presence of source inductance means that commutation of load current from one thyristor to the next, as they are triggered with a firing angle α , can not be instantaneous. This source inductance, L_s , is invariably because of the inductance of the supply lines and the leakage inductance of the input transformer. For this circuit, the overlap of conduction for the duration μ makes the output voltage zero (which is the mean of the overlapping input voltages) during this period.



1 phase centra tap converter. $\alpha=45^\circ$ (I)



1 phase centra tap converter. $\alpha=45^\circ$ (II)

