Chapter 14

THYRISTOR CONVERTERS

Thyristors (SCRs)

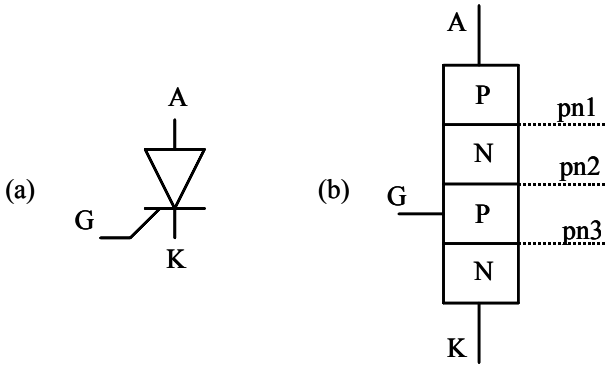

Figure 14-1 Thyristors.

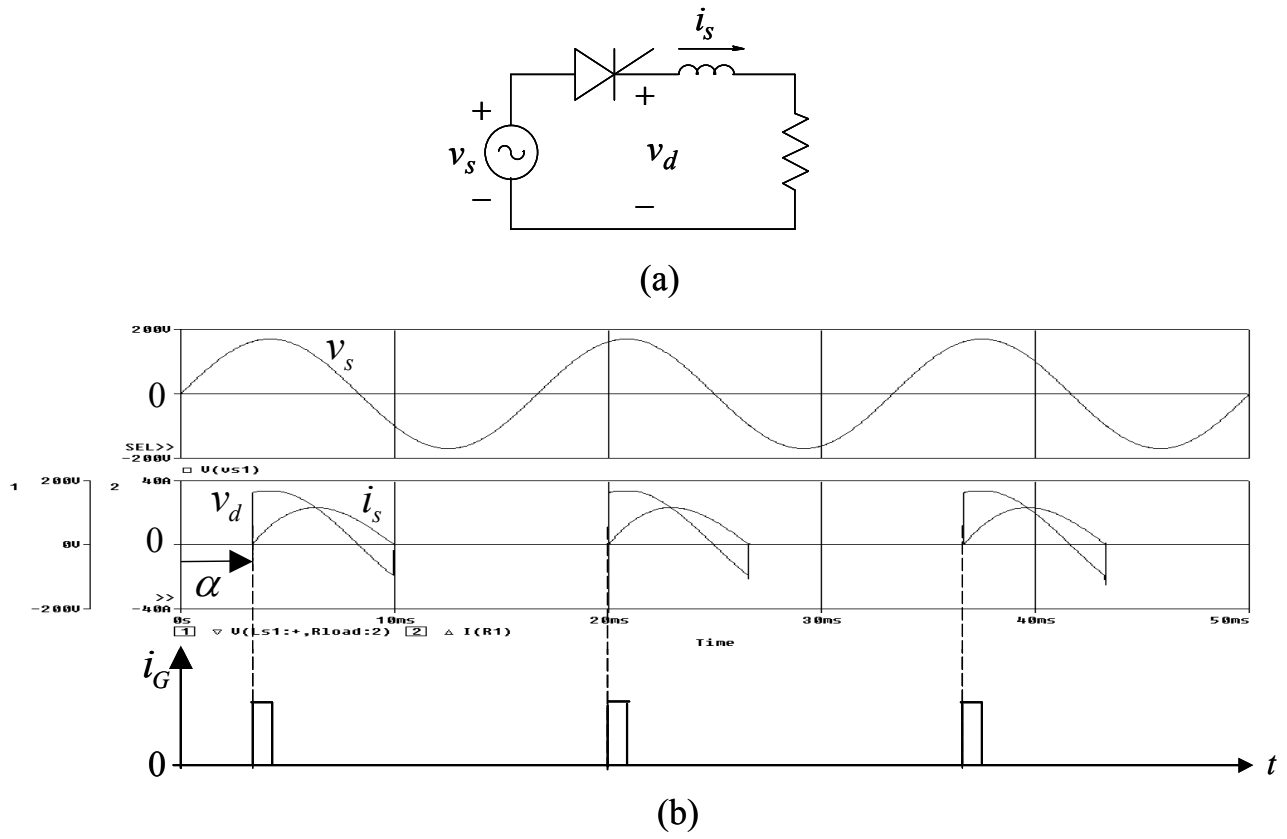

Figure 14-2 A simple thyristor circuit.

Single-Phase, Phase-Controlled Thyristor Converters

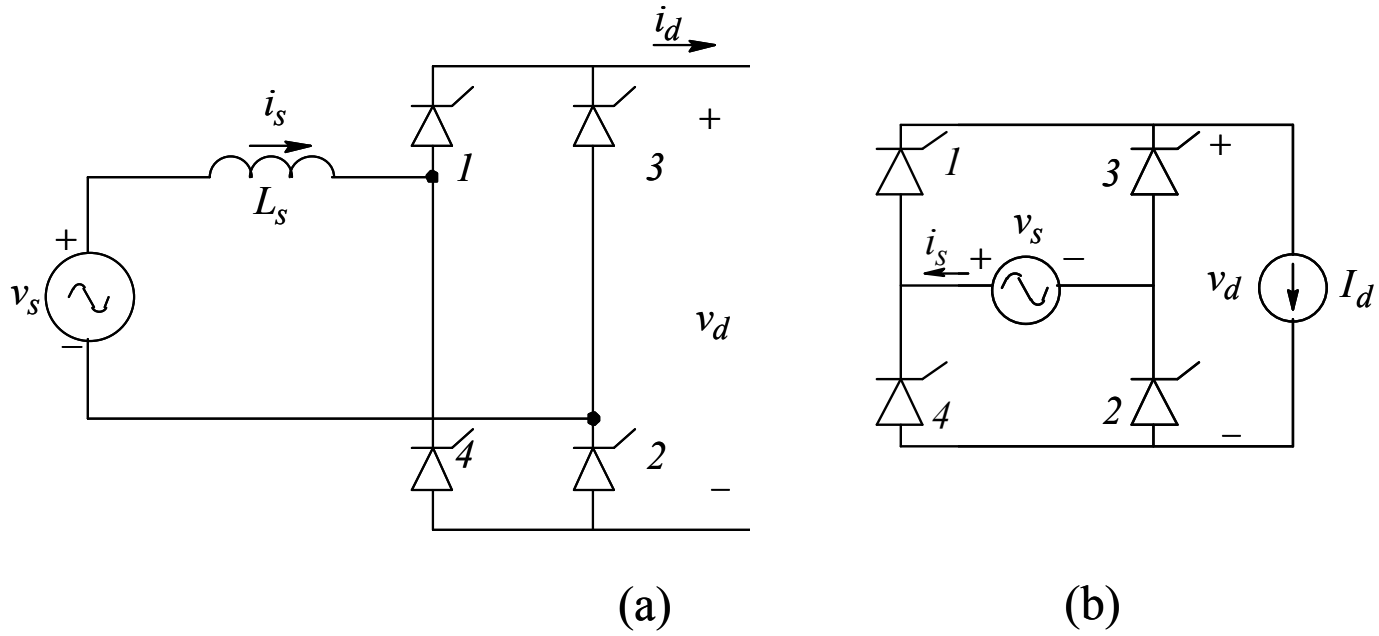

Figure 14-3 Full-Bridge, single-phase thyristor converter.

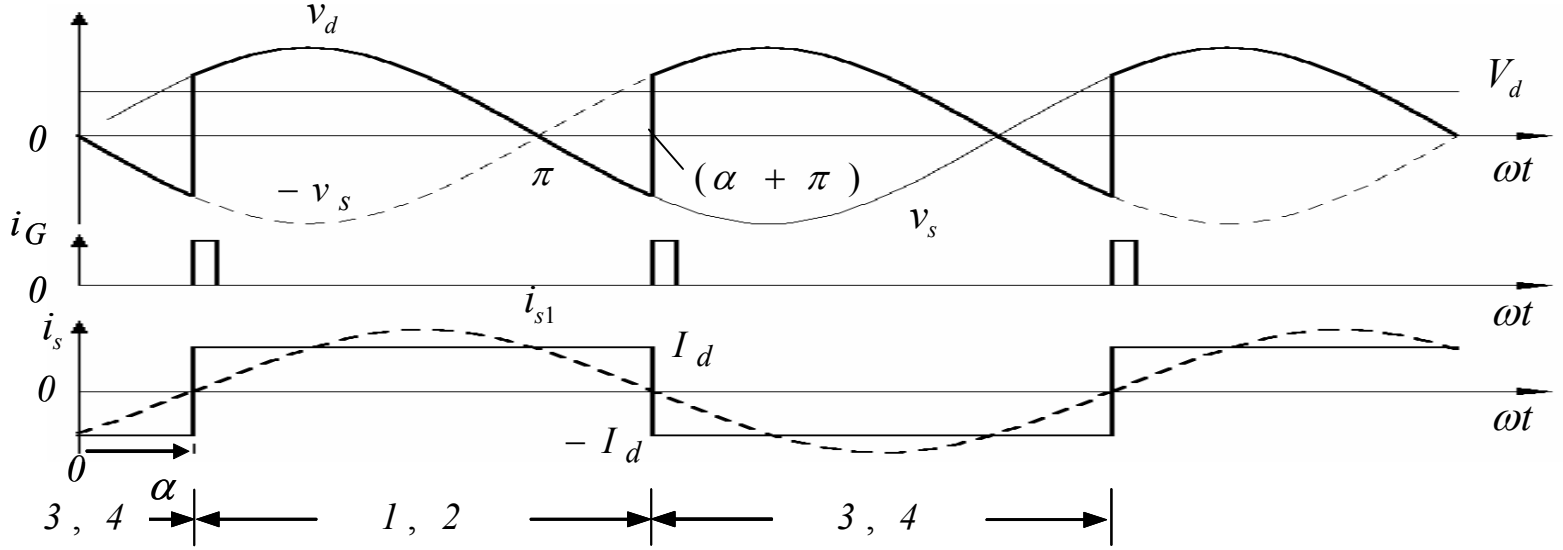

Figure 14-4 Single-phase thyristor converter waveforms.

$$v_d(t) = v_s(t) \quad \text{and} \quad i_s(t) = I_d \qquad \alpha < \omega t \le \alpha + \pi$$

$$v_d(t) = -v_s(t) \quad \text{and} \quad i_s(t) = -I_d \qquad \alpha + \pi < \omega t \le \alpha + 2\pi$$

$$V_d = \frac{1}{\pi}\int_{\alpha}^{\alpha+\pi} \hat{V}_s \sin\omega t \cdot d(\omega t) = \frac{2}{\pi}\hat{V}_s \cos\alpha \qquad \hat{I}_{s1} = \frac{4}{\pi} I_d \qquad P = \frac{1}{2}\hat{V}_s \hat{I}_{s1} \cos\alpha$$

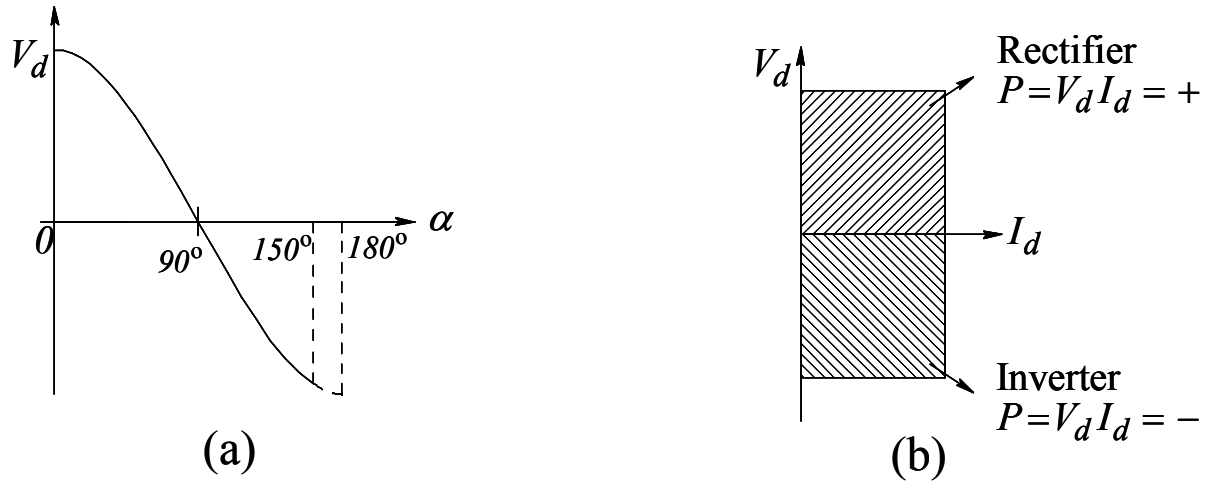

Fig. 14-5 Effect of the delay angle α .

The Effect of L_s on Current Commutation

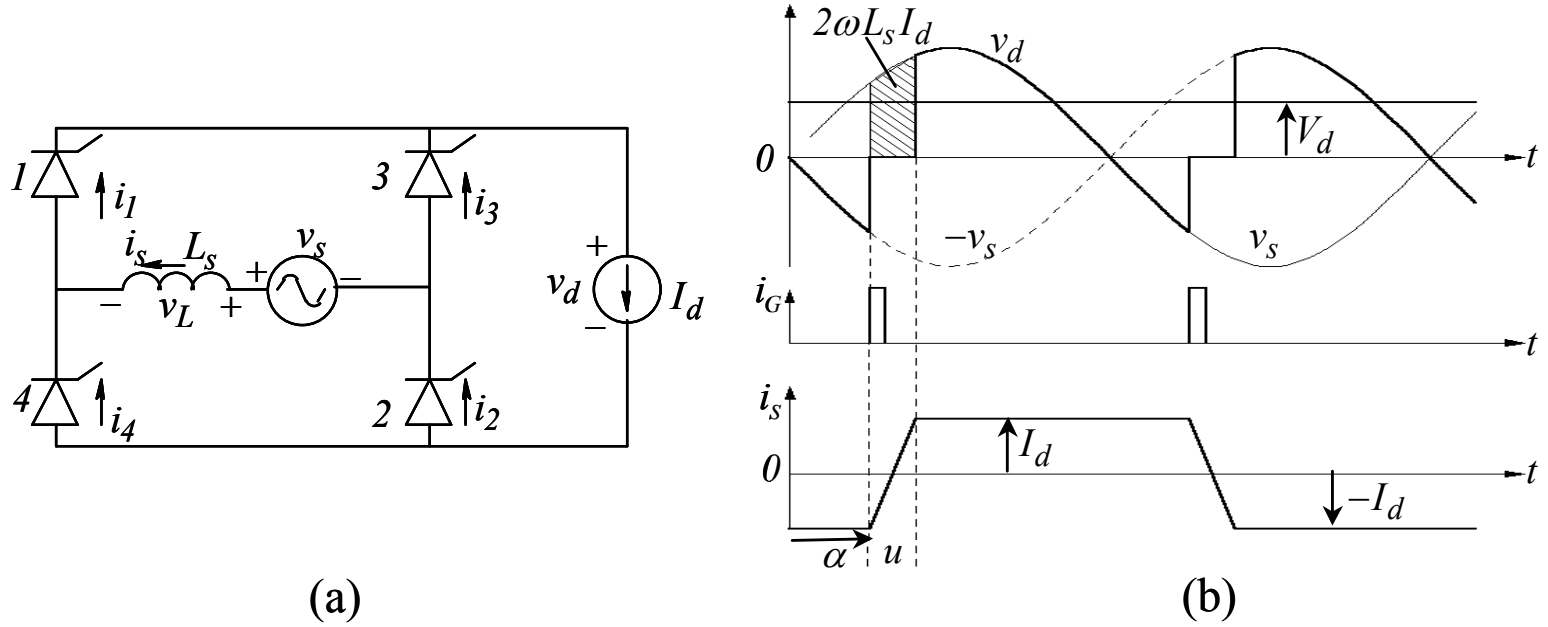

Figure 14-6 Effect of L_s on Current Commutation.

$$\int_{\alpha}^{\alpha+u} v_L \, d(\omega t) = L_s \int_{\alpha}^{\alpha+u} \frac{di_s}{dt} d(\omega t) = \omega L_s \int_{-I_d}^{I_d} di_s = \omega L_s (2I_d)$$

$$\Delta V_d = \frac{2}{\pi} \omega L_s I_d \qquad V_d = \frac{2}{\pi} V_s \cos\alpha - \frac{2}{\pi} \omega L_s I_d$$

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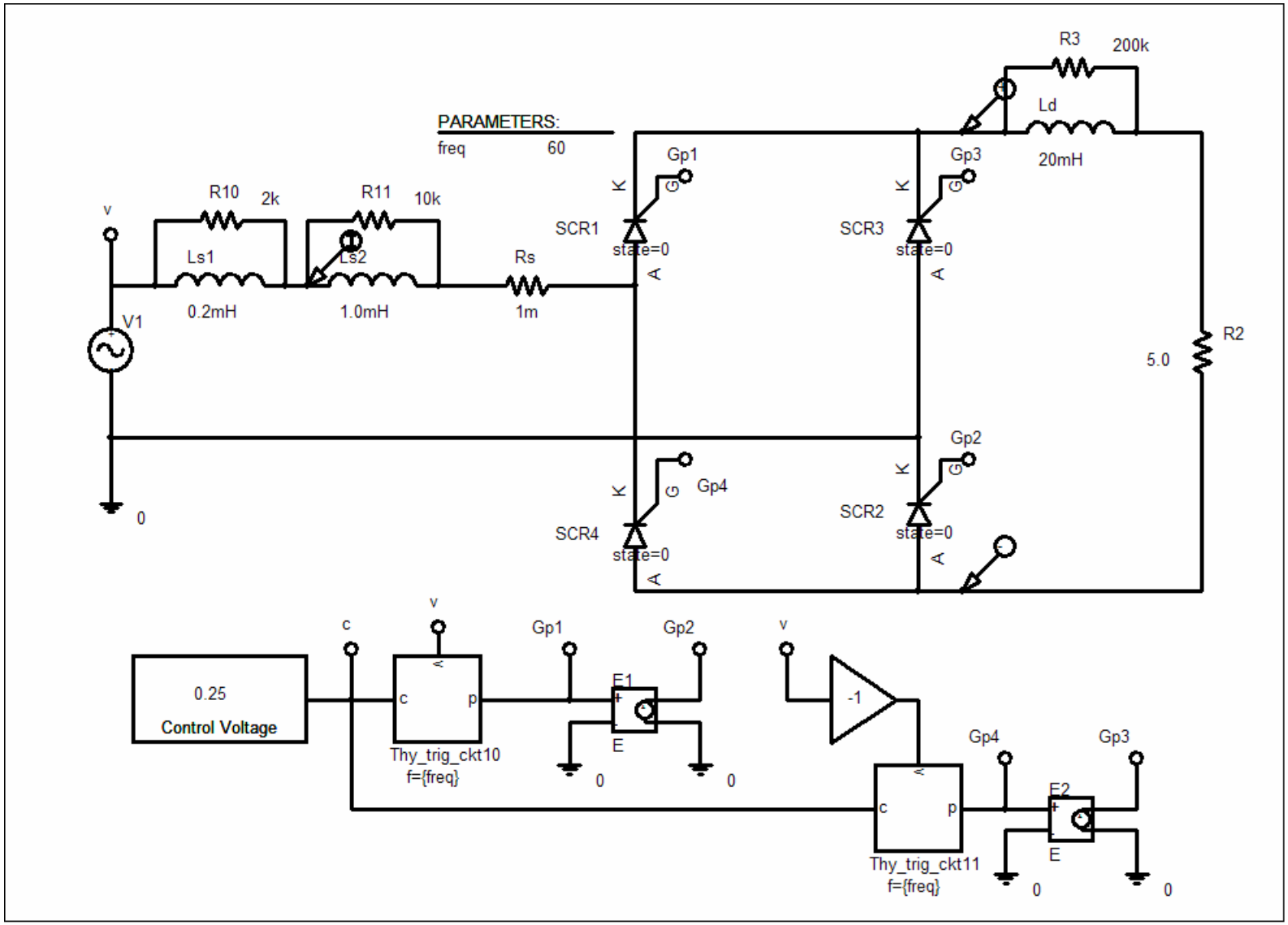
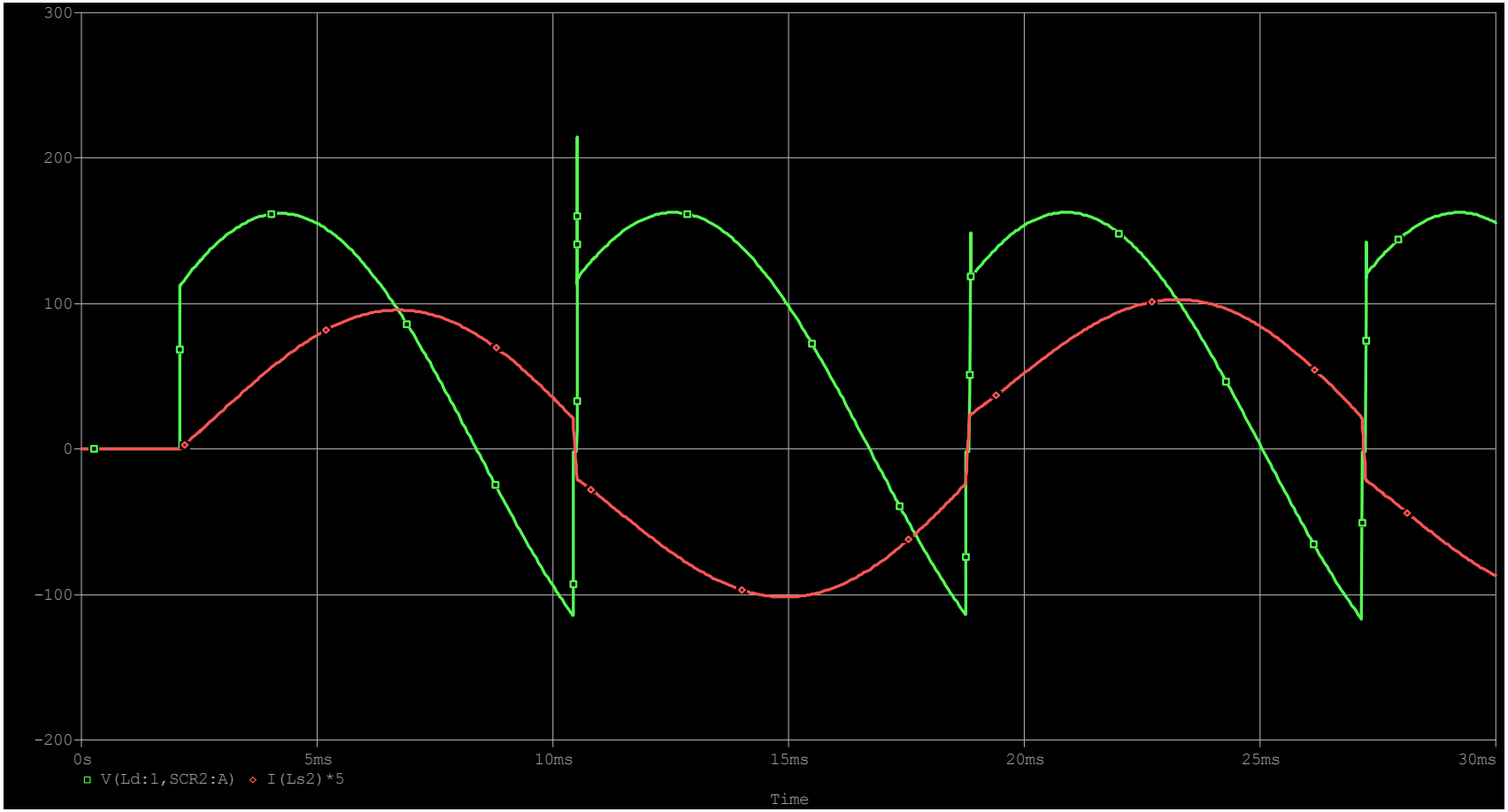


Simulation Results



THREE-PHASE, FULL-BRIDGE THYRISTOR CONVERTERS

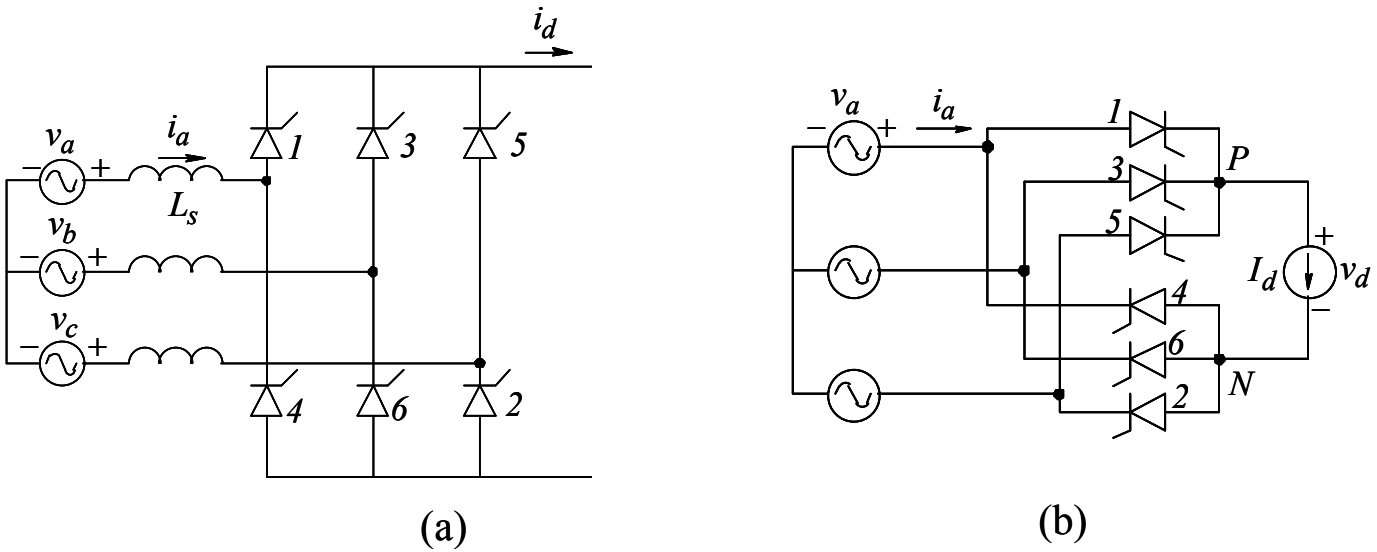


Figure 14-7 Three-phase Full-Bridge thyristor converter.

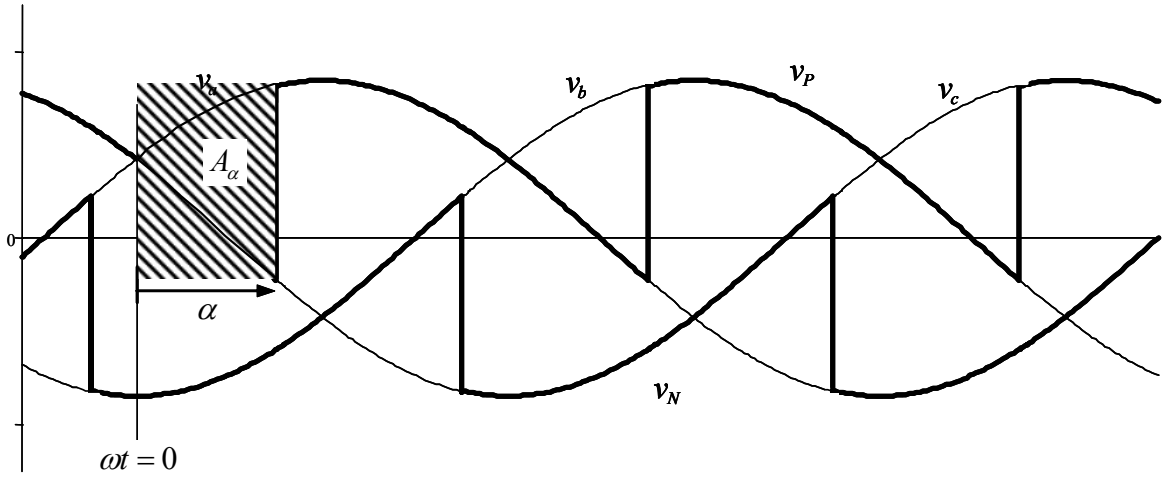


Figure 14-8 Waveforms with $L_s = 0$.

$$V_{do} = \frac{1}{\pi/3}\int_{-\pi/6}^{\pi/6} \hat{V}_{LL}\cos\omega t \cdot d(\omega t) = \frac{3}{\pi}\hat{V}_{LL}$$

$$\Delta V_\alpha = \frac{1}{\pi/3}\underbrace{\int_0^\alpha \hat{V}_{LL}\sin\omega t \cdot d(\omega t)}_{A_\alpha} = \frac{3}{\pi}\hat{V}_{LL}(1-\cos\alpha)$$

Effect of L_s

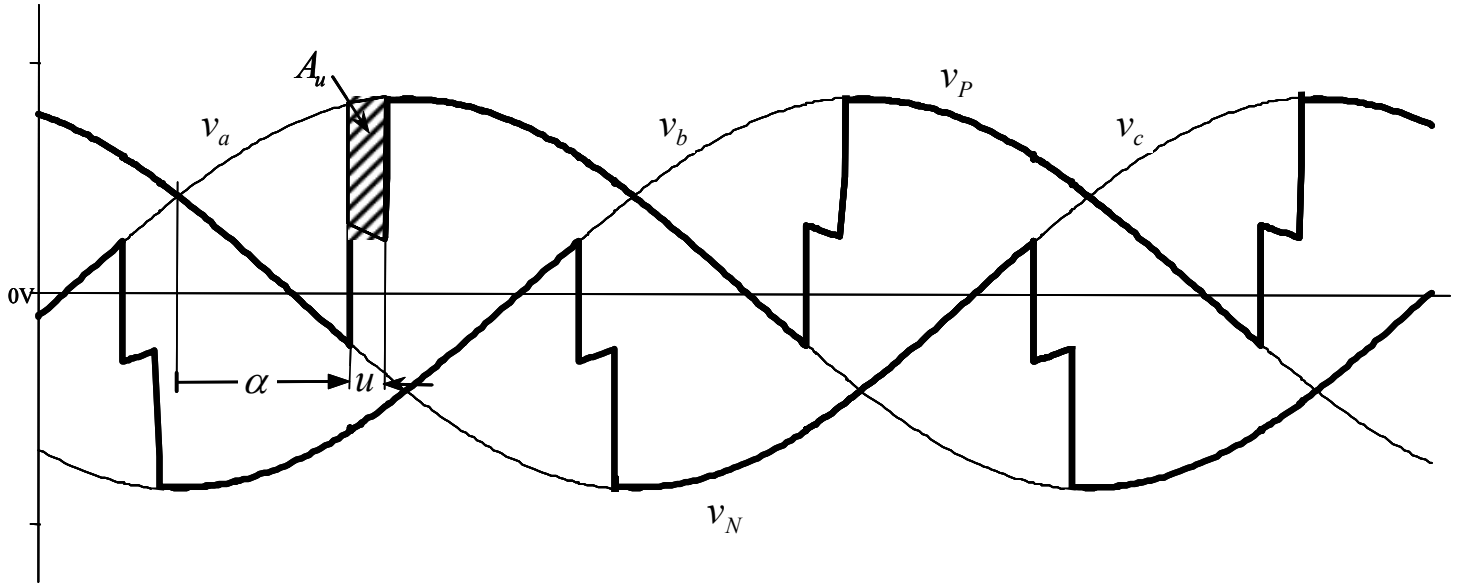


Figure 14-9 Waveforms with L_s .

$$A_u = \int_{\alpha}^{\alpha+u} v_L \, d(\omega t) = \omega L_s \int_0^{I_d} di_s = \omega L_s I_d$$

$$\Delta V_u = \frac{A_u}{\pi/3} = \frac{3}{\pi}\omega L_s I_d$$

$$V_d = V_{do} - \Delta V_\alpha - \Delta V_u$$

$$V_d = \frac{3}{\pi}\hat{V}_{LL}\cos\alpha - \frac{3}{\pi}\omega L_s I_d$$

Current-Link Systems

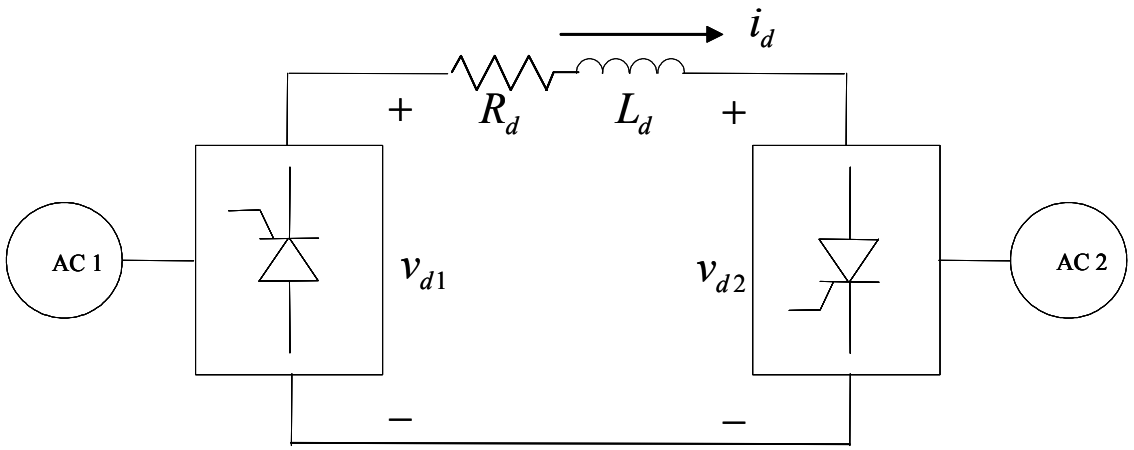


Figure 14-10 Block diagram of current-link systems.

$$V_{d1} = \frac{3}{\pi}\hat{V}_{LL1}\cos\alpha_1 - \frac{3}{\pi}\omega L_{s1} I_d$$

$$V_{d2} = \frac{3}{\pi}\hat{V}_{LL2}\cos\alpha_2 - \frac{3}{\pi}\omega L_{s2} I_d$$

$$I_d = \frac{V_{d1} + V_{d2}}{R_d}$$