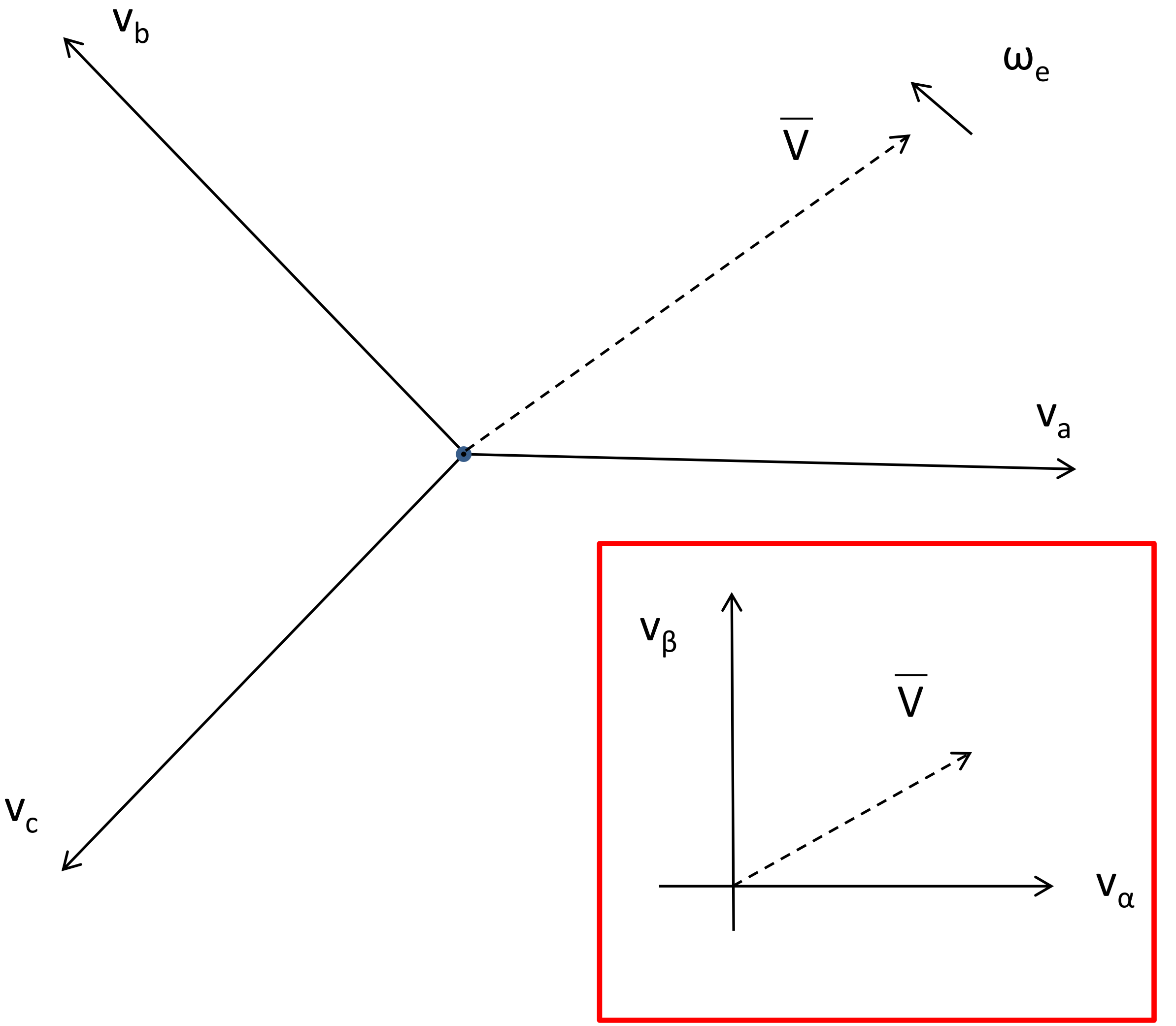
Space Vector Modulation Algorithm

Vectores Giratorios



Transformadas

$$\begin{bmatrix} V_\alpha \\ V_\beta \end{bmatrix} = \begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix}$$

Transformada α-β

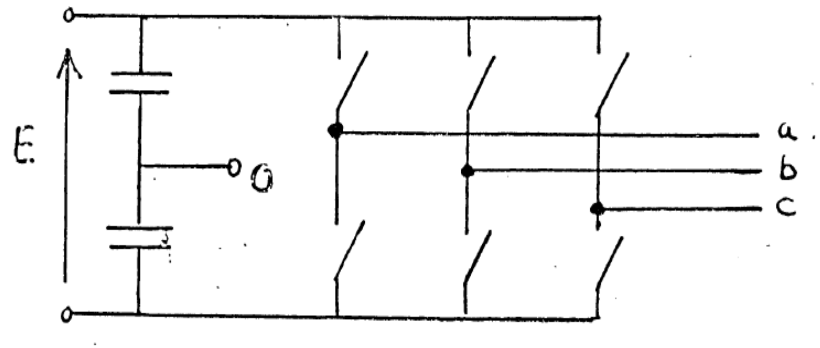
$$\bar{V} = V_a + V_b e^{j2\pi/3} + V_b e^{-j2\pi/3}$$

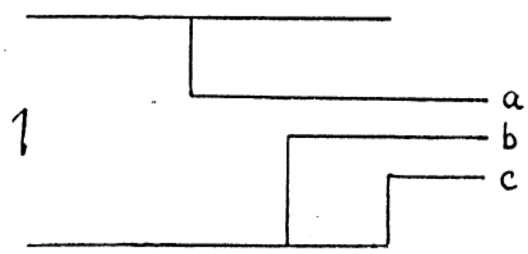
$$\bar{V} = V_m \sin(\omega t) + V_m \sin(\omega t + 2\pi/3) e^{j2\pi/3} + V_m \sin(\omega t - 2\pi/3) e^{-j2\pi/3}$$

$$\bar{V} = \frac{3}{2} V_m e^{j\omega t + \theta}$$

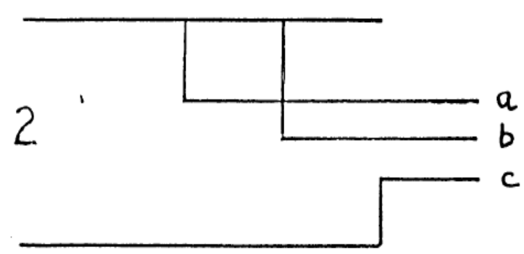
← Vector giratorio con módulo constante

Vectores de un Inversor de Tres Piernas



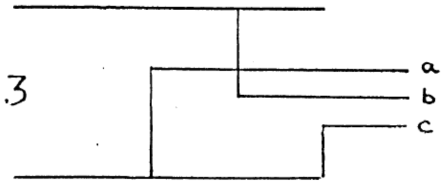


$V_{ab} = E$ $V_{ao} = E/2$
$V_{bc} = 0$ $V_{bo} = -E/2$
$V_{ca} = -E$ $V_{co} = -E/2$

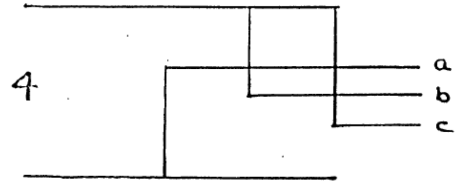


$V_{ab} = 0$
$V_{bc} = E$
$V_{ca} = -E$

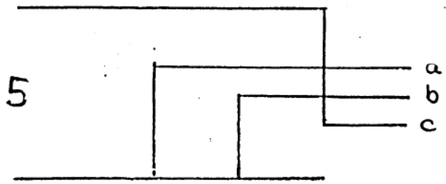
Vectores Activos



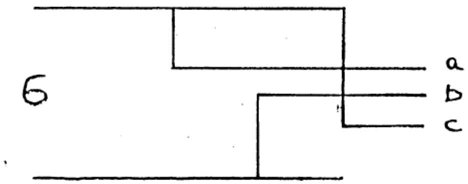
$V_{ab} = -E$
$V_{bc} = E$
$V_{ca} = 0$



$V_{ab} = -E$
$V_{bc} = 0$
$V_{ca} = E$



$V_{ab} = 0$
$V_{bc} = -E$
$V_{ca} = E$

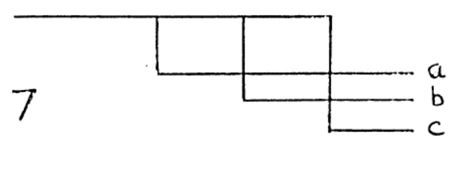


$V_{ab} = E$
$V_{bc} = -E$
$V_{ca} = 0$

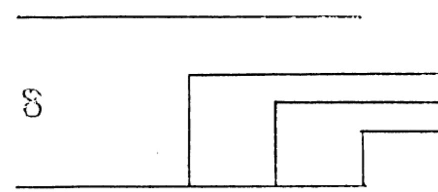
Vectores Activos

6 Vectores Activos
2 Vectores nulos

Vectores Nulos



$V_{ab} = 0$
$V_{bc} = 0$
$V_{ca} = 0$



$V_{ab} = 0$
$V_{bc} = 0$
$V_{ca} = 0$

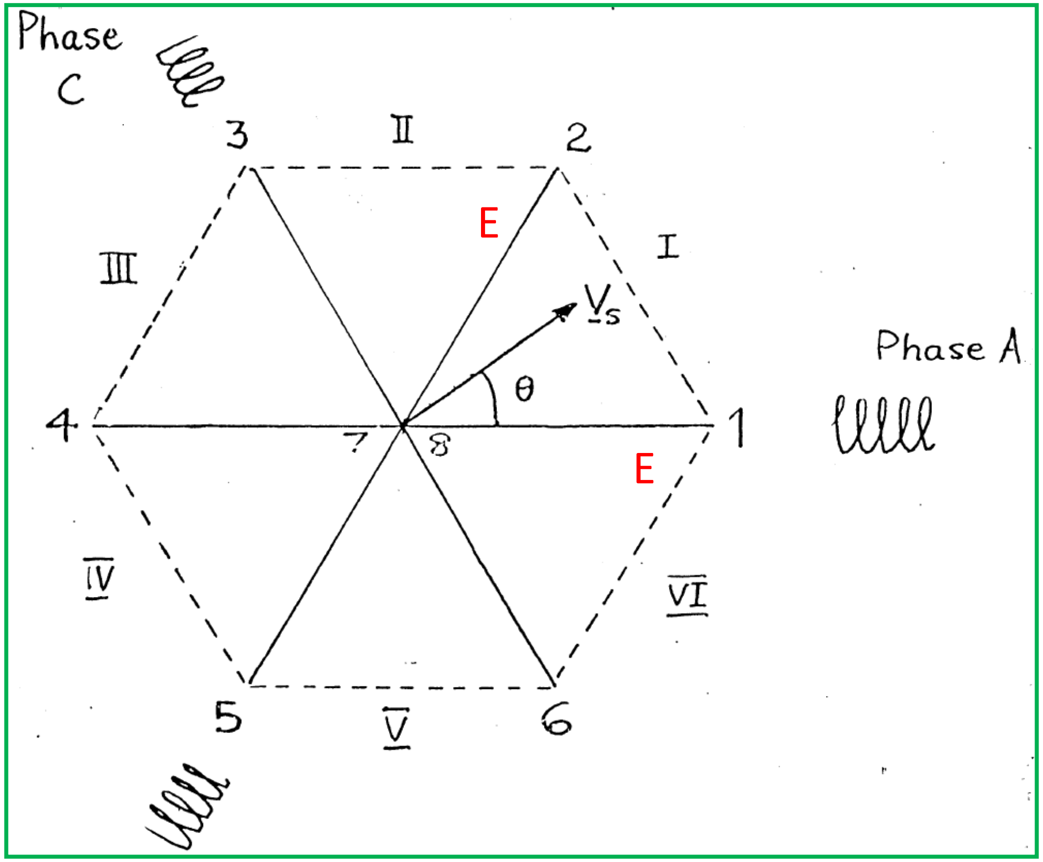
Utilizando la transformada α-β y las ecuaciones:

$$|V| = \sqrt{V_\alpha^2 + V_\beta^2} \qquad \theta_e = \tan^{-1}(V_\beta / V_\alpha)$$

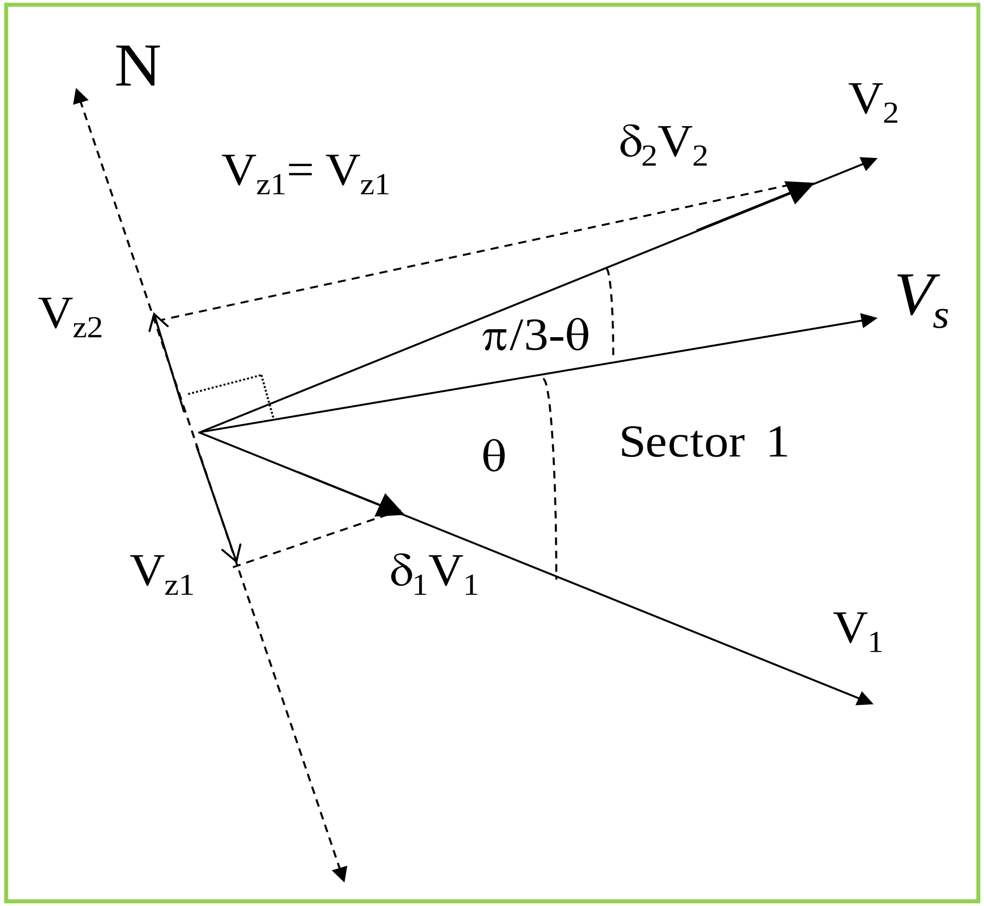
Se obtiene la tabla:

Vector	V_{ao}	V_{bo}	V_{co}	V_{ab}	V_{bc}	V_{ca}	Módulo	Ángulo (Grados)
1	E/2	-E/2	-E/2	E	0	-E	E	0
2	E/2	E/2	-E/2	0	E	-E	E	60
3	-E/2	E/2	-E/2	-E	E	0	E	120
4	-E/2	E/2	E/2	-E	0	E	E	180
5	-E/2	-E/2	E/2	0	-E	E	E	240
6	E/2	-E/2	E/2	E	-E	0	E	300
7	E/2	E/2	E/2	0	0	0	0	X
8	-E/2	-E/2	-E/2	0	0	0	0	X

Diagrama de Vectores



Cálculo del Ciclo de Trabajo



Cálculo del Ciclo de Trabajo

$$V_s = \delta_1 E \cos\theta + \delta_2 E \cos\left(\pi/3 - \theta\right)$$

$$\delta_1 E\, sen(\theta) = \delta_2 E\, sen(\pi/3 - \theta) \Rightarrow \delta_1 = \delta_2 \frac{sen\left(\pi/3 - \theta\right)}{sen(\theta)}$$

Cálculo del Ciclo de Trabajo

$$\delta_2\left[sen(\pi/3-\theta)\cos(\theta)+\cos(\pi/3-\theta)sen(\theta)\right]=\frac{V_s}{E}sen(\theta)$$

$$\delta_2\begin{bmatrix}(sen(\pi/3)\cos(\theta)-\cos(\pi/3)\sin(\theta))\cos(\theta)+\\(\cos(\pi/3)\cos(\theta)+\sin(\pi/3)\sin(\theta))\sin(\theta)\end{bmatrix}=\frac{V_s}{E}sen(\theta)$$

$$\delta_2=\frac{2V_s}{\sqrt{3}E}sen(\theta)$$

$$\delta_1=\frac{2V_s}{\sqrt{3}E}sen(\pi/3-\theta)$$

$$\delta_0=1-(\delta_1+\delta_2)$$

Otras Consideraciones

- Se debe recordar que V_s, el voltaje a sintetizar se obtuvo a partir de la transformada α-β.

$$|V_s| = \sqrt{V_\alpha^2 + V_\beta^2} = \frac{3}{2} V_m$$

Definiendo:

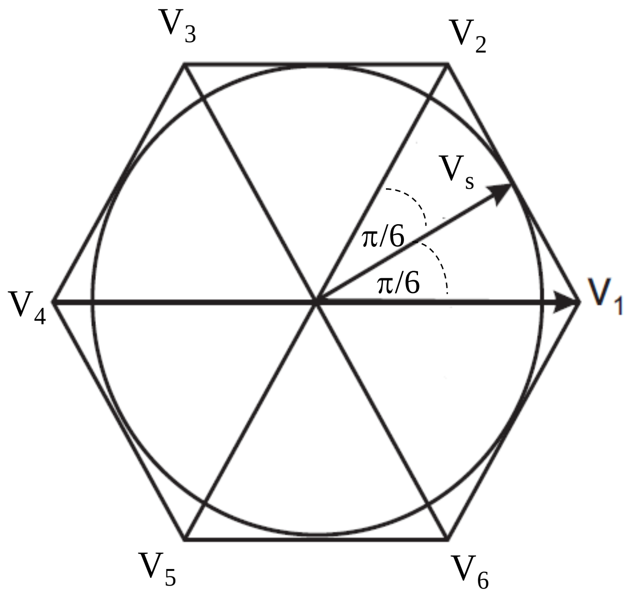
$$m = 2\frac{V_m}{E} \longleftarrow$$

m=índice de modulación
V_m=Valor máximo de V_s

$$\delta_1 = \frac{\sqrt{3}}{2} m\ sen(\pi/3 - \theta)$$

$$\delta_2 = \frac{\sqrt{3}}{2} m\ sen(\theta)$$

Valor Máximo de Voltaje a Sintetizar

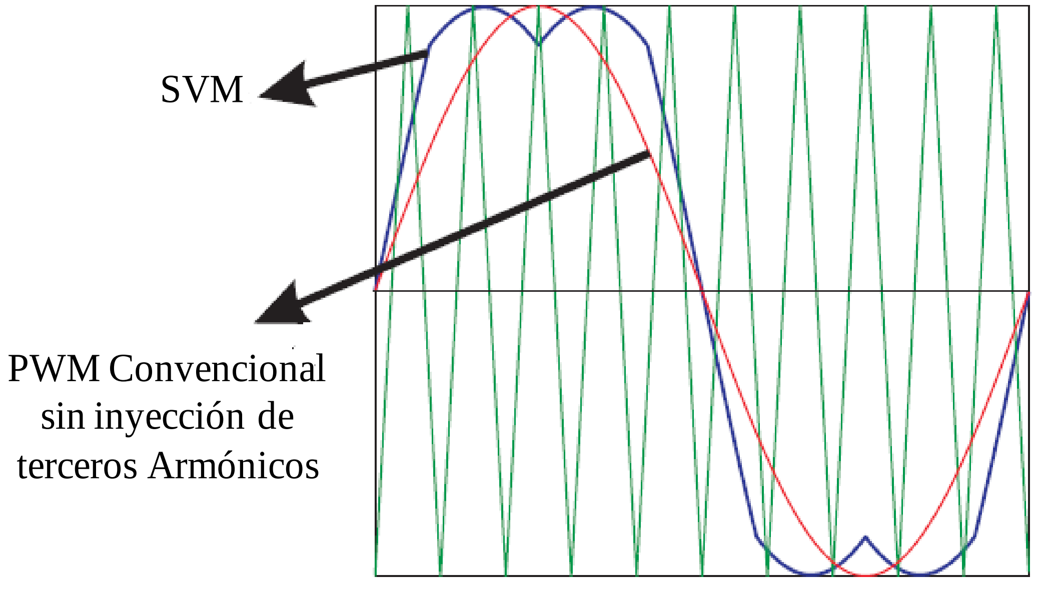


- El valor del voltaje máximo a sintetizar, es un círculo circunscrito en el hexágono.

$$E\cos(\pi/6) = V_s^{\max} \Rightarrow \frac{\sqrt{3}}{2}E = \frac{3}{2}V_m^{\max} \Rightarrow m_{\max} = \frac{2}{\sqrt{3}}$$

$$m_{max} \approx 1.1547$$

SVM y PWM



Implementación de un Patrón Simétrico Doble

V_{a0}	E/2	E/2	E/2	-E/2	-E/2	E/2	E/2	E/2
V_{b0}	E/2	E/2	-E/2	-E/2	-E/2	-E/2	E/2	E/2
V_{c0}	E/2	-E/2	-E/2	-E/2	-E/2	-E/2	-E/2	E/2
Vector	V_7	V_2	V_1	V_8	V_8	V_1	V_2	V_7
Time	$\frac{T_0}{4}$	$\frac{T_2}{2}$	$\frac{T_1}{2}$	$\frac{T_0}{4}$	$\frac{T_0}{4}$	$\frac{T_1}{2}$	$\frac{T_2}{2}$	$\frac{T_0}{4}$
	$T_s/2$				$T_s/2$			

- El patrón mostrado tiene baja distorsión armónica por el efecto 'Espejo'.
- Tiene bajas pérdidas debido a que sólo un switch cambia de estado cuando se cambia de vector