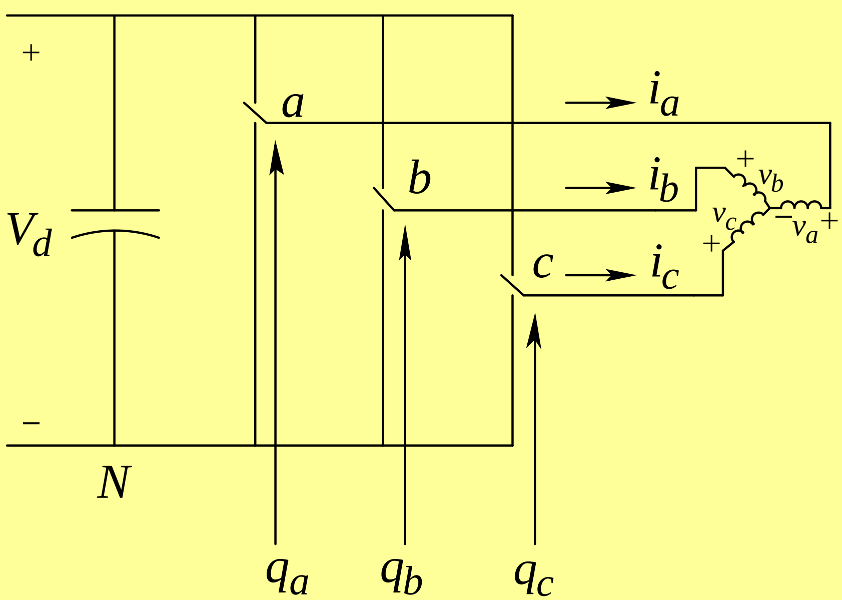
Space-Vector Pulse-Width-Modulated (SV-PWM) Inverters

Advantages

- Full Utilization of the DC Bus Voltage
- Applicable in Vector Control, DTC and V/f Control

Synthesis of Stator Voltage Space Vector



$$\vec{v}_s^{\,a}(t) = v_a(t)e^{j0} + v_b(t)e^{j2\pi/3} + v_c(t)e^{j4\pi/3}$$

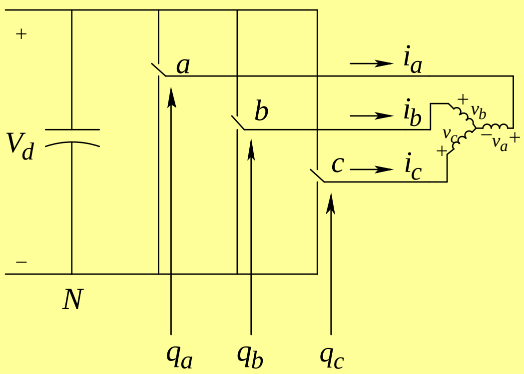
$$v_a = v_{aN} + v_N; \quad v_b = v_{bN} + v_N; \quad v_c = v_{cN} + v_N$$

$$e^{j0} + e^{j2\pi/3} + e^{j4\pi/3} = 0$$

$$\vec{v}_s^{\,a}(t) = v_{aN}e^{j0} + v_{bN}e^{j2\pi/3} + v_{cN}e^{j4\pi/3}$$

$$\vec{v}_s^{\,a}(t) = V_d\,(q_a e^{j0} + q_b e^{j2\pi/3} + q_c e^{j4\pi/3})$$

Basic Voltage Vectors



$$\vec{v}_s^{\,a}(t) = V_d\,(q_a e^{j0} + q_b e^{j2\pi/3} + q_c e^{j4\pi/3})$$

$$\vec{v}_s^{\,a}(000) = \vec{v}_0 = 0$$

$$\vec{v}_s^{\,a}(001) = \vec{v}_1 = V_d e^{j0}$$

$$\vec{v}_s^{\,a}(010) = \vec{v}_2 = V_d e^{j2\pi/3}$$

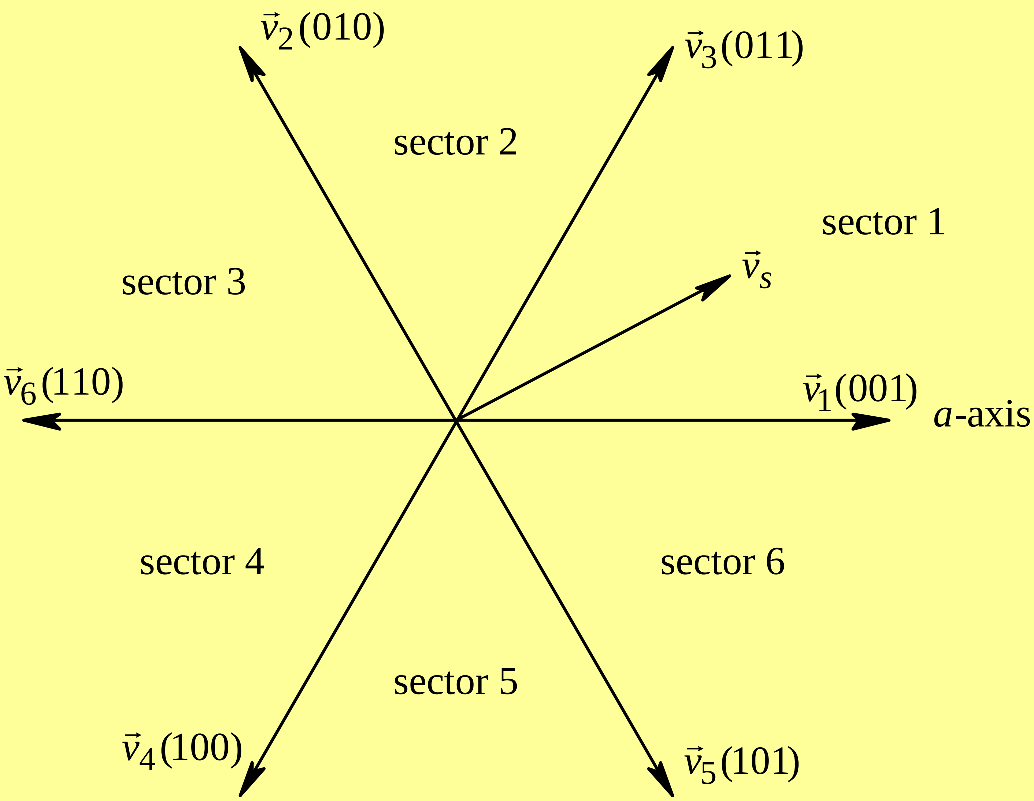
$$\vec{v}_s^{\,a}(011) = \vec{v}_3 = V_d e^{j\pi/3}$$

$$\vec{v}_s^{\,a}(100) = \vec{v}_4 = V_d e^{j4\pi/3}$$

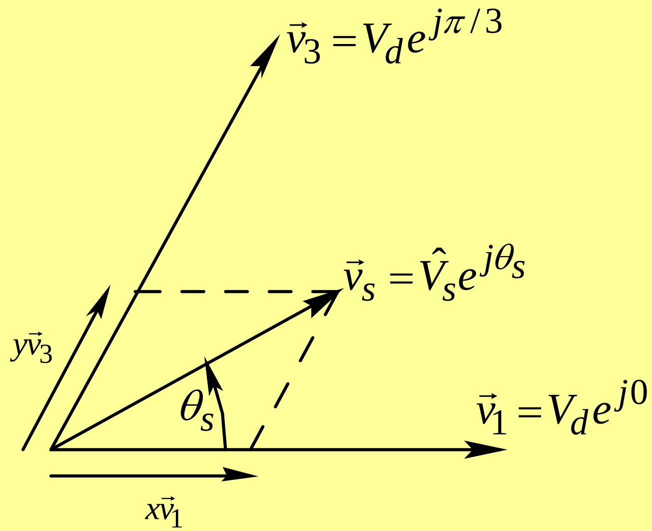
$$\vec{v}_s^{\,a}(101) = \vec{v}_5 = V_d e^{j5\pi/3}$$

$$\vec{v}_s^{\,a}(110) = \vec{v}_6 = V_d e^{j\pi}$$

$$\vec{v}_s^{\,a}(111) = \vec{v}_7 = 0$$



Synthesis of Voltage Vector in Sector 1

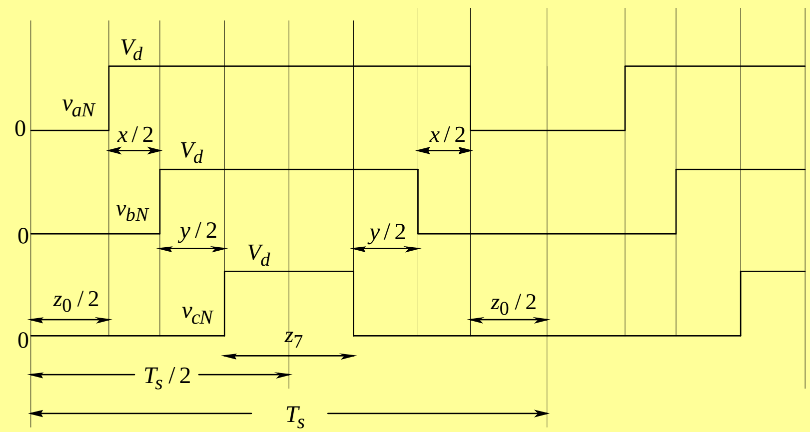


$$\vec{v}_s^{\,a} = \frac{1}{T_s}[xT_s\vec{v}_1 + yT_s\vec{v}_3 + zT_s \cdot 0]$$

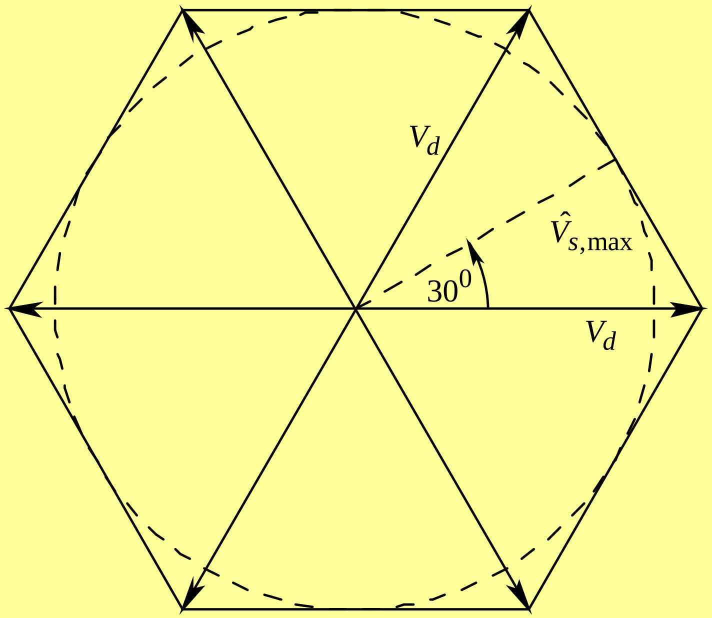
$$\vec{v}_s^{\,a} = x\vec{v}_1 + y\vec{v}_3$$

$$x + y + z = 1$$

$$\hat{V}_s e^{j\theta_s} = xV_d e^{j0} + yV_d e^{j\pi/3}$$



Limit on the Amplitude of the Stator Voltage Space Vector



$$(1)\ \vec{v}^{\,a}_{s,\max}(t) = \hat{V}_{s,\max} e^{j\omega_{syn}t}$$

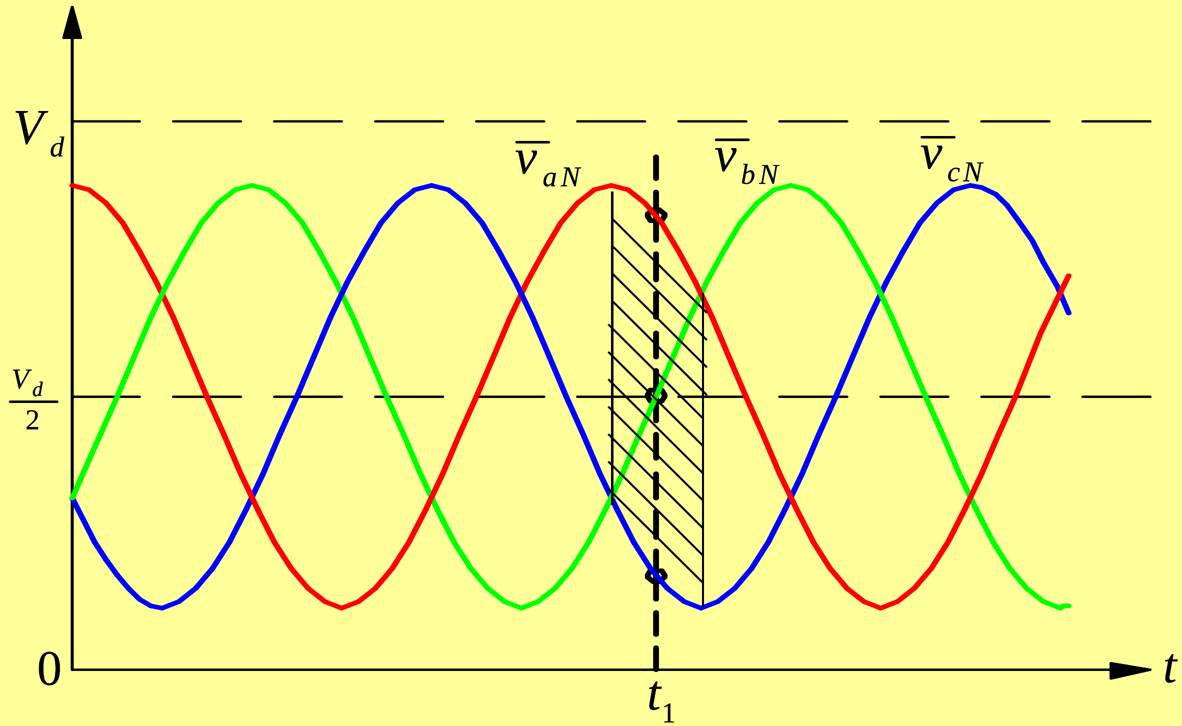
$$(2)\ \hat{V}_{s,\max} = V_d \cos\left(\frac{60^0}{2}\right) = \frac{\sqrt{3}}{2} V_d$$

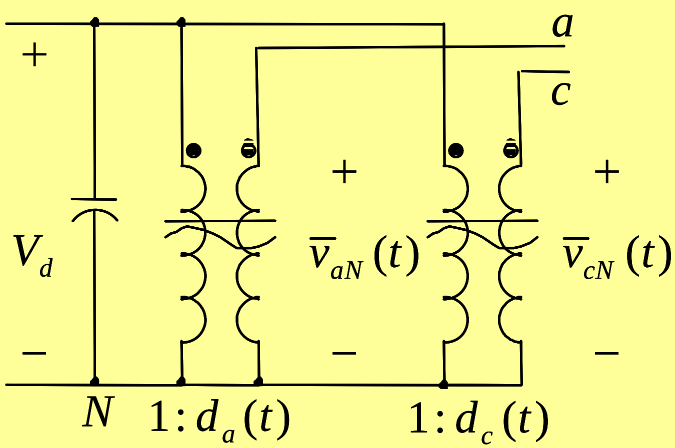
$$(3)\ \hat{V}_{phase,\max} = \frac{2}{3}\hat{V}_{s,\max} = \frac{V_d}{\sqrt{3}}$$

$$(4)\ V_{LL,\max}(rms) = \sqrt{3}\,\frac{\hat{V}_{phase,\max}}{\sqrt{2}} = \frac{V_d}{\sqrt{2}} = 0.707 V_d$$

$$(5)\ V_{LL,\max}(rms) = \frac{\sqrt{3}}{2\sqrt{2}} V_d = 0.612 V_d$$ (sinusoidal PWM)

SV-PWM





$$\bar{v}_{aN} = \bar{v}_{com} + \bar{v}_{an} = d_a V_d$$

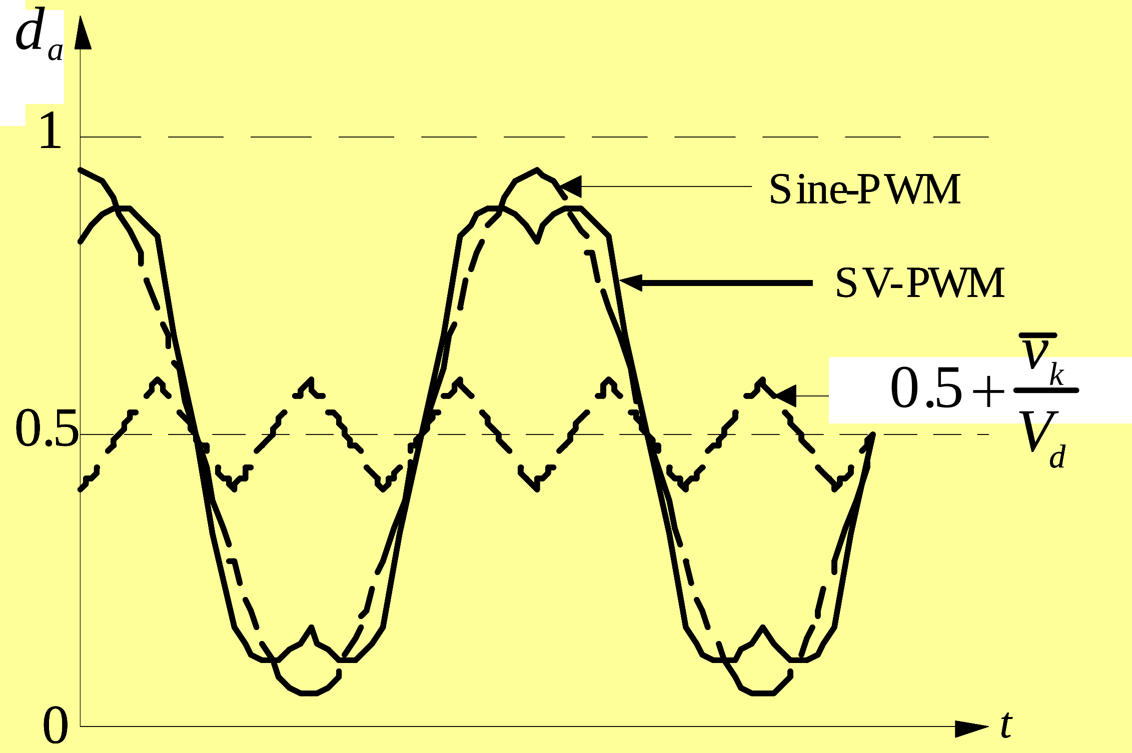
$$\bar{v}_{cN} = \bar{v}_{com} + \bar{v}_{cn} = d_c V_d$$

$$d_a = 1 - \Delta d \qquad d_c = 0 + \Delta d$$

$$\bar{v}_{com} = \frac{V_d}{2} - \frac{\bar{v}_{an} + \bar{v}_{cn}}{2}$$

SV-PWM versus Sine-PWM

$$\bar{v}_{com}(t) = \frac{V_d}{2} + \underbrace{\left(-\frac{1}{2}\right)\left(\max(\bar{v}_{an}, \bar{v}_{bn}, \bar{v}_{cn}) + \min(\bar{v}_{an}, \bar{v}_{bn}, \bar{v}_{cn})\right)}_{\bar{v}_k(t)}$$



Summary

Space-Vector Pulse-Width-Modulated (SV-PWM) Inverters

Advantages

- Full Utilization of the DC Bus Voltage
- Applicable in Vector Control, DTC and V/f Control