



Técnicas de modulación para accionamientos multifásicos

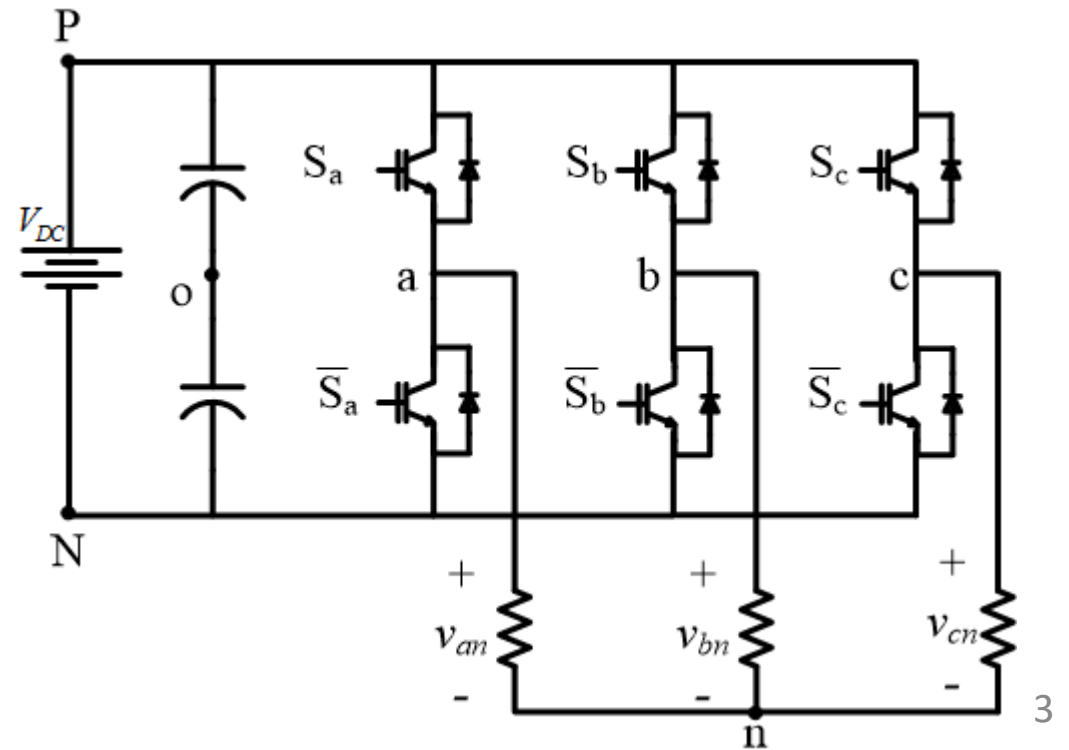
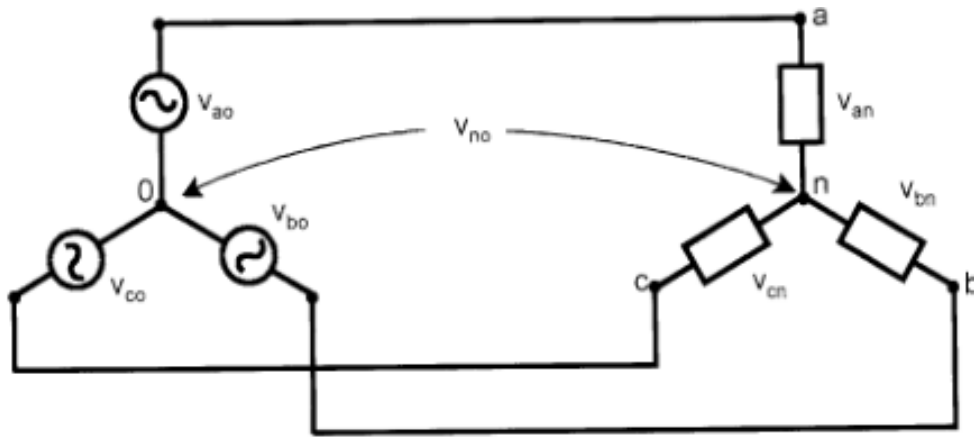
Joel Prieto

**Programa de Vinculación de Científicos y Tecnólogos
PVT 014/2015**

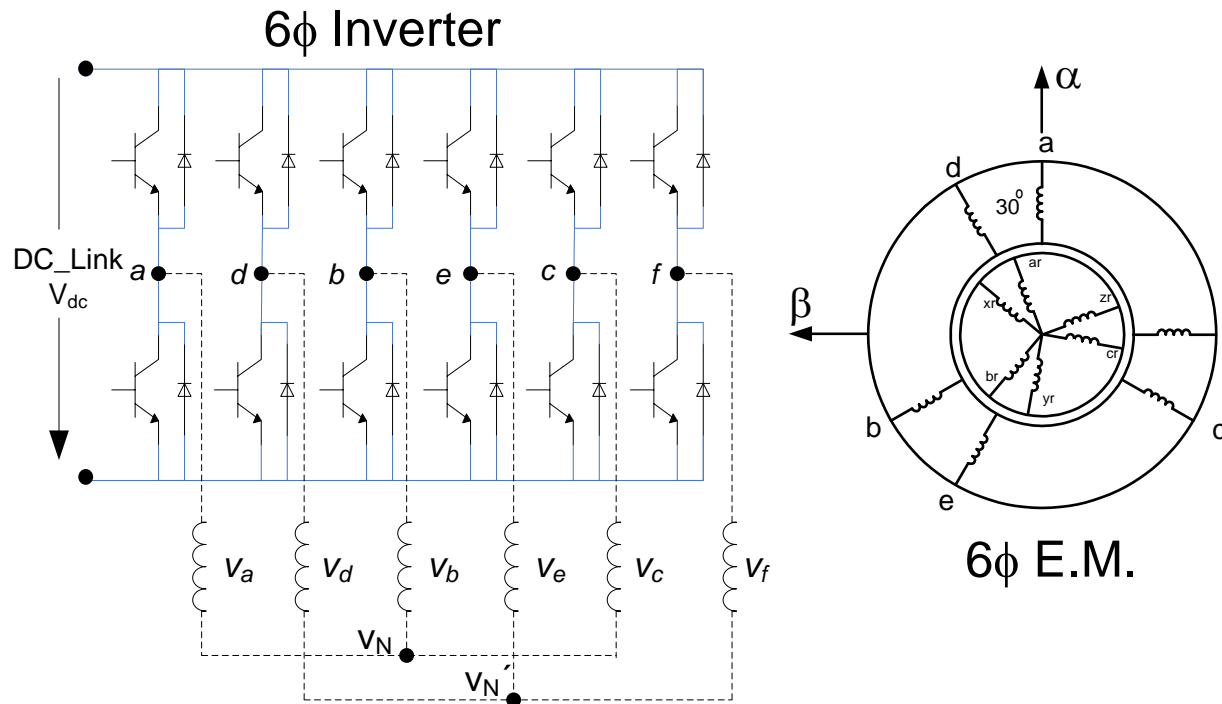
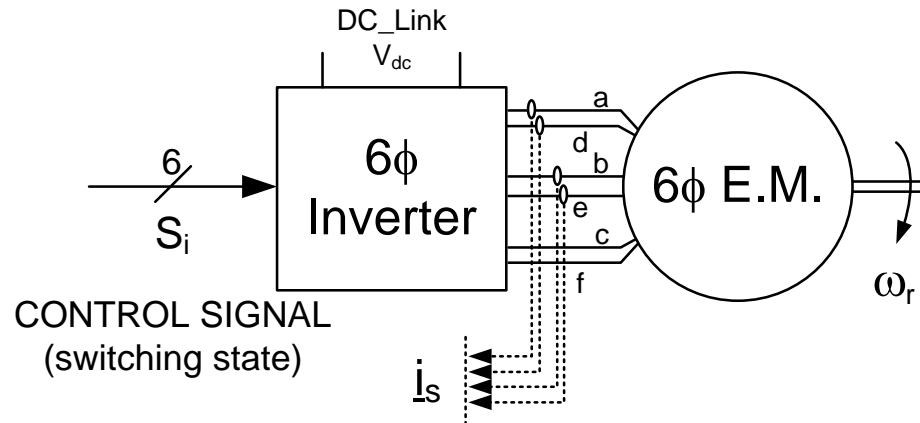
2016

- **Introducción**
- Objetivos
- Técnicas de modulación para accionamientos multifásicos
 - Continuos and Discontinuos
 - Análisis de rizado de corriente
 - Técnicas SVPWM para zona de sobremodulación
 - Mitigación de tensión de modo común
- Conclusiones

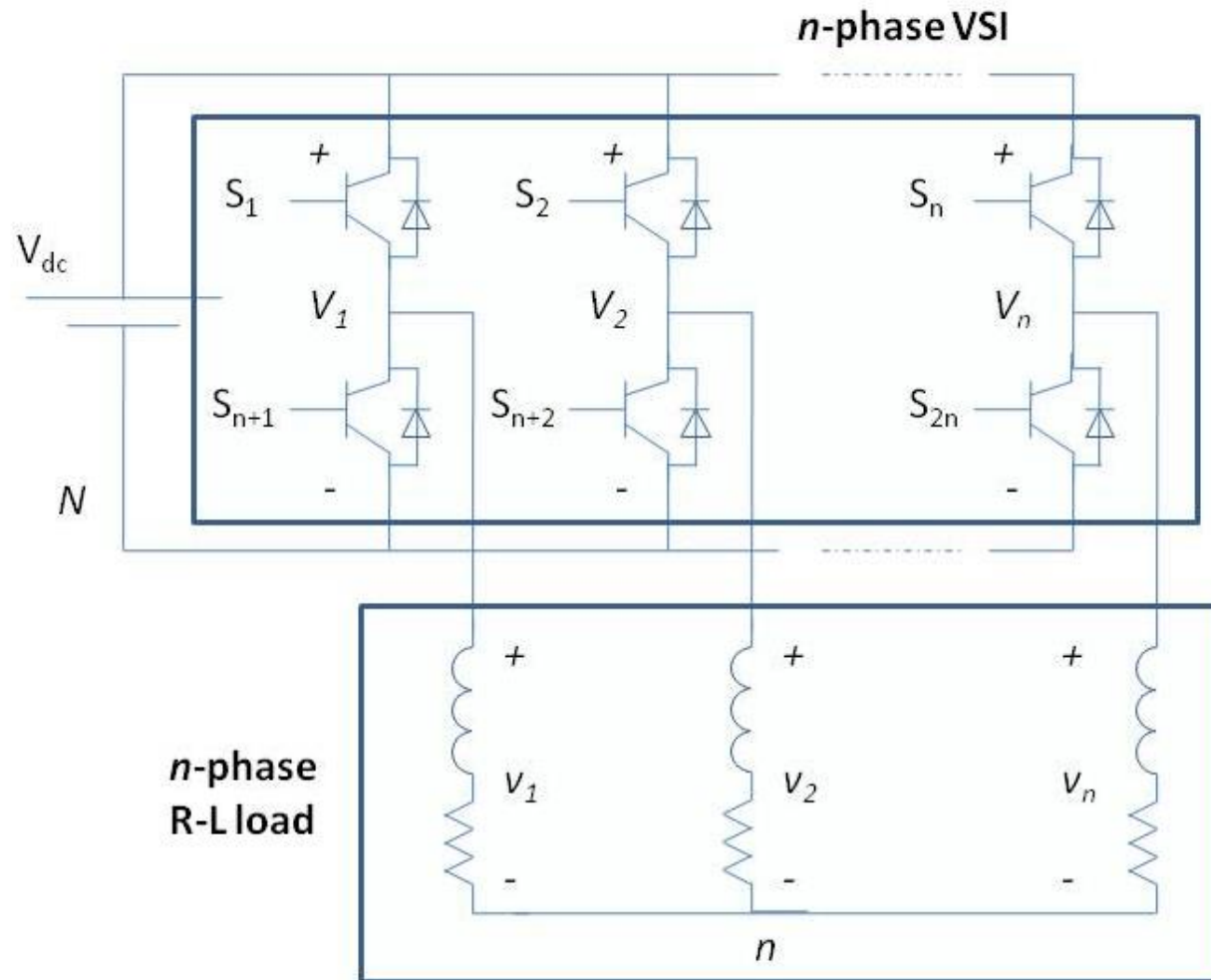
Introducción



Introducción



Introducción



- Accionamientos multifásicos, principales áreas de interés:
 - Propulsión marítima
 - Vehículos eléctricos e híbridos
 - Tracción en trenes
 - Aplicaciones aviónicas
 - Otras aplicaciones de altas potencias

- Accionamientos multifásicos, principales áreas de interés:
 - Propulsión marítima

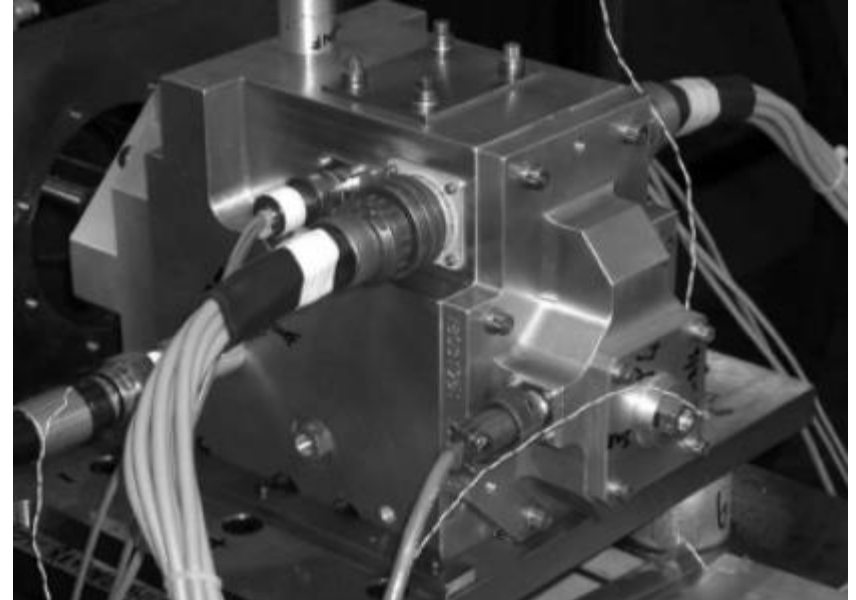
20MW @ 180rpm, 15 fases

Medidas: 3.3m x 3m x 3.6m



- Accionamientos multifásicos, principales áreas de interés:
 - Aplicaciones aviónicas

Motor de imanes permanentes para bomba de combustible:
16kW - 4 fases,
6 polos, tolerante a fallos



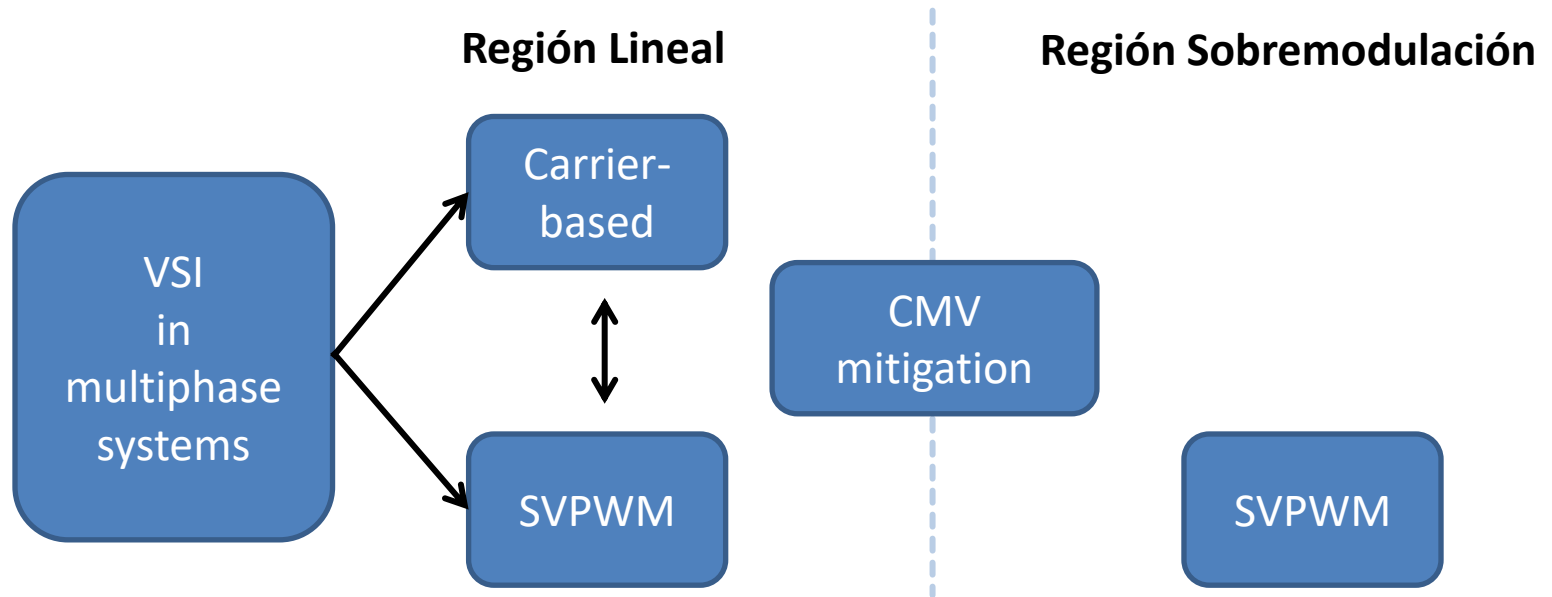
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- Estudiar y caracterizar las estrategias de modulación para convertidores multifásicos de 5 y 6 fases en la región lineal y de sobremodulación
- Proponer nuevas técnicas de modulación para convertidores multifásicos

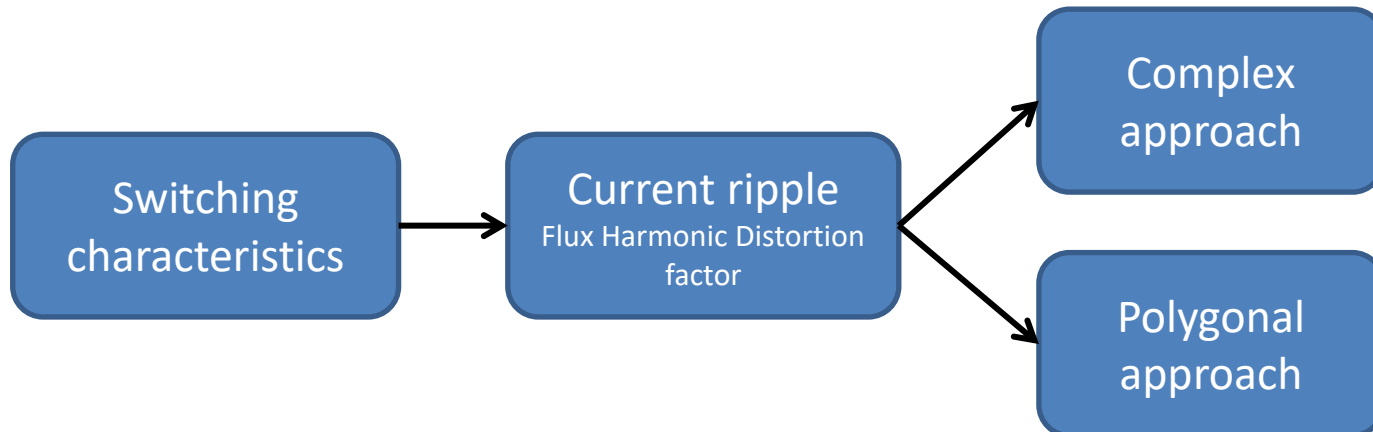
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- Conclusiones

Técnicas de modulación

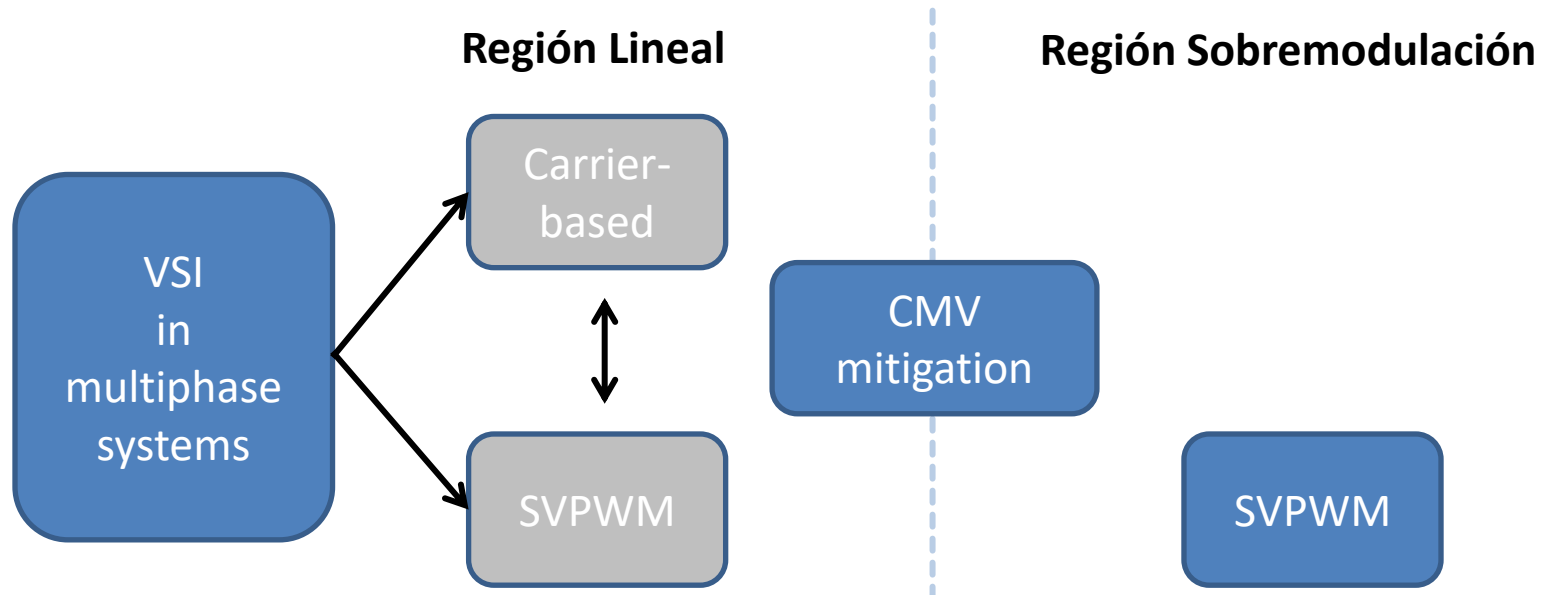
Técnicas PWM para convertidores multifasicos



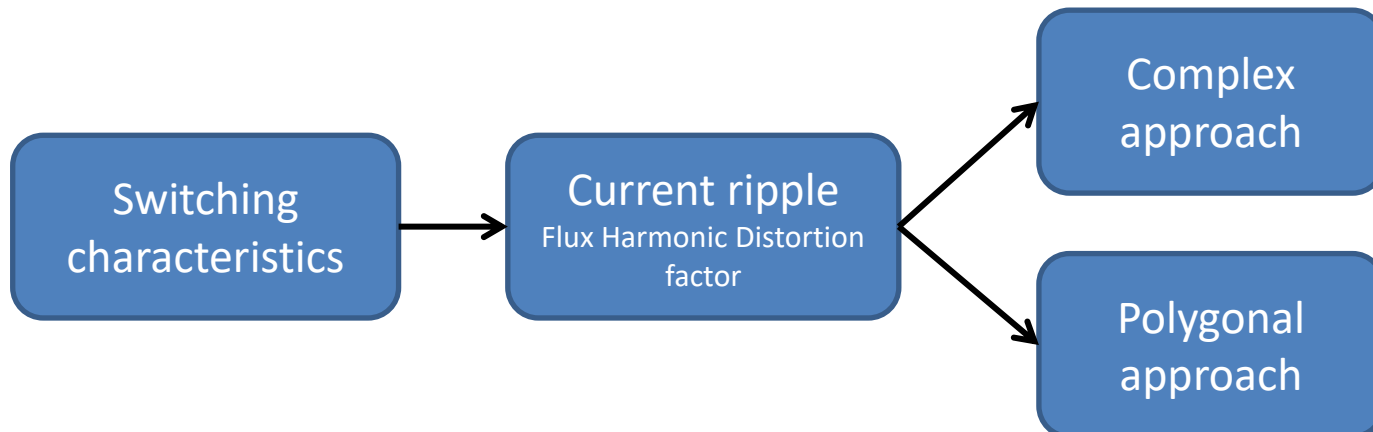
Indicadores de rendimiento



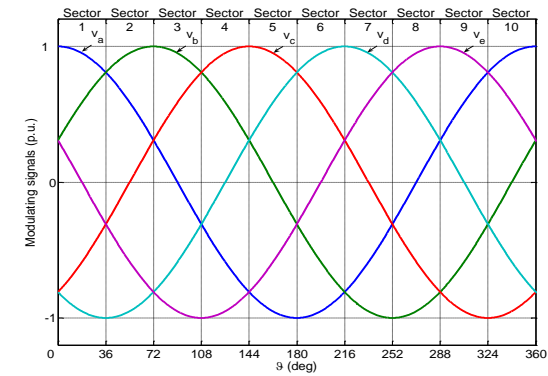
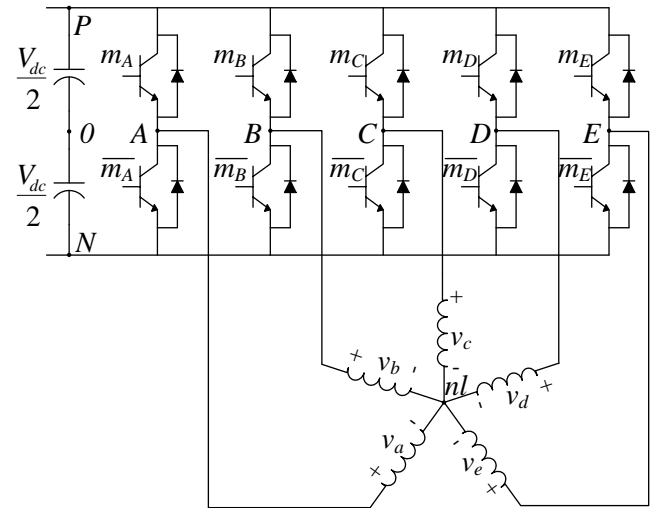
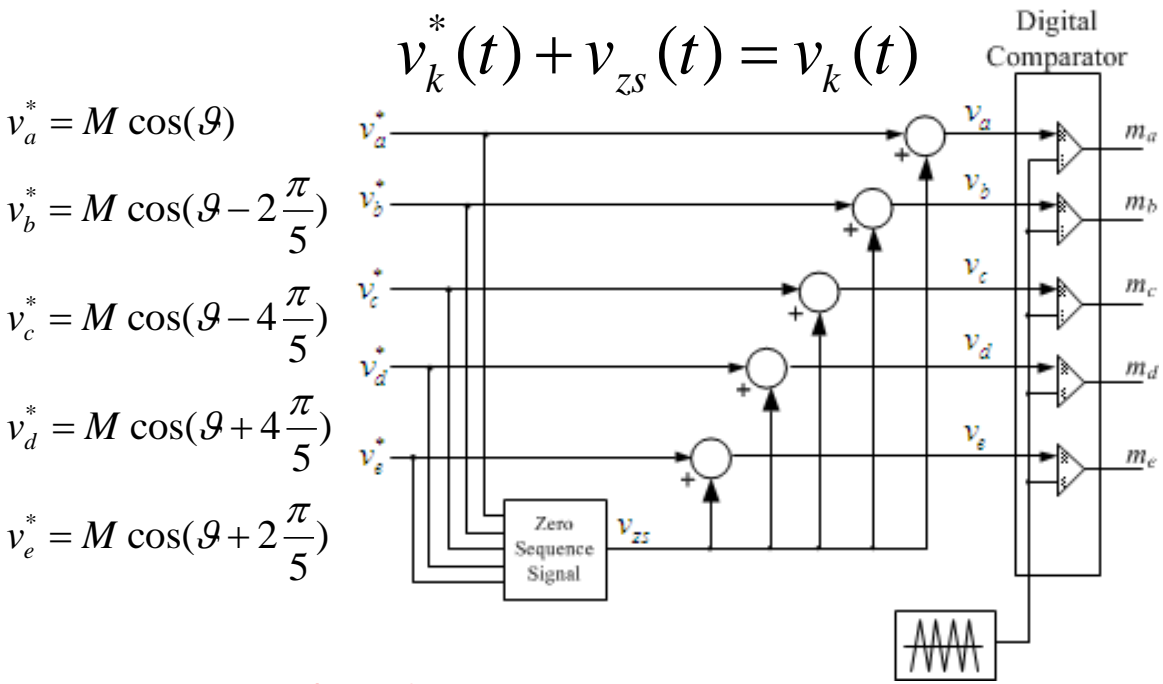
Técnicas PWM para convertidores multifasicos



Indicadores de rendimiento



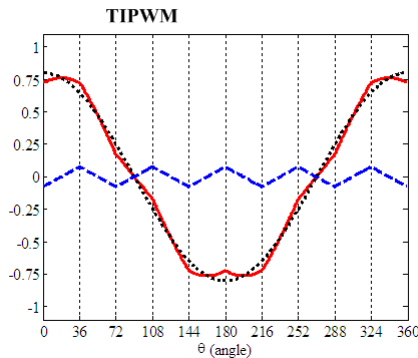
VSI multifásico: Carrier-based PWM



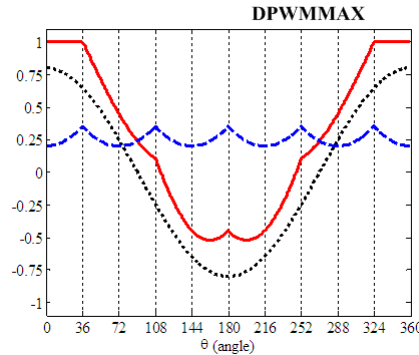
ZSI utilizado para:

- Mejorar la calidad de la corriente
- Maximizar el índice de modulación

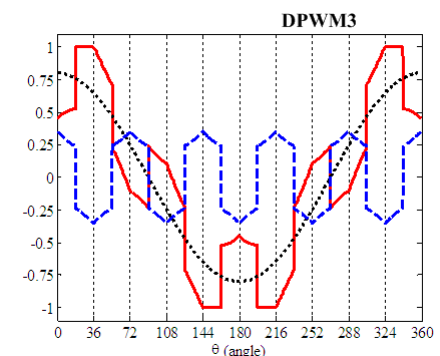
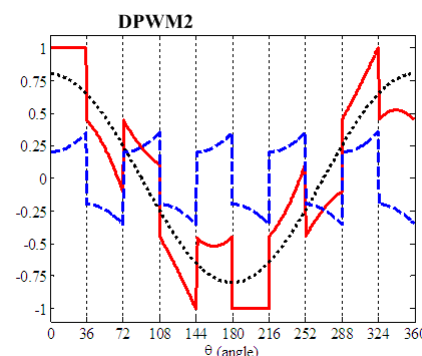
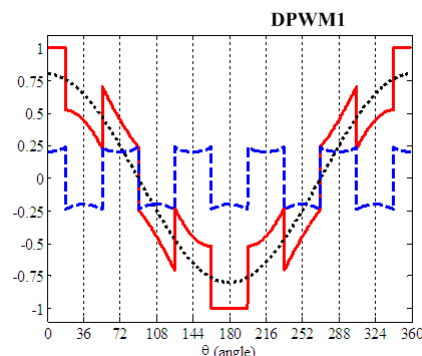
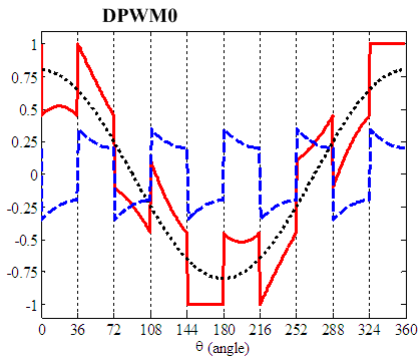
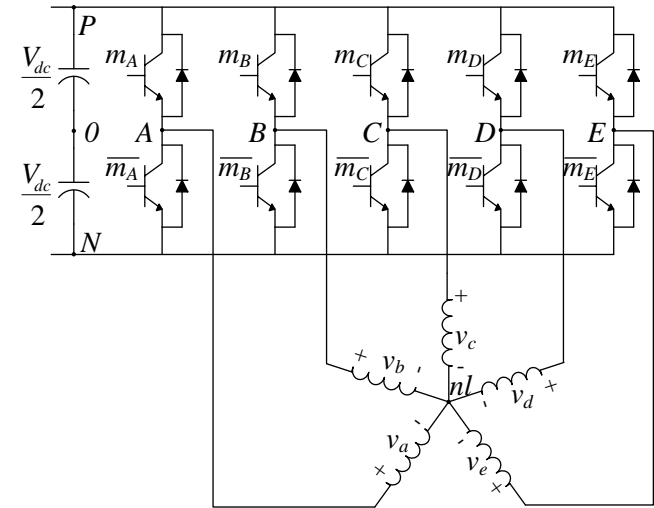
Carrier-based PWM



$$v_{zs} = -0.5 (\max\{v_i^*\} + \min\{v_i^*\})$$



$$v_{zs} = V_{dc}/2 - \max\{v_i^*\}$$

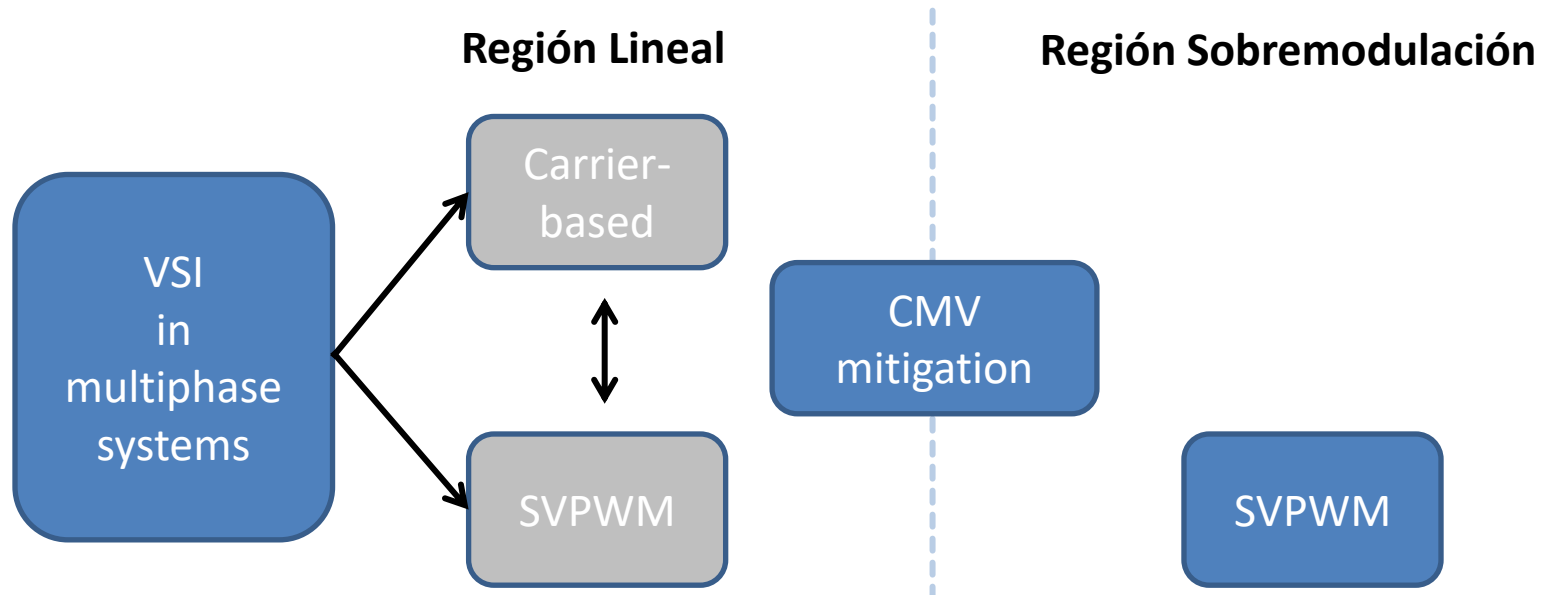


Tensión de fase

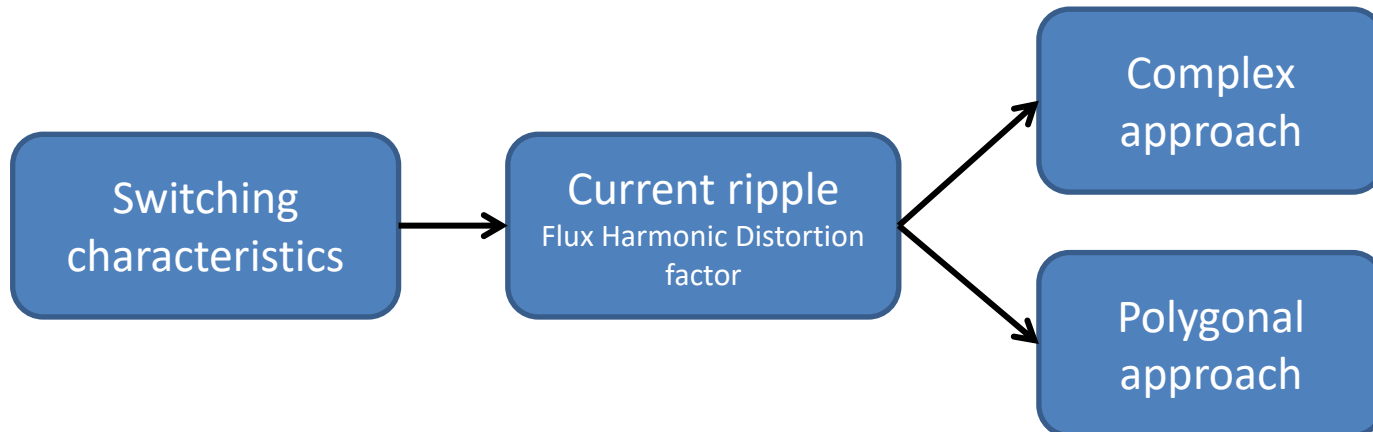
Tensión de rama

Señal de Secuencia cero

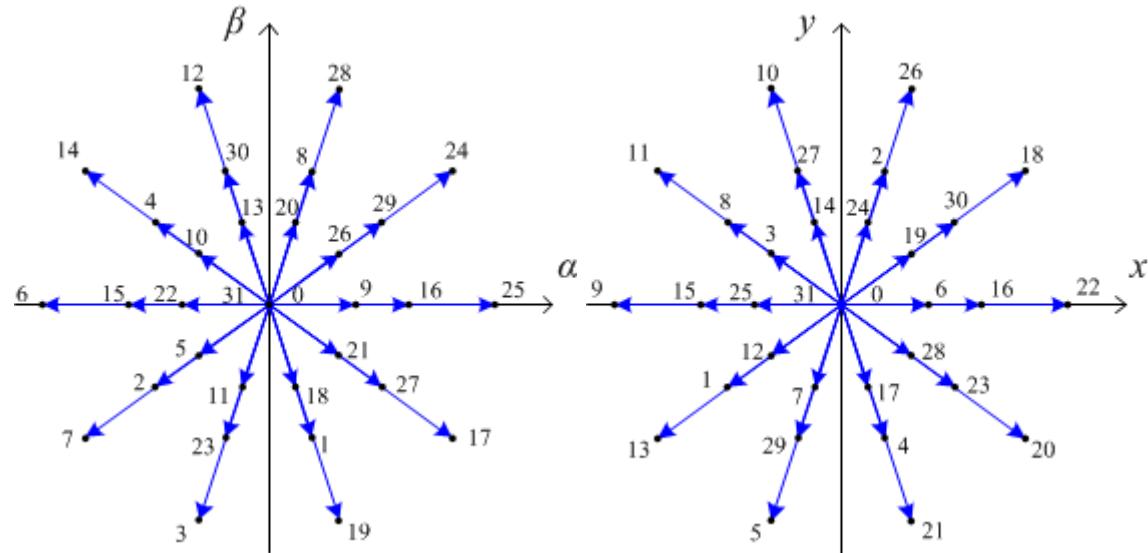
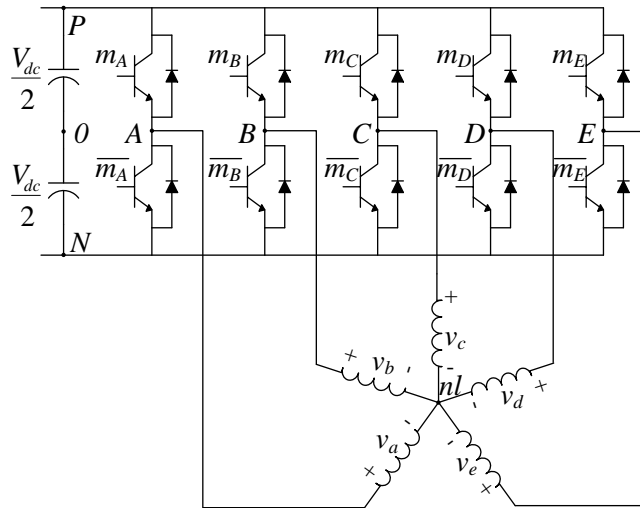
Técnicas PWM para convertidores multifasicos



Indicadores de rendimiento



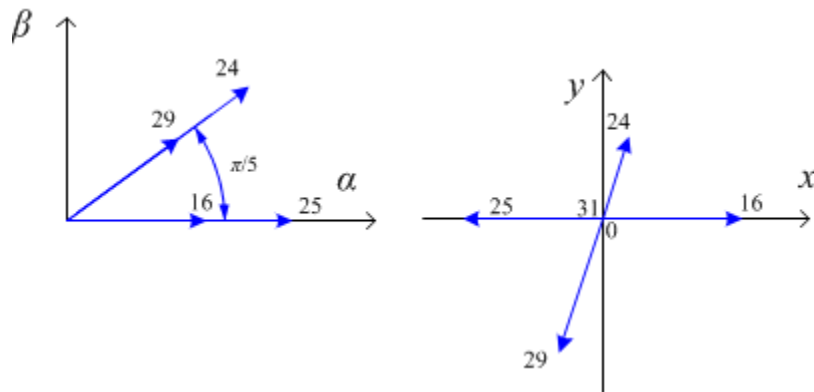
VSI multifásico: SVPWM



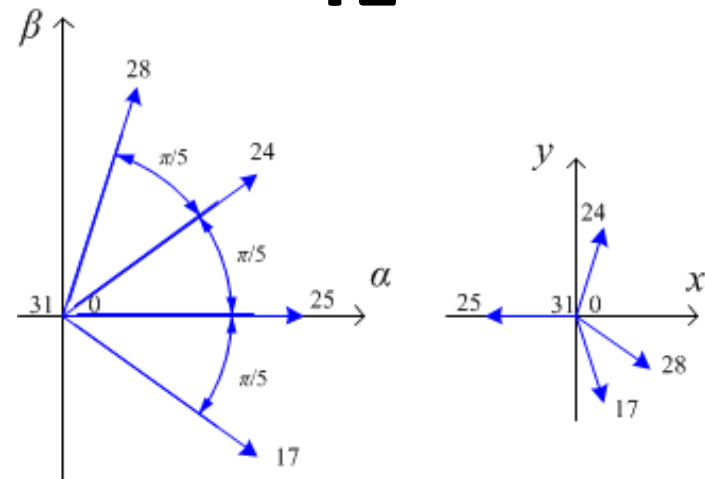
- $2^5 = 32$ estados de conmutación y vectores disponibles
- Cada estado de conmutación puede ser representados en dos planos independientes
- La referencia es obtenida con la utilización selectiva de algunos estados de conmutación aplicados en cierta secuencia

VSI multifásico: SVPWM

2L + 2M



4L

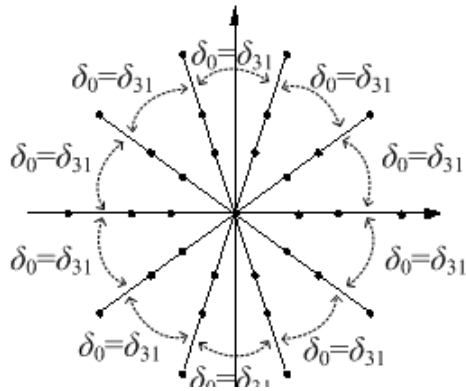


(2L+2M) SVPWM	(4L) SVPWM
$\delta_{am} = MK_1 \sin\left(s\frac{\pi}{5} - \vartheta\right)$	$\delta_{cl} = MK_1 \sin\left(s\frac{\pi}{5} - \vartheta\right)$
$\delta_{al} = MK_2 \sin\left(s\frac{\pi}{5} - \vartheta\right)$	$\delta_{al} = MK_1 \left[\sin\left(\vartheta - (s-1)\frac{\pi}{5}\right) + (2J_1 - 1) \sin\left(s\frac{\pi}{5} - \vartheta\right) \right]$
$\delta_{bm} = MK_1 \sin\left(\vartheta - (s-1)\frac{\pi}{5}\right)$	$\delta_{bl} = MK_1 \left[\sin\left(s\frac{\pi}{5} - \vartheta\right) + (2J_1 - 1) \sin\left(\vartheta - (s-1)\frac{\pi}{5}\right) \right]$
$\delta_{bl} = MK_2 \sin\left(\vartheta - (s-1)\frac{\pi}{5}\right)$	$\delta_{dl} = MK_1 \sin\left(\vartheta - (s-1)\frac{\pi}{5}\right)$
$\delta_z = 1 - MK_2 \cos\left((2s-1)\frac{\pi}{10} - \vartheta\right)$	$\delta_z = 1 - MK_2 \cos\left((2s-1)\frac{\pi}{10} - \vartheta\right)$

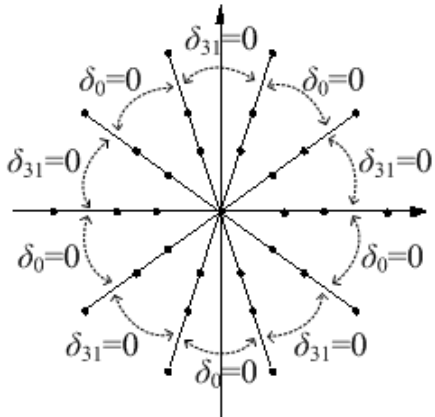
PWM Continuo y Discontinuo

SVPWM

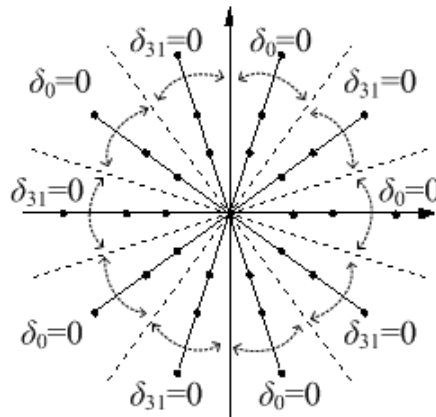
SVPWM



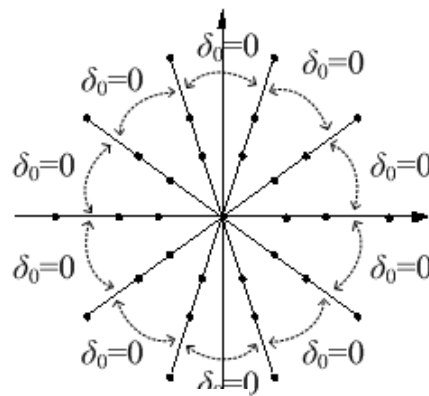
DPWM0



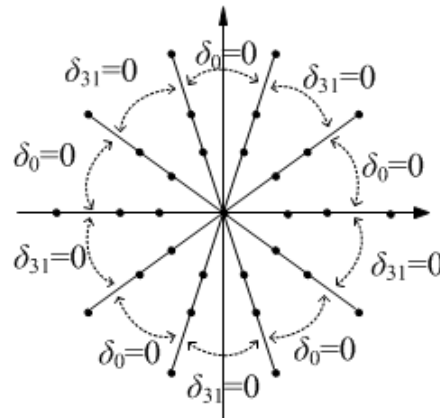
DPWM1



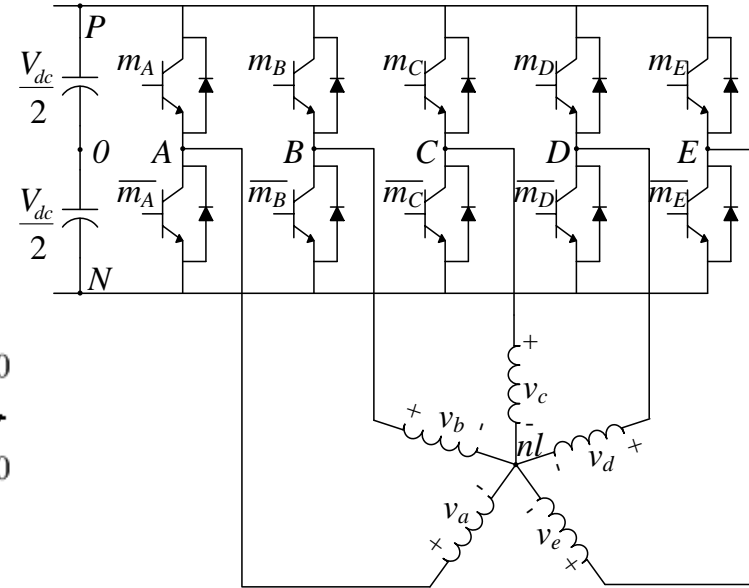
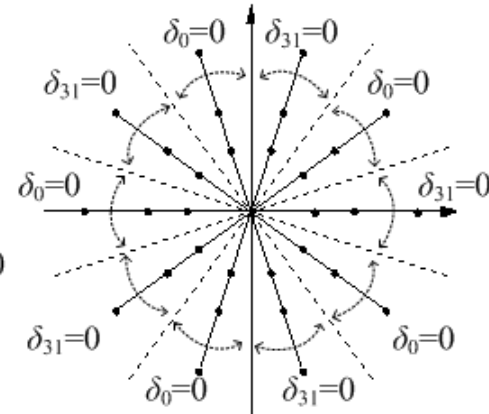
DPWMMAX



DPWM2



DPWM3

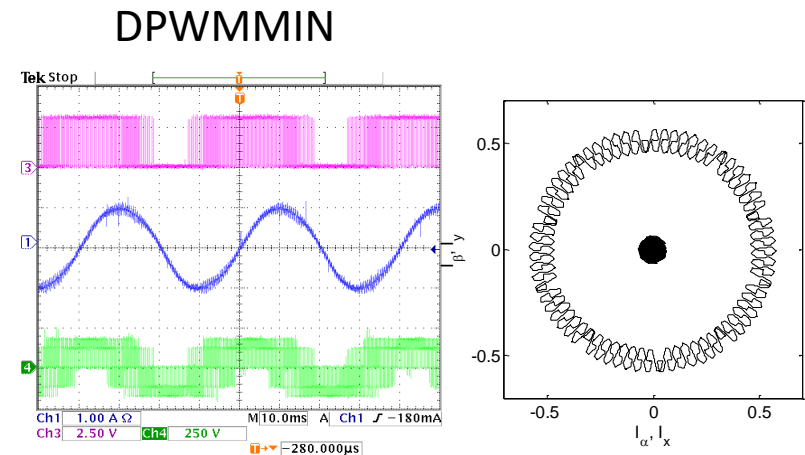
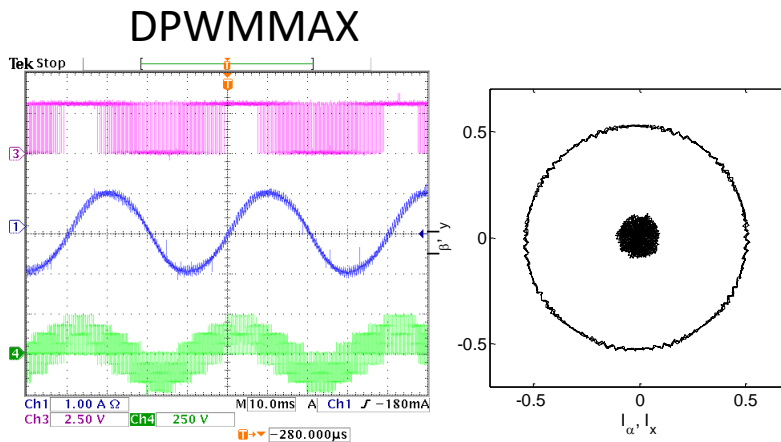
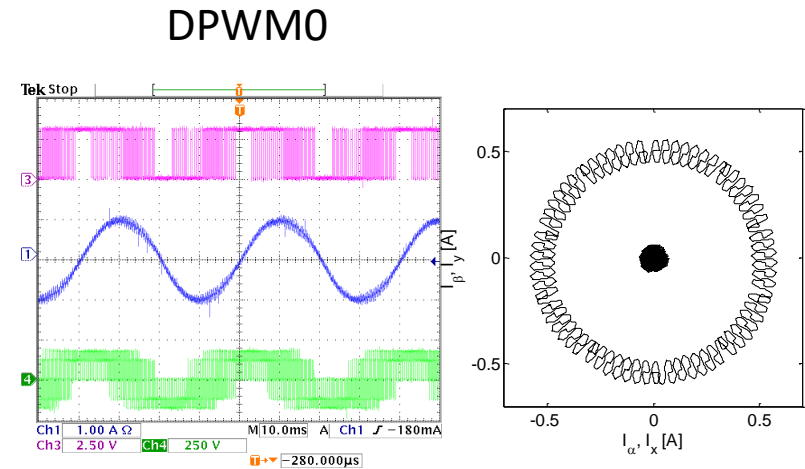
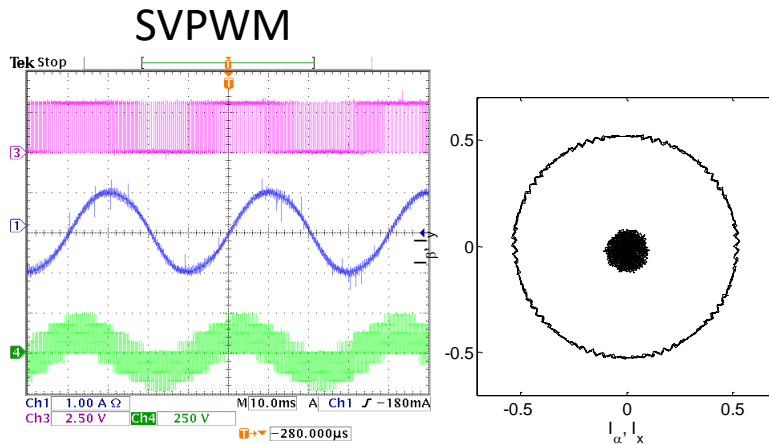


PWM Continuo y Discontinuo

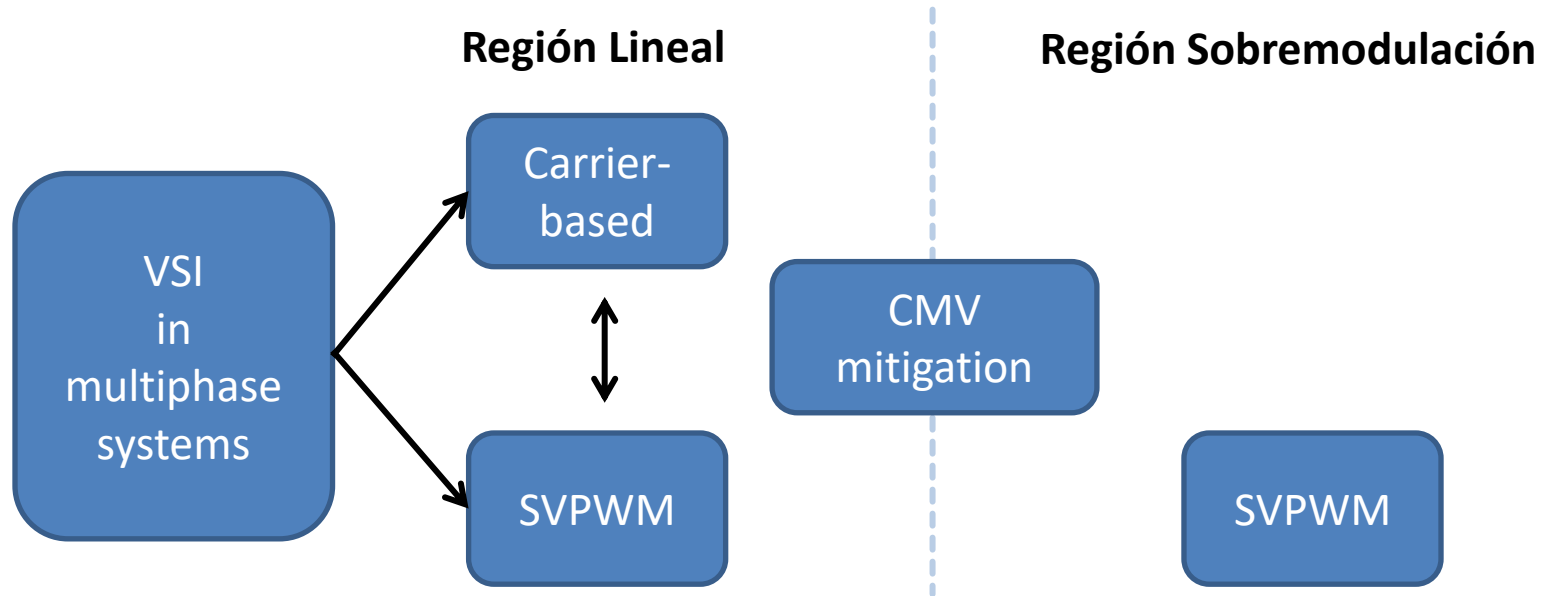
Tienen diferentes patrones de conmutación que generan diferentes resultados en la corriente

2L + 2M SVPWM

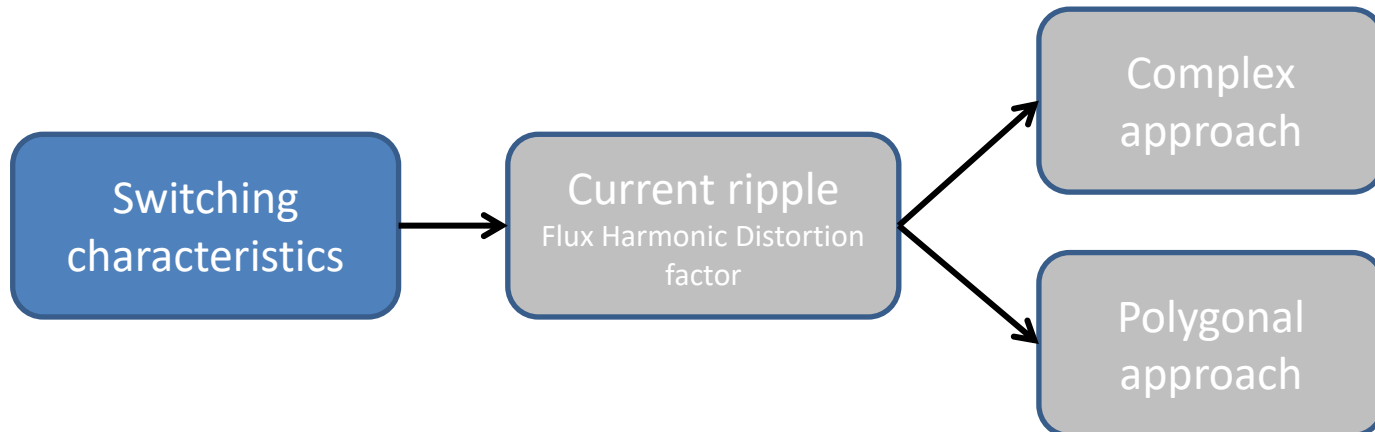
4L SVPWM



Técnicas PWM para convertidores multifasicos



Indicadores de rendimiento



Consideraciones:

- ✓ Alta frecuencia de conmutación
- ✓ Fuerza contraelectromotriz constante durante un periodo de conmutación, e igual a la referencia de tensión
- ✓ Resistencia equivalente de los devanados despreciables y cambio lineal de la corriente

Pasos de análisis:

- ✓ Harmonic Flux trajectories (por periodo de conmutación)

$$\Delta \bar{\lambda} = \int_0^{\frac{T_s}{2}} (\bar{v} - \bar{v}^*) dt$$

- ✓ Harmonics Flux RMS (por periodo de conmutación)

$$\Delta \lambda^2_{RMS}(M, \theta) = \frac{2}{T_s} \int_0^{\frac{T_s}{2}} \Delta \lambda^2 dt$$

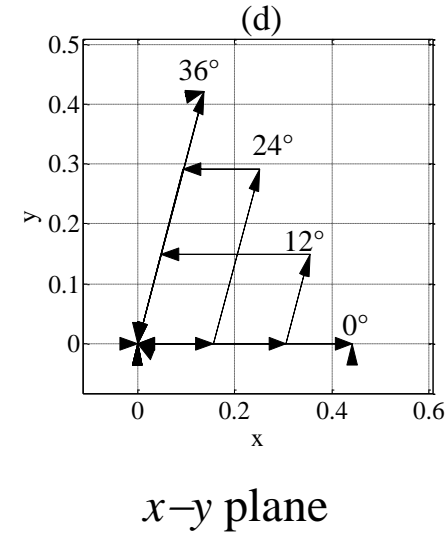
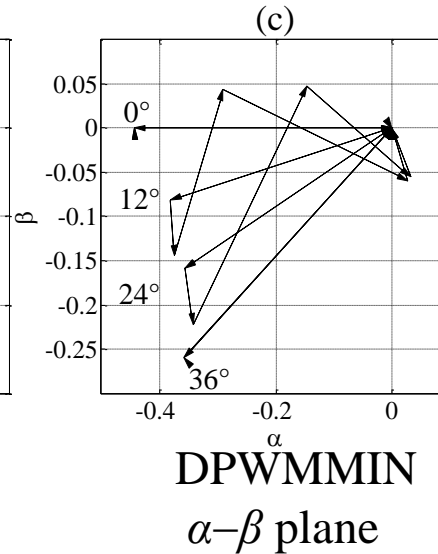
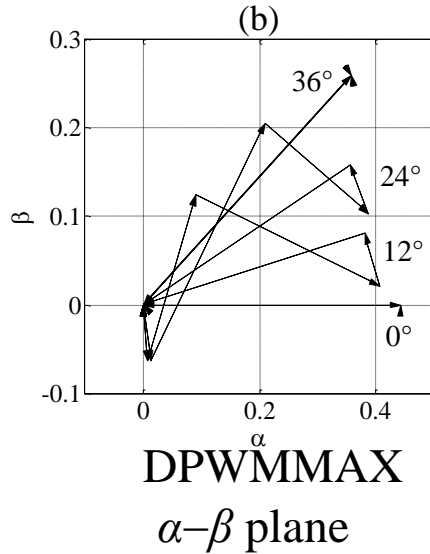
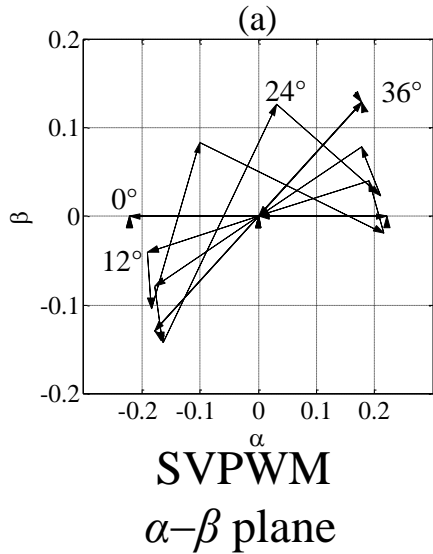
- ✓ Flux HDF (por periodo de la fundamental)

$$\lambda^2_{srms}(M) = \frac{1}{2\pi} \int_{2\pi} \lambda^2_{srms}(M, \theta) d\theta$$

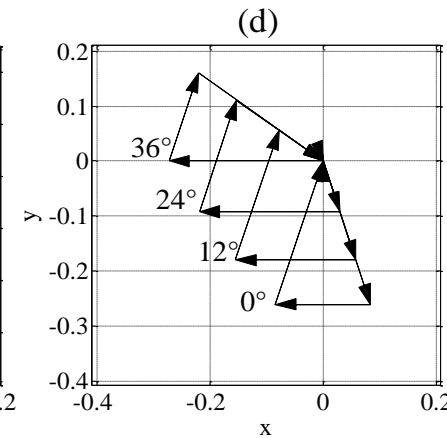
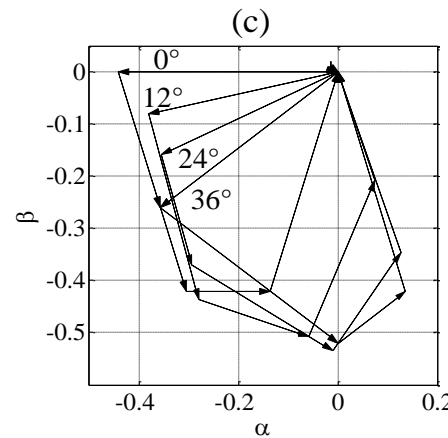
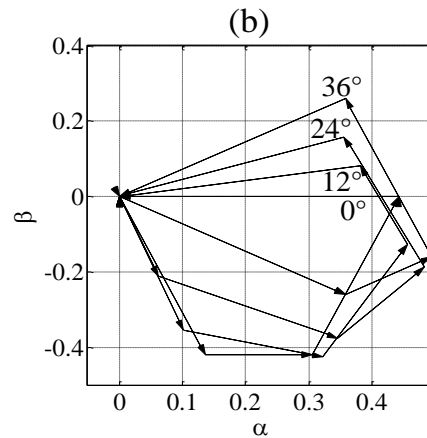
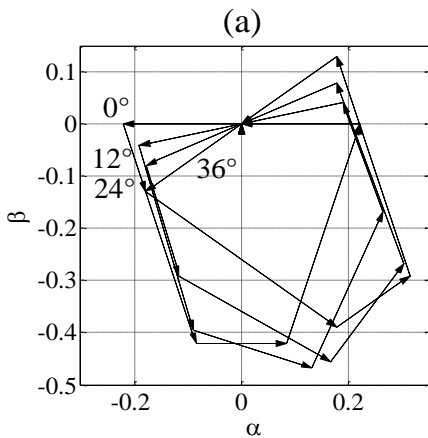
Rizado de Corriente: Paso 1

$M = 0.8$

2L + 2M SVPWM



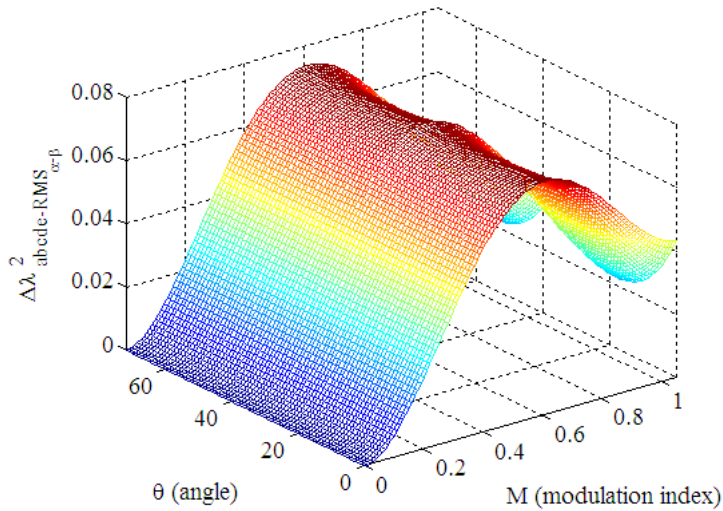
4L SVPWM



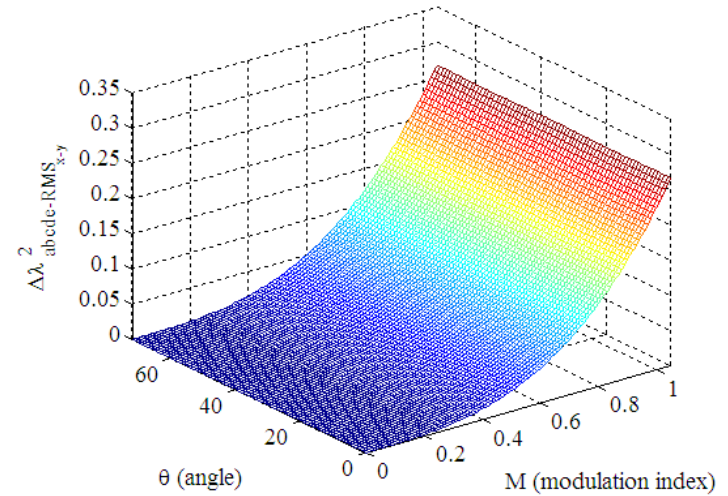
Harmonic Flux trajectories

Rizado de Corriente: Paso 2

2L+2M SVPWM

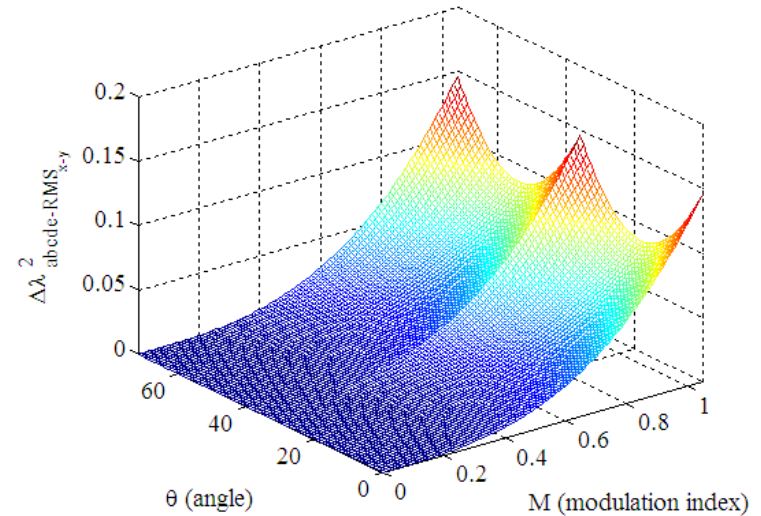
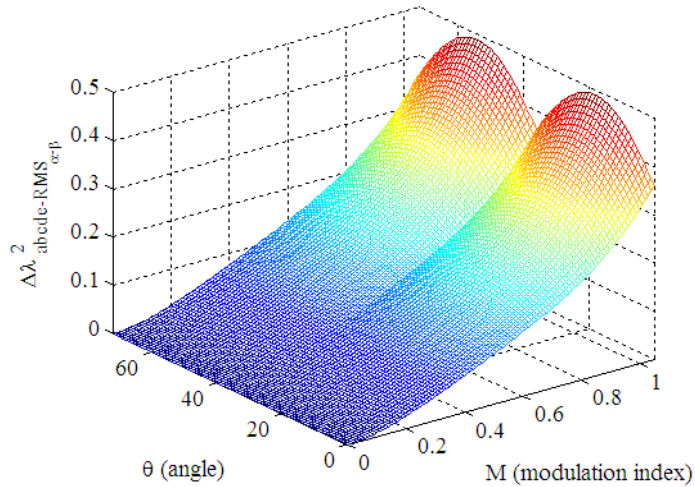


$\alpha\text{-}\beta$ plane



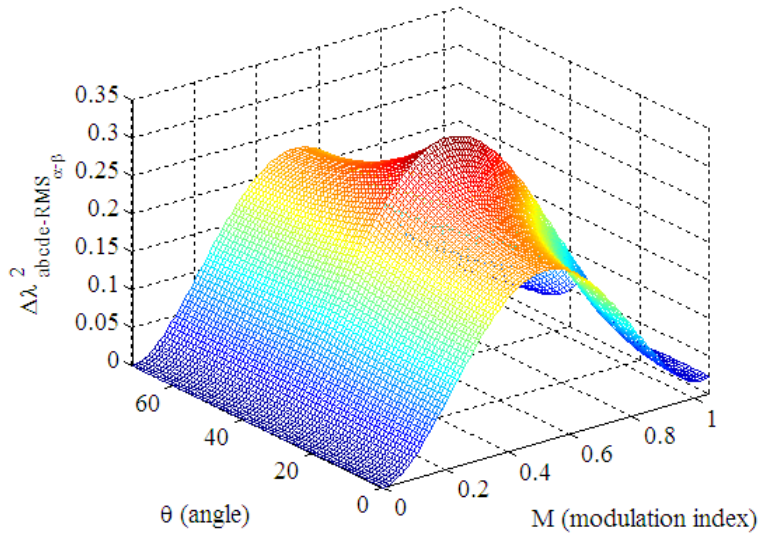
$x\text{-}y$ plane

4L SVPWM

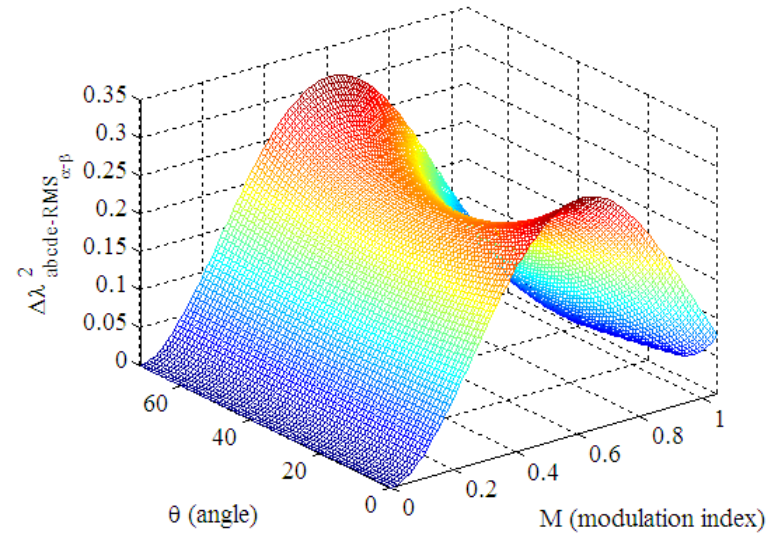


Harmonic Flux RMS

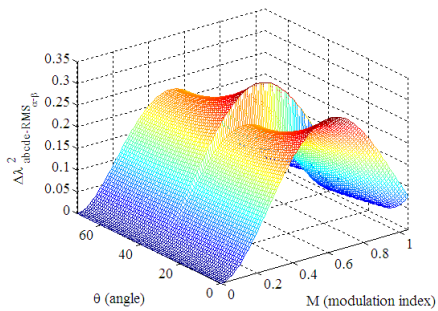
Rizado de Corriente: Paso 3



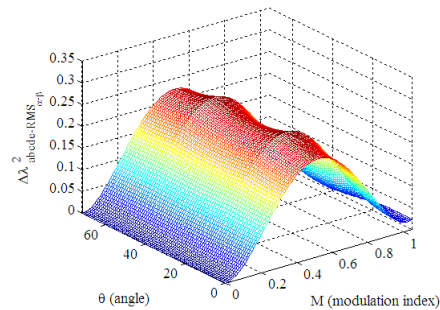
2L+2M DPWMMAX
 $\alpha-\beta$ plane



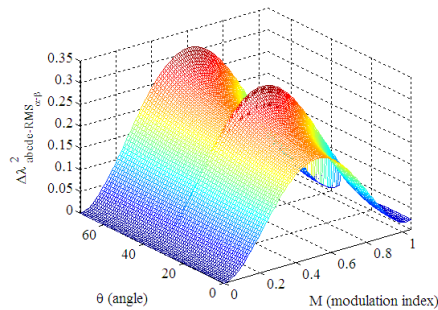
2L+2M DPWMMIN
 $\alpha-\beta$ plane



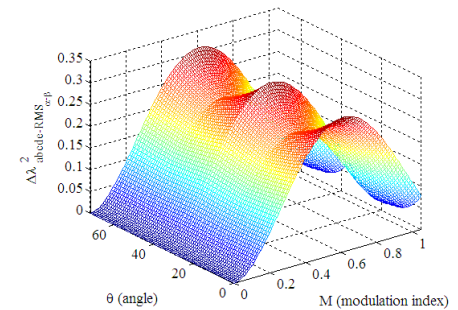
2L+2M DPWM0



2L+2M DPWM1



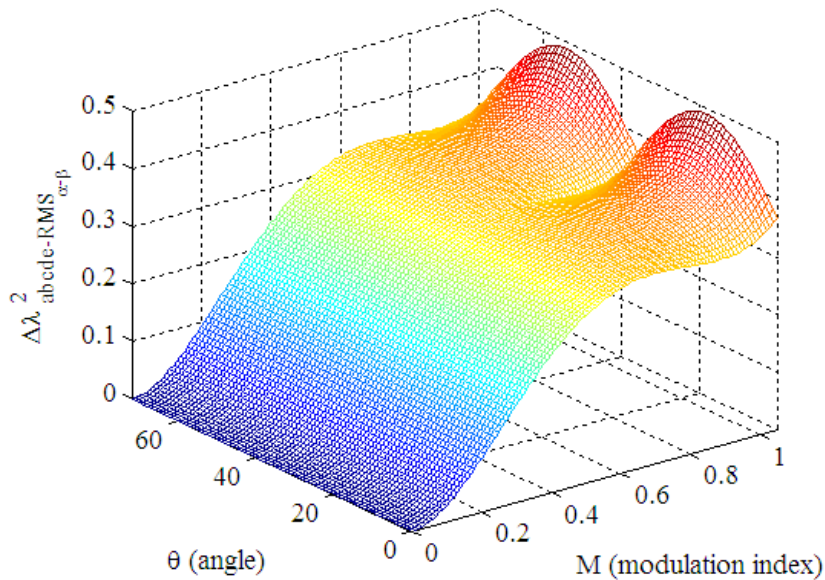
2L+2M DPWM2



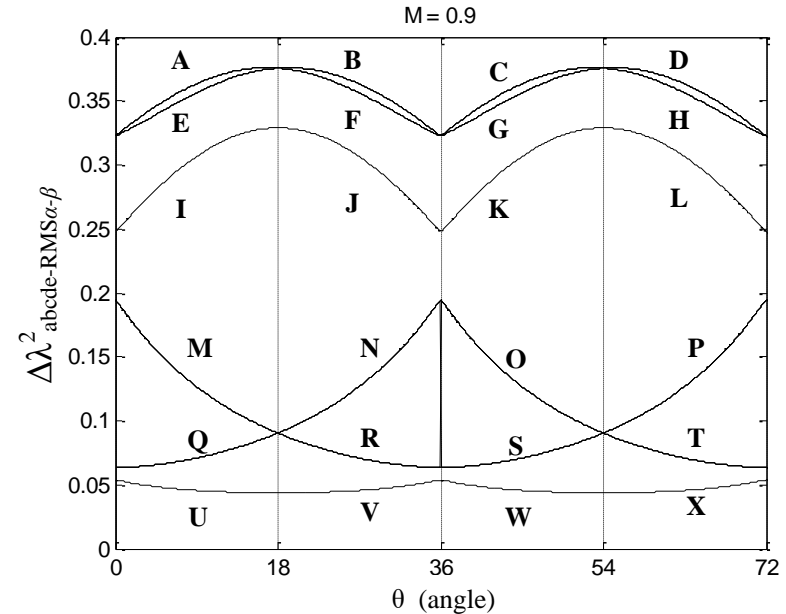
2L+2M DPWM3

Harmonic Flux RMS

Rizado de Corriente: Paso 2

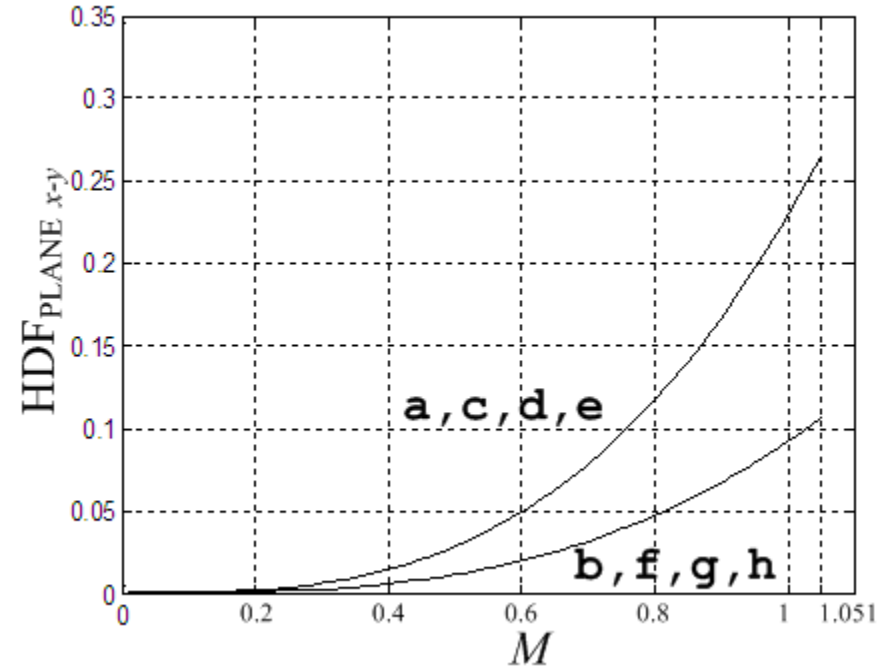
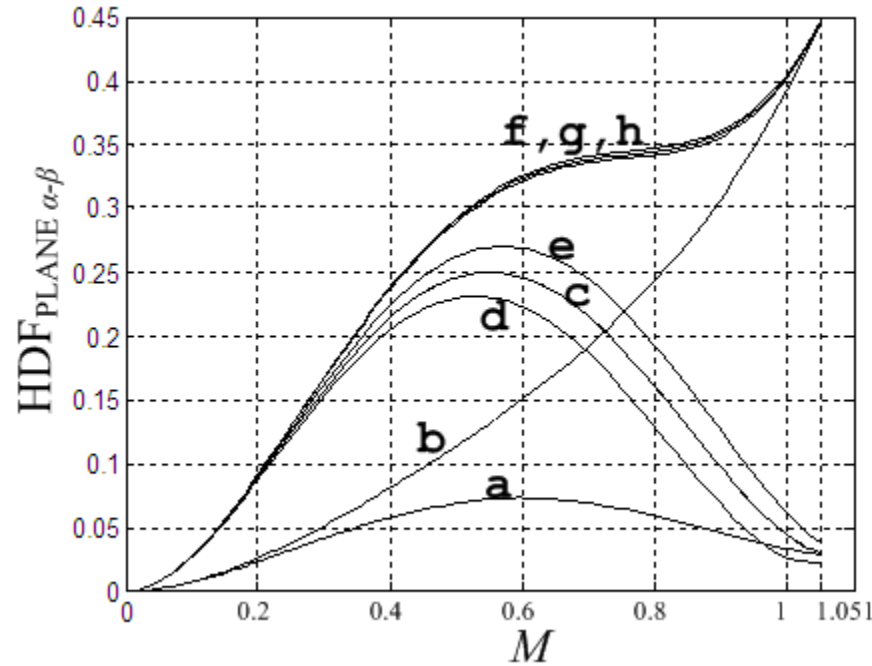


4L discontinuous SVPWM
 $\alpha-\beta$ plane



(2L+2M) SVPWM	→ U-V-W-X	(4L) SVPWM	→ I-J-K-L
(2L+2M) DPWMMAX	→ Q-N-O-T	(4L) DPWMMAX	→ A-F-G-D
(2L+2M) DPWMMIN	→ M-R-S-P	(4L) DPWMMIN	→ E-B-C-H
(2L+2M) DPWM0	→ M-R-O-T	(4L) DPWM0	→ E-B-G-D
(2L+2M) DPWM1	→ Q-R-S-T	(4L) DPWM1	→ A-B-C-D
(2L+2M) DPWM2	→ Q-N-S-P	(4L) DPWM2	→ A-F-C-H
(2L+2M) DPWM3	→ M-N-O-P	(4L) DPWM3	→ E-F-G-H

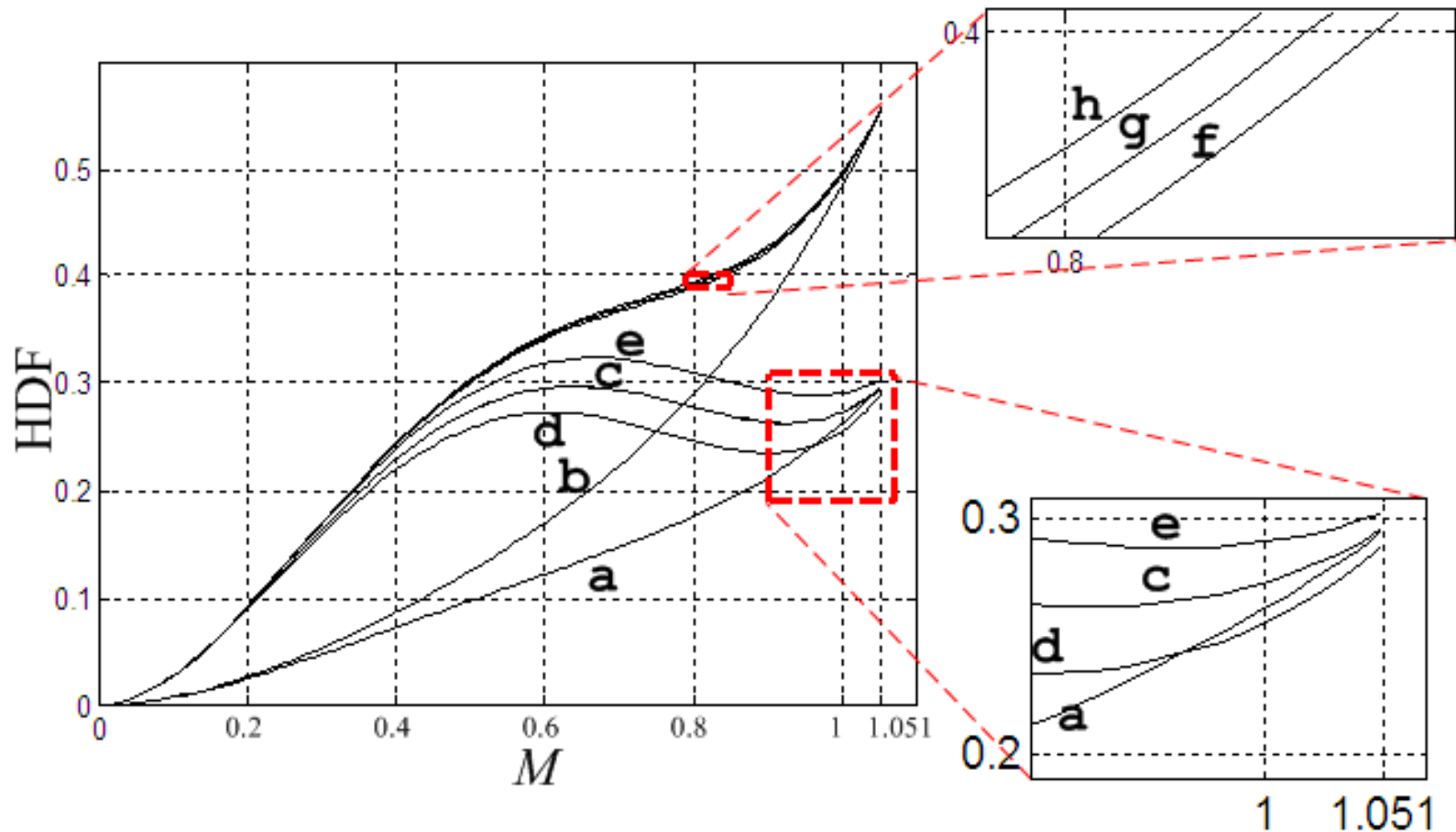
Rizado de Corriente: Paso 3



PWM TECHNIQUES

- | | | | |
|--------------------------|-----------------------------|--------------------------|--------------------------|
| a → (2L+2M) SVPWM | c → (2L+2M) DPWMMAX, | d → (2L+2M) DPWM1 | g → (4L) DPWMMAX, |
| b → (4L) SVPWM | (2L+2M) DPWMIN, | e → (2L+2M) DPWM3 | (4L) DPWMIN, |
| | (2L+2M) DPWM0, | f → (4L) DPWM3 | (4L) DPWM0, |
| | (2L+2M) DPWM2 | h → (4L) DPWM1 | (4L) DPWM2 |

Rizado de Corriente: Paso 3



PWM TECHNIQUES

- | | | | |
|--------------------------|-----------------------------|--------------------------|--------------------------|
| a → (2L+2M) SVPWM | c → (2L+2M) DPWMMAX, | d → (2L+2M) DPWM1 | g → (4L) DPWMMAX, |
| b → (4L) SVPWM | (2L+2M) DPWMIN, | e → (2L+2M) DPWM3 | (4L) DPWMIN, |
| | (2L+2M) DPWM0, | f → (4L) DPWM3 | (4L) DPWM0, |
| | (2L+2M) DPWM2 | h → (4L) DPWM1 | (4L) DPWM2 |

No podemos medir el HDF, pero podemos medir el THD de la corriente

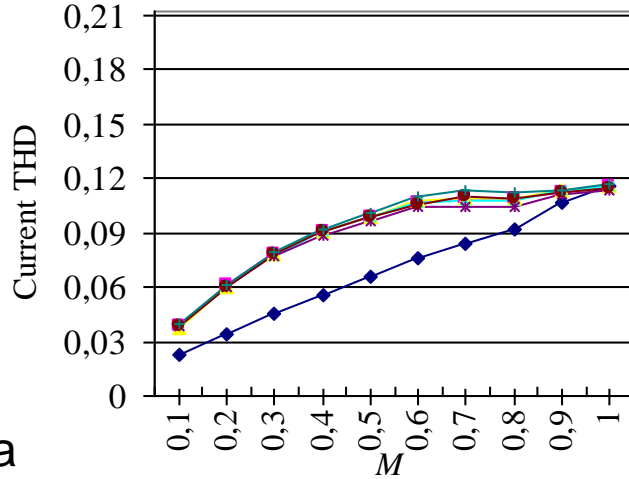
$$\text{THD}_i = \left(\frac{V_{dc} T_s}{8} \right) \frac{\sqrt{HDF_{\alpha-\beta} / L_{\alpha-\beta}^2 + HDF_{x-y} / L_{x-y}^2}}{I_1}$$

Análisis de rizado de corriente

Resultados experimentales

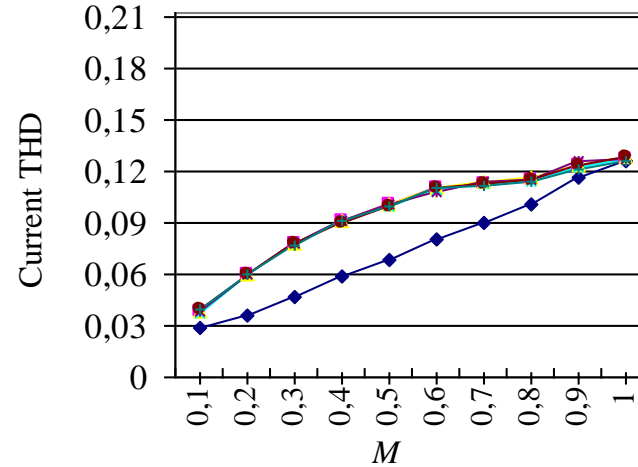
◆ SVPWM ■ DPWMMAX ▲ DPWMMIN
✦ DPWM0 ✧ DPWM1 ● DPWM2 ✦ DPWM3

2L+2M (same BSF)



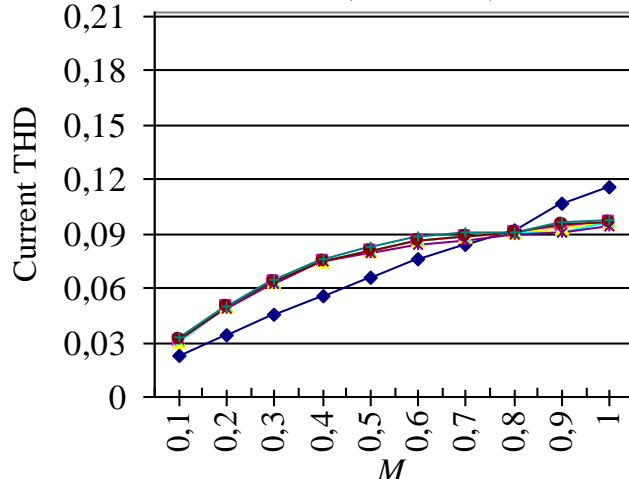
(a)

4L (same BSF)



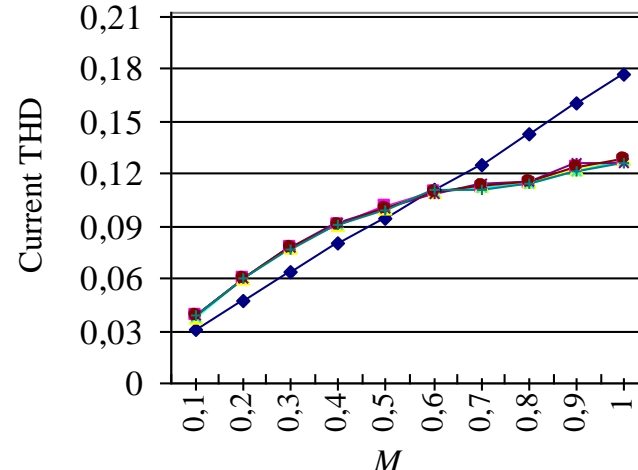
(b)

2L+2M (same ASF)



(c)

4L (same ASF)



(d)

Misma frecuencia base de conmutación

Misma frecuencia promedio de conmutación

Análisis de rizado de corriente

HDF es independiente de la carga, pero el THD de corriente no. De hecho:

$$\text{THD}_i = \left(\frac{V_{dc} T_s}{8} \right) \frac{\sqrt{HDF_{\alpha-\beta} / L_{\alpha-\beta}^2 + HDF_{x-y} / L_{x-y}^2}}{I_1}$$

Las máquinas multifásicas tienen diferentes valores de inductancias para diferentes planos

Análisis de rizado de corriente

FLUX HDF FOR (2L+2M) PWM TECHNIQUES USING THE POLYGON CONNECTION AND THE SAME BASE SWITCHING FREQUENCY.

PWM Method	HDF Analytical expression
SVPWM (2L+2M)	$HDF_{P1} = \frac{1}{16\pi} (8\pi - 35K_1 + 20K_2 - 2\pi J_1 - 10\pi J_2)M^4 - \frac{8}{9\pi} (3K_1 - K_2)M^3 + \frac{1}{3}(1 - J_2)M^2$ $HDF_{P2} = \frac{1}{16\pi} (6\pi - 15K_1 + 5K_2 + 4\pi J_1 - 2\pi J_2)M^4 - \frac{8}{9\pi} (K_1 + 3K_2)M^3 + \frac{1}{3}(1 + J_1)M^2$ $HDF = \frac{1}{16\pi} (14\pi - 50K_1 + 25K_2 + 2\pi J_1 - 12\pi J_2)M^4 - \frac{16}{9\pi} (2K_1 + K_2)M^3 + \frac{1}{3}(2 + J_1 - J_2)M^2$
DPWMMAX, DPWMMIN, DPWM0, DPWM2 (2L+2M)	$HDF_{P1} = \frac{1}{8\pi} (6\pi - 5K_1 + 10K_2 - 6\pi J_2)M^4 - \frac{1}{9\pi} (159K_1 - 53K_2)M^3 + \frac{4}{3}(1 - J_2)M^2$ $HDF_{P2} = \frac{1}{8\pi} (6\pi + 5K_1 + 15K_2 + 6\pi J_1)M^4 - \frac{1}{9\pi} (98K_1 + 69K_2)M^3 + \frac{4}{3}(1 + J_1)M^2$ $HDF = \frac{1}{8\pi} (12\pi + 25K_2 + 6\pi J_1 - 6\pi J_2)M^4 - \frac{1}{9\pi} (257K_1 + 16K_2)M^3 + \frac{4}{3}(2 + J_1 - J_2)M^2$
DPWM1 (2L+2M)	$HDF_{P1} = \frac{1}{4\pi} (3\pi + 15K_1 - 5K_2 - 3\pi J_2)M^4 + \frac{2}{9\pi} (45 - 12K_1 + 4K_2 - 45J_1 - 90J_2)M^3 + \frac{4}{3}(1 - J_2)M^2$ $HDF_{P2} = \frac{1}{4\pi} (3\pi + 10K_1 + 5K_2 + 3\pi J_1)M^4 + \frac{2}{9\pi} (-4K_1 - 12K_2 - 45J_1 - 45J_2)M^3 + \frac{4}{3}(1 + J_1)M^2$ $HDF = \frac{1}{4\pi} (6\pi + 25K_1 + 3\pi J_1 - 3\pi J_2)M^4 + \frac{2}{9\pi} (45 - 16K_1 - 8K_2 - 90J_1 - 135J_2)M^3 + \frac{4}{3}(2 + J_1 - J_2)M^2$
DPWM3 (2L+2M)	$HDF_{P1} = \frac{1}{4\pi} (3\pi - 20K_1 + 15K_2 - 3\pi J_2)M^4 + \frac{2}{9\pi} (-45 - 147K_1 + 49K_2 + 45J_1 + 90J_2)M^3 + \frac{4}{3}(1 - J_2)M^2$ $HDF_{P2} = \frac{1}{4\pi} (3\pi - 5K_1 + 10K_2 + 3\pi J_1)M^4 + \frac{2}{9\pi} (-94K_1 - 57K_2 + 45J_1 + 45J_2)M^3 + \frac{4}{3}(1 + J_1)M^2$ $HDF = \frac{1}{4\pi} (6\pi - 25K_1 + 25K_2 + 3\pi J_1 - 3\pi J_2)M^4 + \frac{2}{9\pi} (-45 - 241K_1 - 8K_2 + 90J_1 + 135J_2)M^3 + \frac{4}{3}(2 + J_1 - J_2)M^2$

Análisis de rizado de corriente

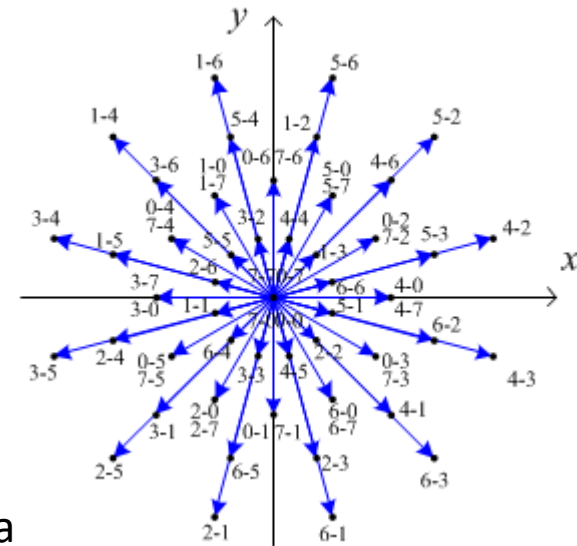
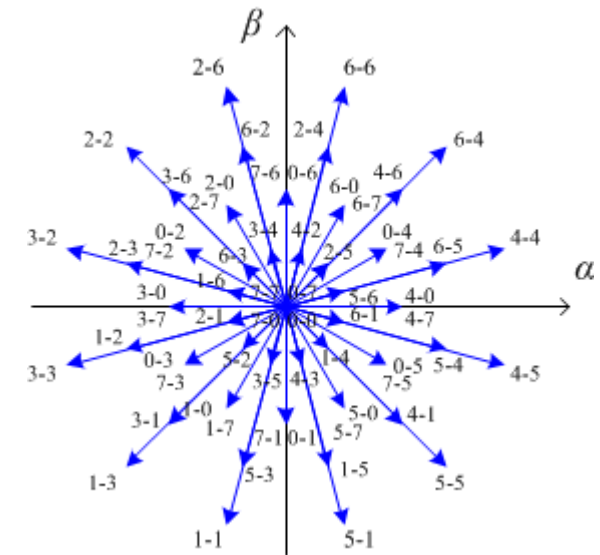
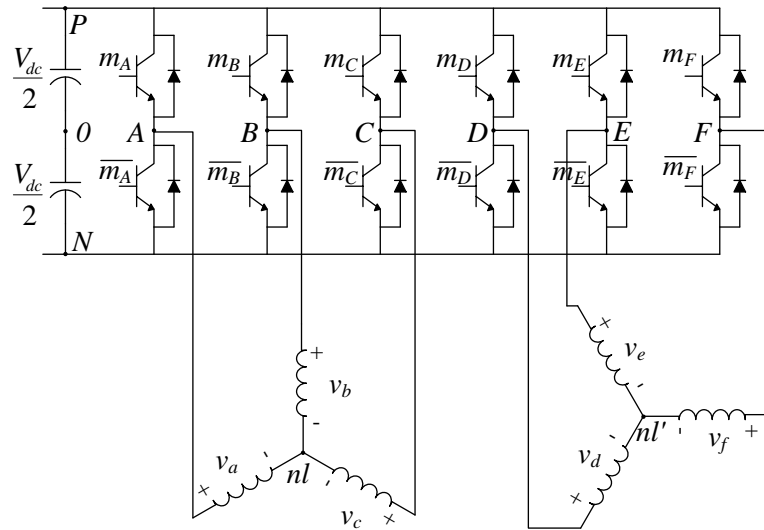
FLUX HDF FOR (4L) PWM TECHNIQUES USING THE POLYGON CONNECTION AND THE SAME BASE SWITCHING FREQUENCY.

PWM Method	HDF Analytical expression
SVPWM (4L)	$HDF_{F1} = \frac{1}{16\pi} (8\pi - 35K_1 + 20K_2 - 2\pi J_1 - 10\pi J_2)M^4 + \frac{1}{9\pi} (-24K_1 + 8K_2)M^3 + \frac{1}{3}(1 - J_2)M^2$ $HDF_{F2} = \frac{1}{16\pi} (6\pi - 15K_1 + 5K_2 + 4\pi J_1 - 2\pi J_2)M^4 + \frac{1}{9\pi} (-96K_1 + 37K_2)M^3 + \frac{1}{3}(1 + J_1)M^2$ $HDF = \frac{1}{16\pi} (14\pi - 50K_1 + 25K_2 + 2\pi J_1 - 12\pi J_2)M^4 + \frac{1}{3\pi} (-40K_1 + 15K_2)M^3 + \frac{1}{3}(2 + J_1 - J_2)M^2$
DPWMMAX, DPWMMIN, DPWM0, DPWM2 (4L)	$HDF_{F1} = \frac{1}{8\pi} (6\pi - 5K_1 + 10K_2 - 6\pi J_2)M^4 + \frac{1}{9\pi} (-159K_1 + 53K_2)M^3 + \frac{4}{3}(1 - J_2)M^2$ $HDF_{F2} = \frac{1}{8\pi} (6\pi + 5K_1 + 15K_2 + 6\pi J_1)M^4 + \frac{1}{9\pi} (-186K_1 - 8K_2)M^3 + \frac{4}{3}(1 + J_1)M^2$ $HDF = \frac{1}{8\pi} (12\pi + 25K_2 + 6\pi J_1 - 6\pi J_2)M^4 - \frac{5}{3\pi} (23K_1 - 3K_2)M^3 + \frac{4}{3}(2 + J_1 - J_2)M^2$
DPWM1 (4L)	$HDF_{F1} = \frac{1}{16\pi} (12\pi + 30K_1 - 5K_2 - 12\pi J_2)M^4 - \frac{1}{9\pi} (18 + 189K_1 - 113K_2 + 24J_1 + 6J_2)M^3 + \frac{4}{3}(1 - J_2)M^2$ $HDF_{F2} = \frac{1}{16\pi} (12\pi + 25K_1 + 20K_2 + 12\pi J_1)M^4 - \frac{1}{9\pi} (42 + 156K_1 - 82K_2 + 66J_1 + 24J_2)M^3 + \frac{4}{3}(1 + J_1)M^2$ $HDF = \frac{1}{16\pi} (24\pi + 55K_1 + 15K_2 + 12\pi J_1 - 12\pi J_2)M^4 - \frac{5}{9\pi} (12 + 69K_1 - 39K_2 + 18J_1 + 6J_2)M^3 + \frac{4}{3}(2 + J_1 - J_2)M^2$
DPWM3 (4L)	$HDF_{F1} = \frac{1}{16\pi} (12\pi - 50K_1 + 45K_2 - 12\pi J_2)M^4 - \frac{1}{9\pi} (-18 + 129K_1 + 7K_2 - 24J_1 - 6J_2)M^3 + \frac{4}{3}(1 - J_2)M^2$ $HDF_{F2} = \frac{1}{16\pi} (12\pi - 5K_1 + 40K_2 + 12\pi J_1)M^4 - \frac{1}{9\pi} (-42 + 216K_1 + 98K_2 - 66J_1 - 24J_2)M^3 + \frac{4}{3}(1 + J_1)M^2$ $HDF = \frac{1}{16\pi} (24\pi - 55K_1 + 85K_2 + 12\pi J_1 - 12\pi J_2)M^4 - \frac{5}{9\pi} (-12 + 69K_1 + 21K_2 - 18J_1 - 6J_2)M^3 + \frac{4}{3}(2 + J_1 - J_2)M^2$

Análisis de rizado de corriente

Caso Seis fases:

Double Zero-Sequence Injection PWM

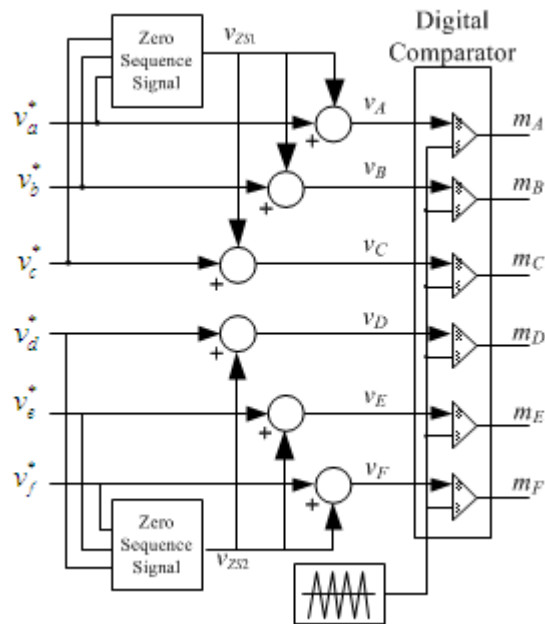


- $2^6 = 64$ estados de conmutación (peros solo 49 vectores diferentes de tensión).
- Cada vector puede ser representado en dos planos diferentes
- La referencia es obtenida con la utilización selectiva de algunos estados de conmutación aplicados en cierta secuencia

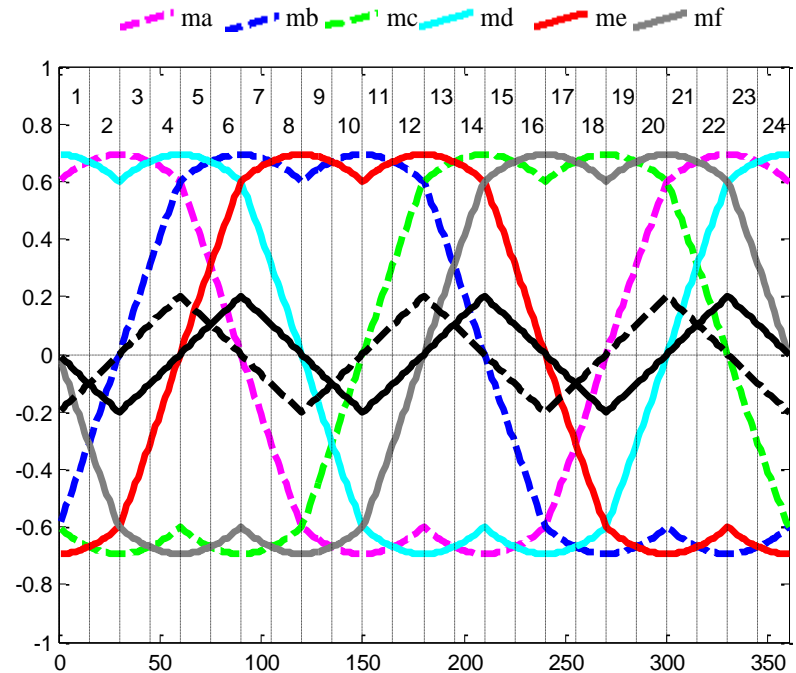
Six phase case:

Double Zero-Sequence Injection PWM

Diagrama de bloques



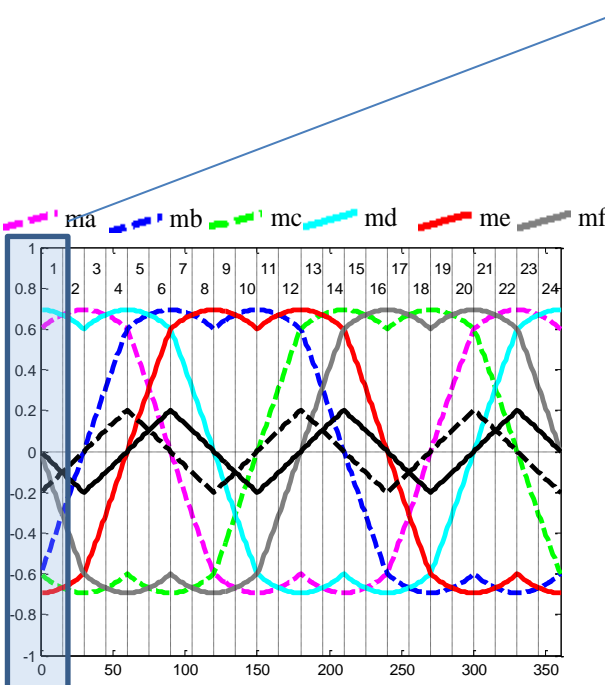
Señales moduladoras y secuencia cero



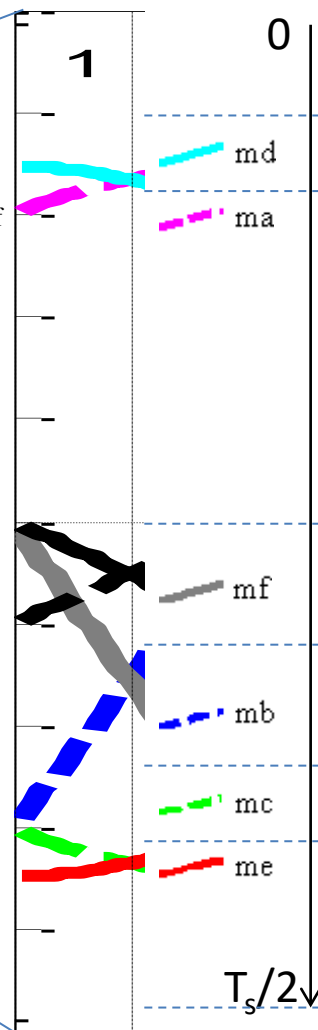
Dos conjuntos de tensiones de referencia con la misma amplitud desfasadas 30°

Análisis de rizado de corriente

Carrier-based signals



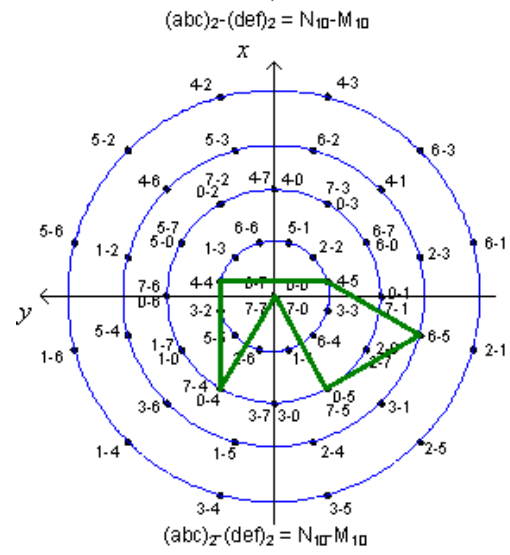
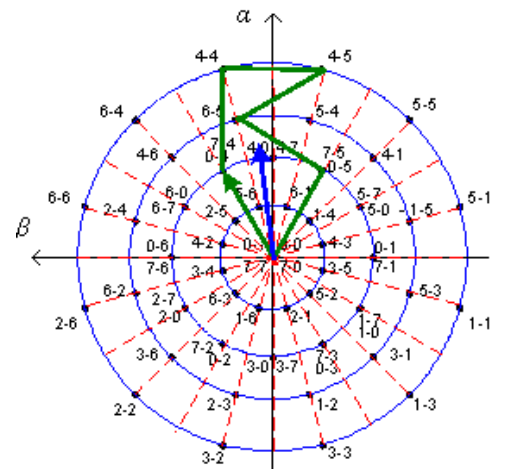
Sector 1



Switching states

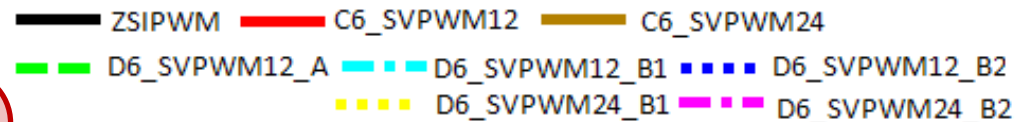
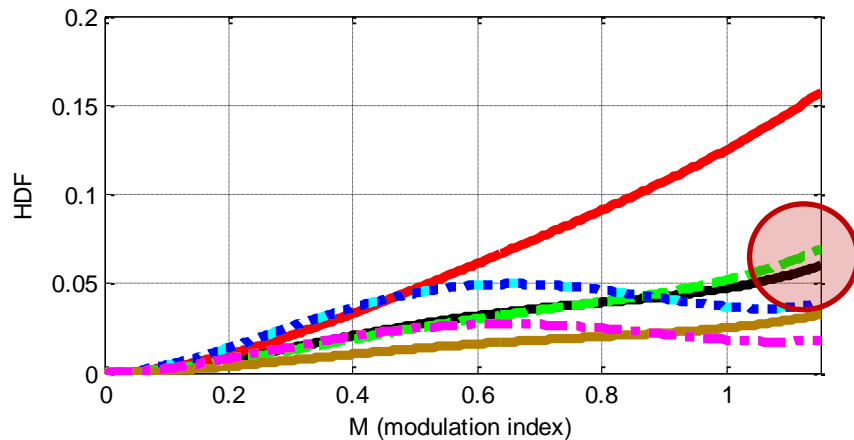
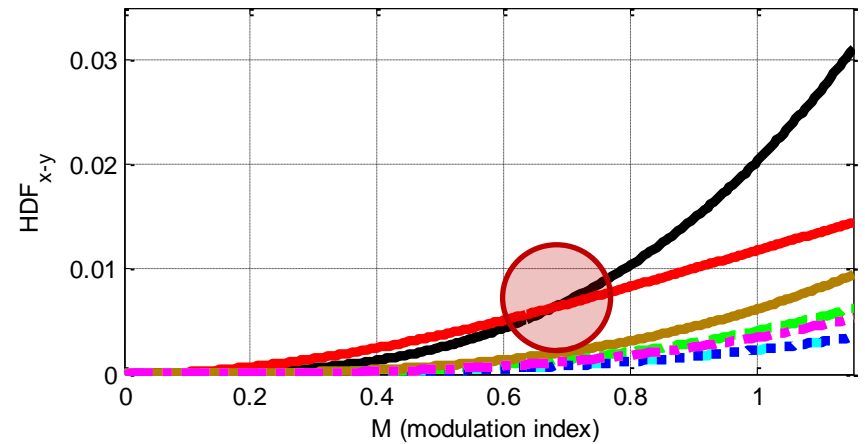
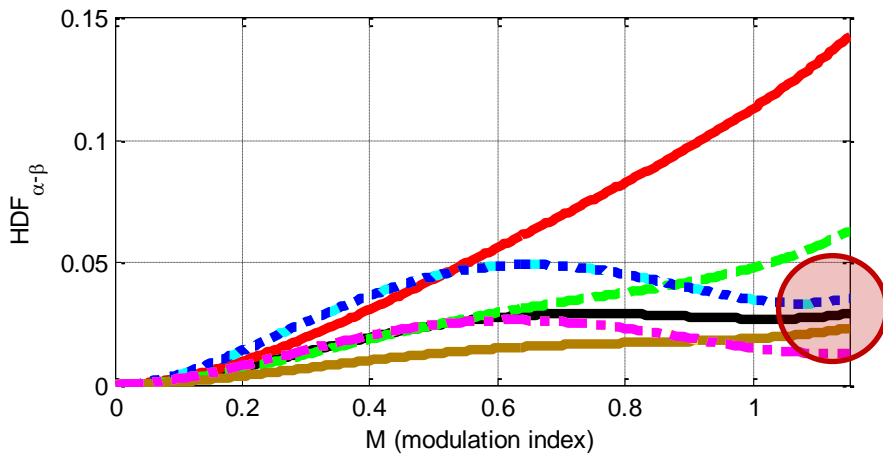
abc - def	
000 - 000	(0-0)
000 - 100	(0-4)
100 - 100	(4-4)
100 - 101	(4-5)
110 - 101	(6-5)
111 - 101	(7-5)
111 - 111	(7-7)

Space Vector equivalence



Análisis de rizado de corriente

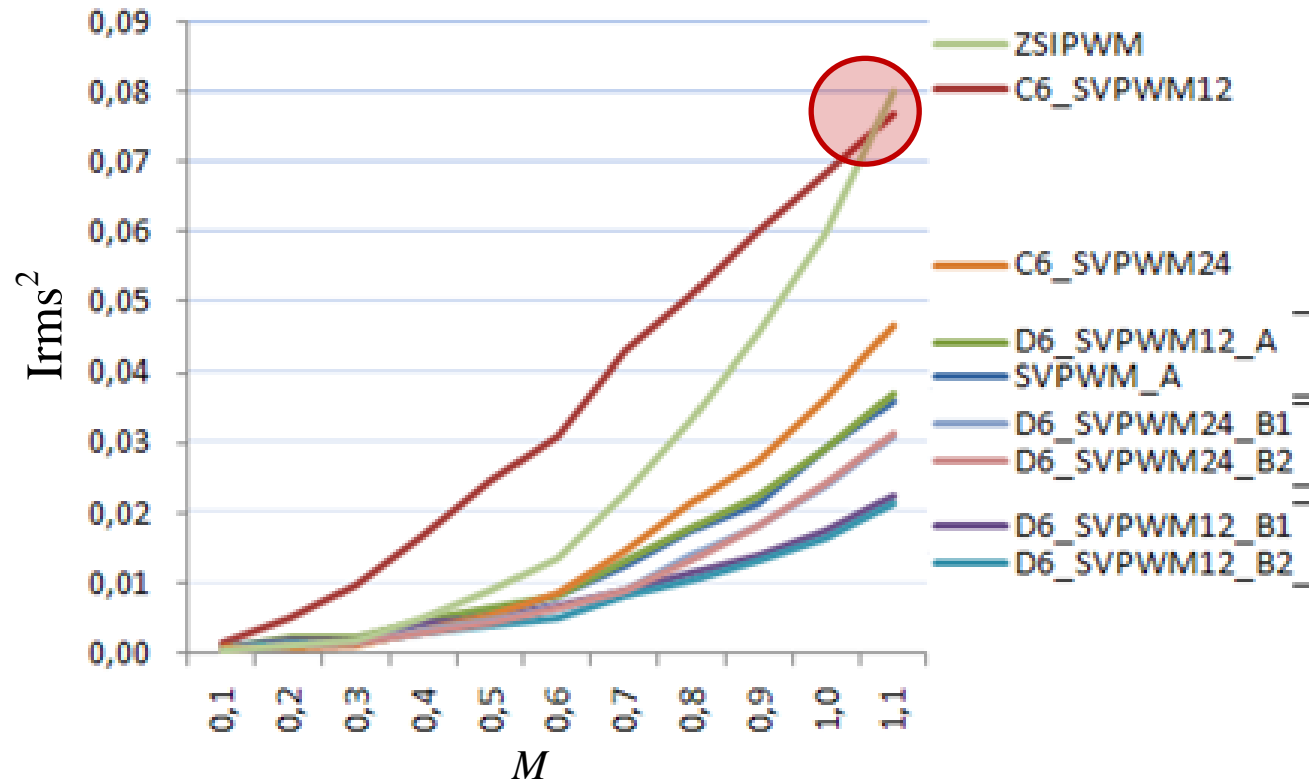
Total Flux Harmonic Distortion Factor (same average switching frequency)



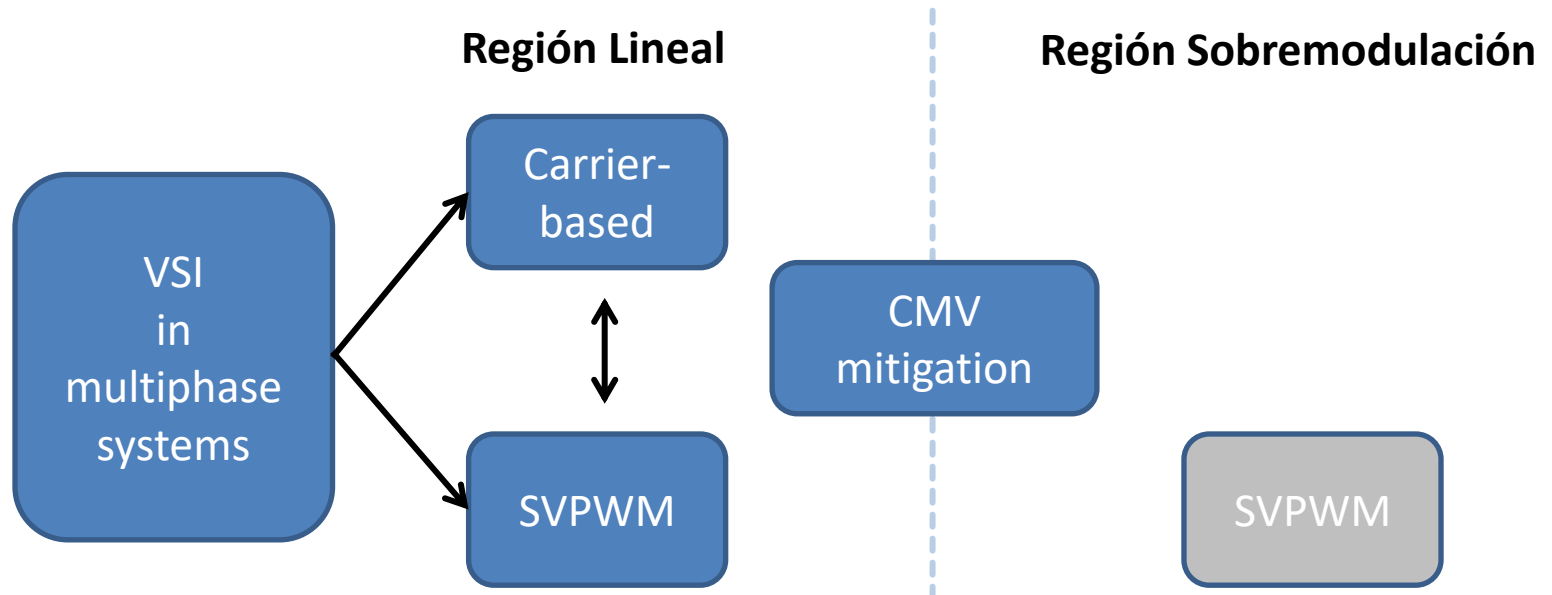
Análisis de rizado de corriente

2 kHz average switching frequency

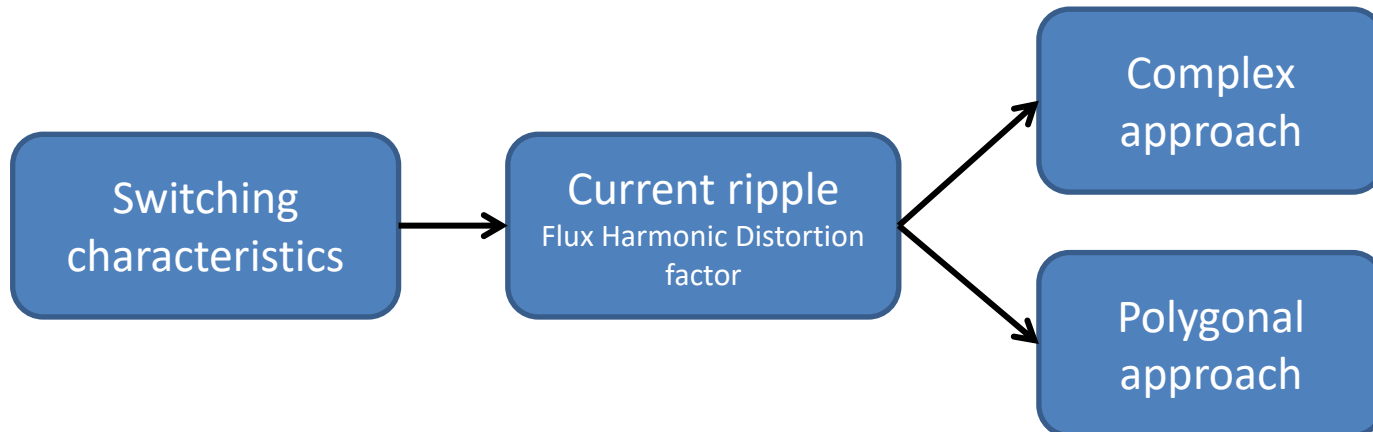
Vdc: 300V



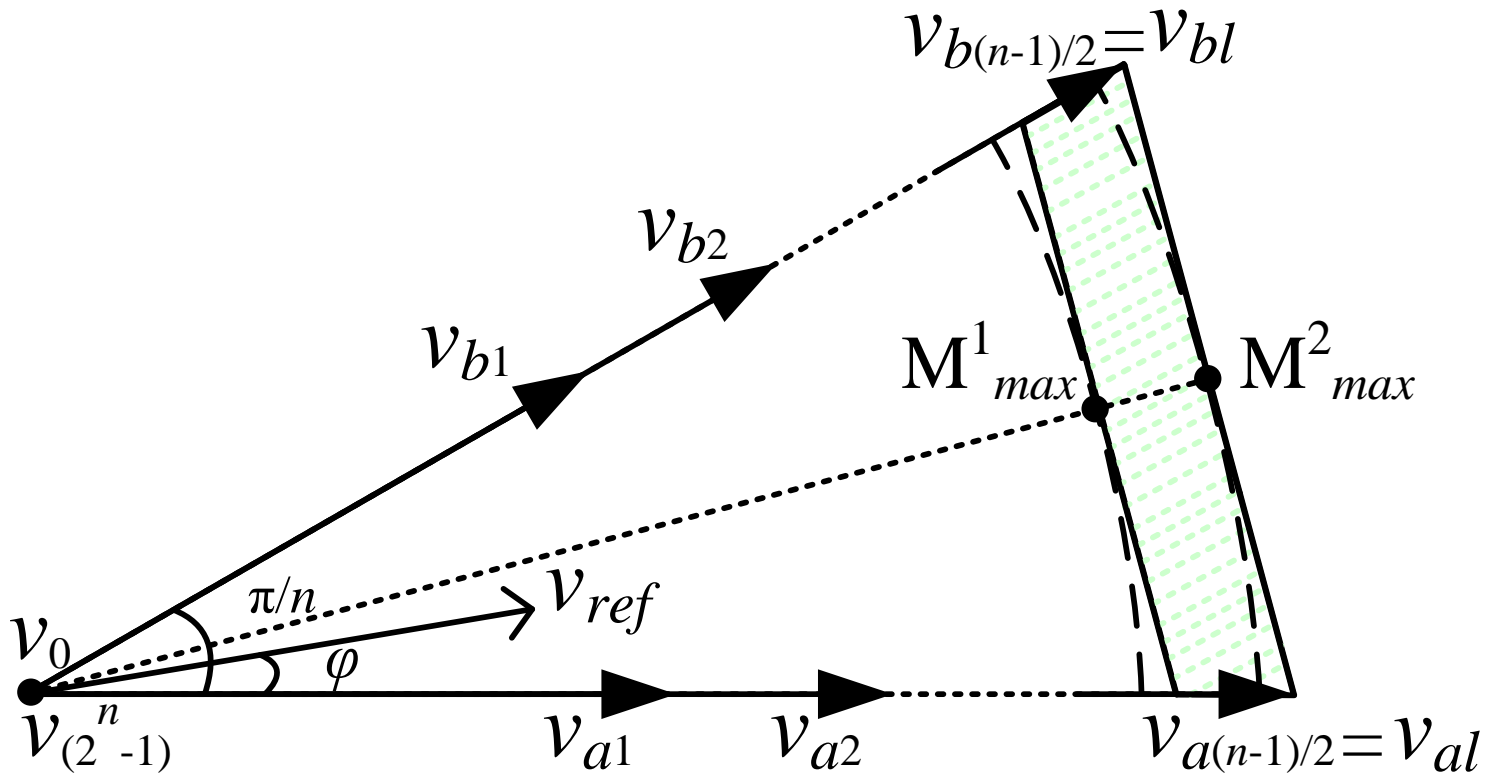
Técnicas PWM para convertidores multifasicos



Indicadores de rendimiento



SVPWM Overmodulation Region



SVPWM Overmodulation Region

Evaluate δ_{ax} and δ_{bx} from (3) and (4)

If $\left(\sum_{x=1}^{(n-1)/2} (\delta_{ax} + \delta_{bx}) \right) \leq 1$ then 'REM linear region
 use δ_{ax} and δ_{bx} values

Else 'REM overmodulation zone
 Evaluate δ_{al} and δ_{bl} from (5) and (6)
 If $\delta_{al} + \delta_{bl} \leq 1$ then
 $R = 1/(\delta_{al} + \delta_{bl})$
 Evaluate (12)

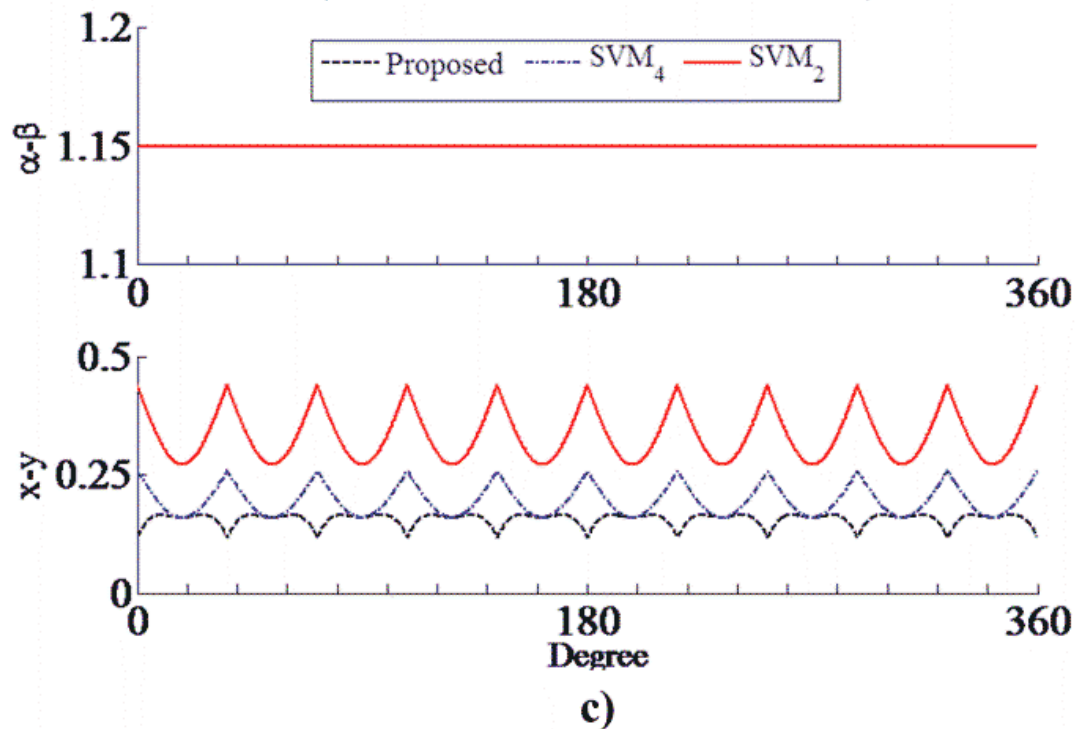
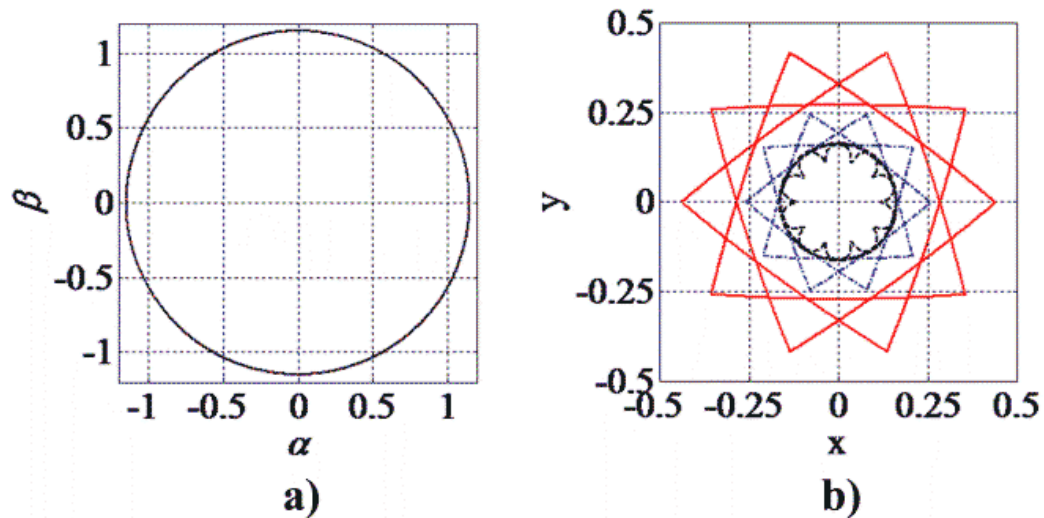
Else
 Reference vector cannot be achieved

End if

End if

$$\begin{bmatrix} \delta_{a1} \\ \delta_{a2} \\ \delta_{a3} \\ \delta_{a4} \\ \vdots \\ \delta_{a(n-1)/2-1} \\ \delta_{a(n-1)/2} \end{bmatrix} = \begin{bmatrix} |v_{a1}| & |v_{a2}| & |v_{a3}| & \cdots & |v_{a((n-1)/2-2)}| & |v_{a((n-1)/2-1)}| & |v_{a(n-1)/2}| \\ 1 & 1 & 1 & \cdots & 1 & 1 & 1 \\ -K_2/K_1 & 1 & 0 & \cdots & 0 & 0 & 0 \\ 0 & -K_3/K_2 & 1 & \cdots & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & 1 & 0 & 0 \\ 0 & 0 & 0 & \cdots & -K_{(n-1)/2-1}/K_{(n-2)/2} & 1 & 0 \end{bmatrix}^{-1} \begin{bmatrix} |v_{al}| \cdot \delta_{al} \\ R \cdot \delta_{al} \\ 0 \\ \vdots \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

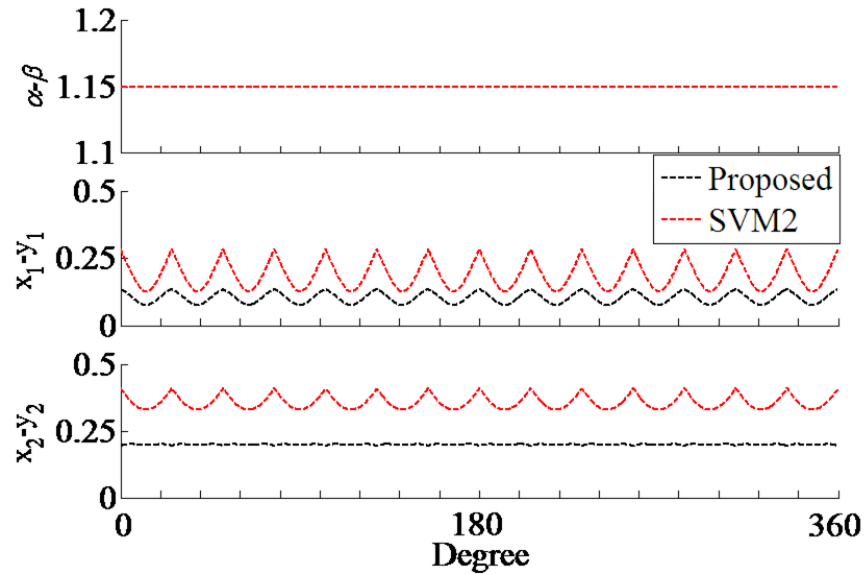
SVPWM Overmodulation Region



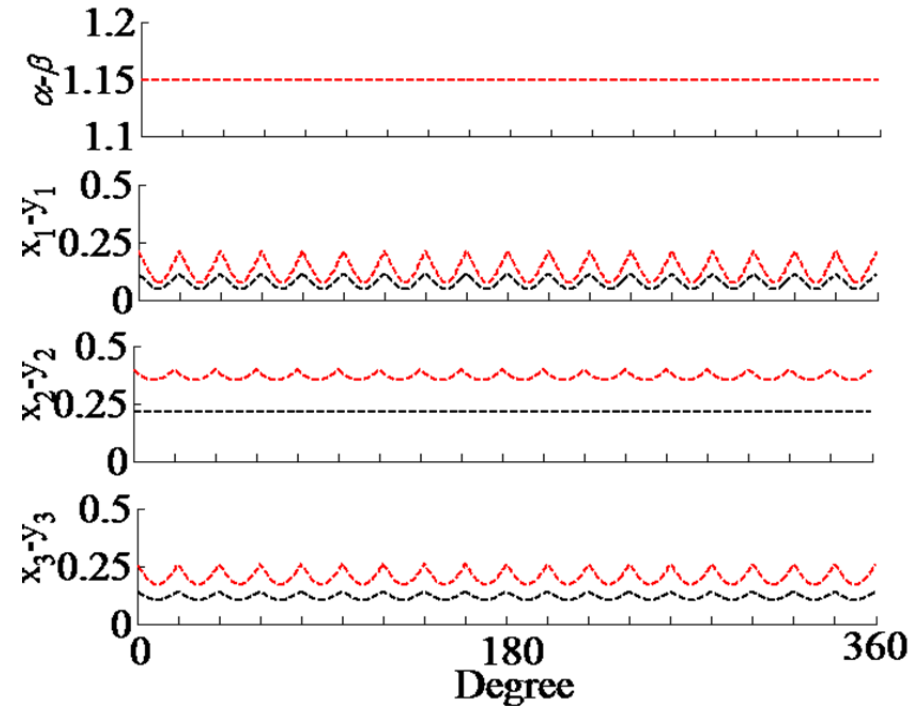
SVPWM Overmodulation Region

General case for odd number of phases

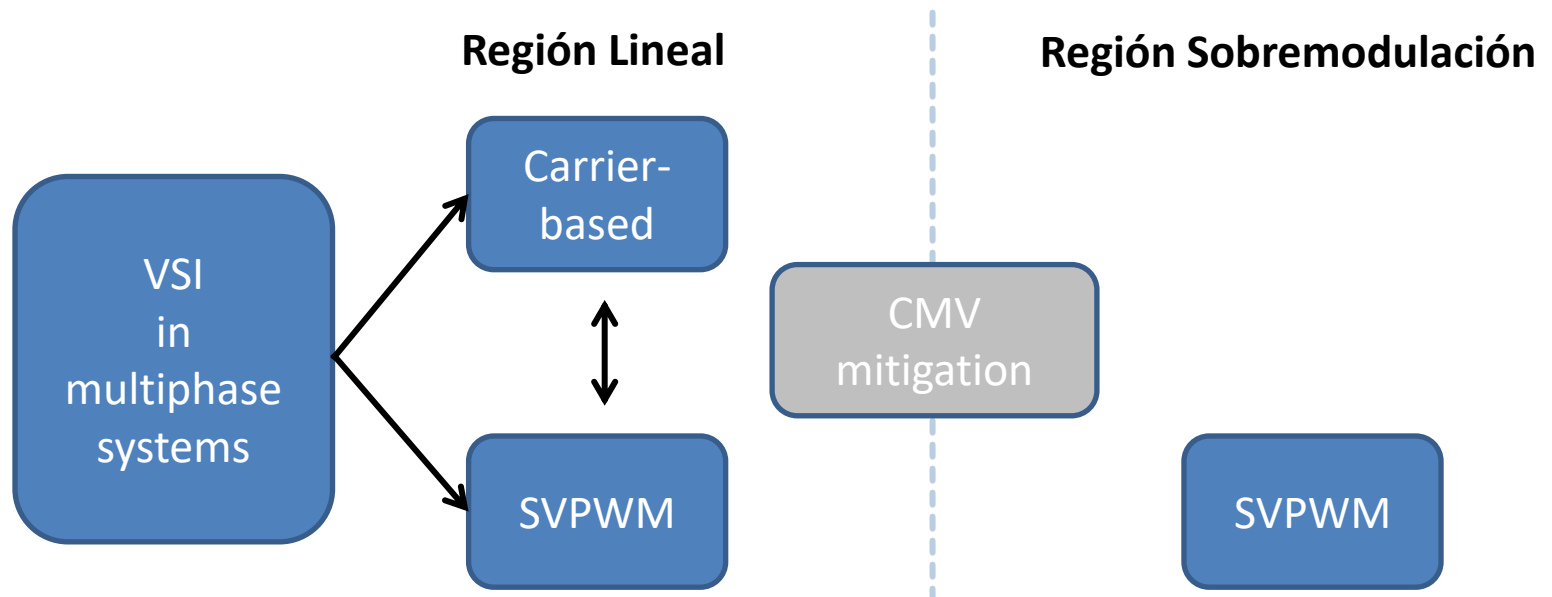
7-phase



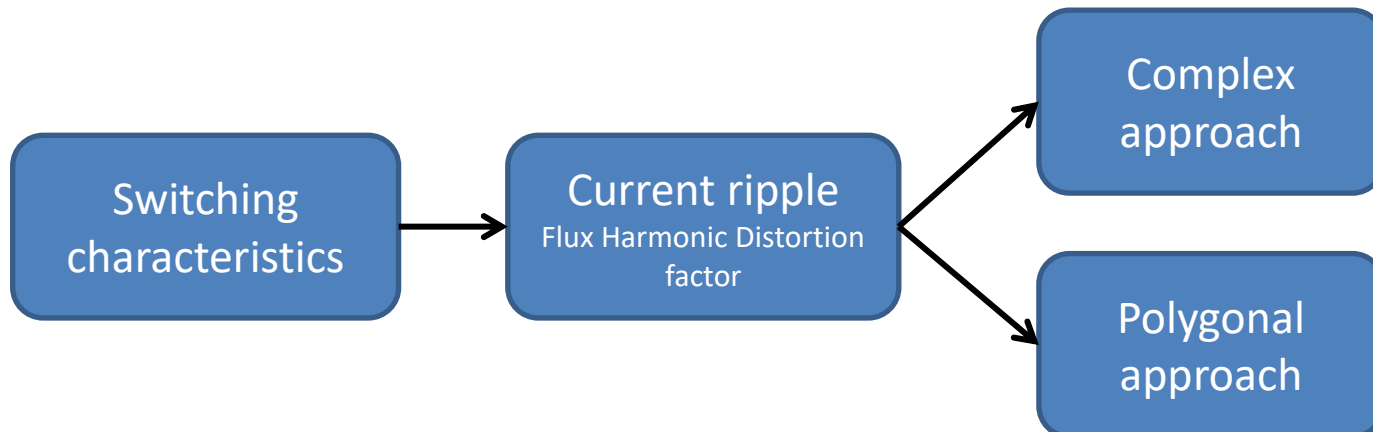
9-phase



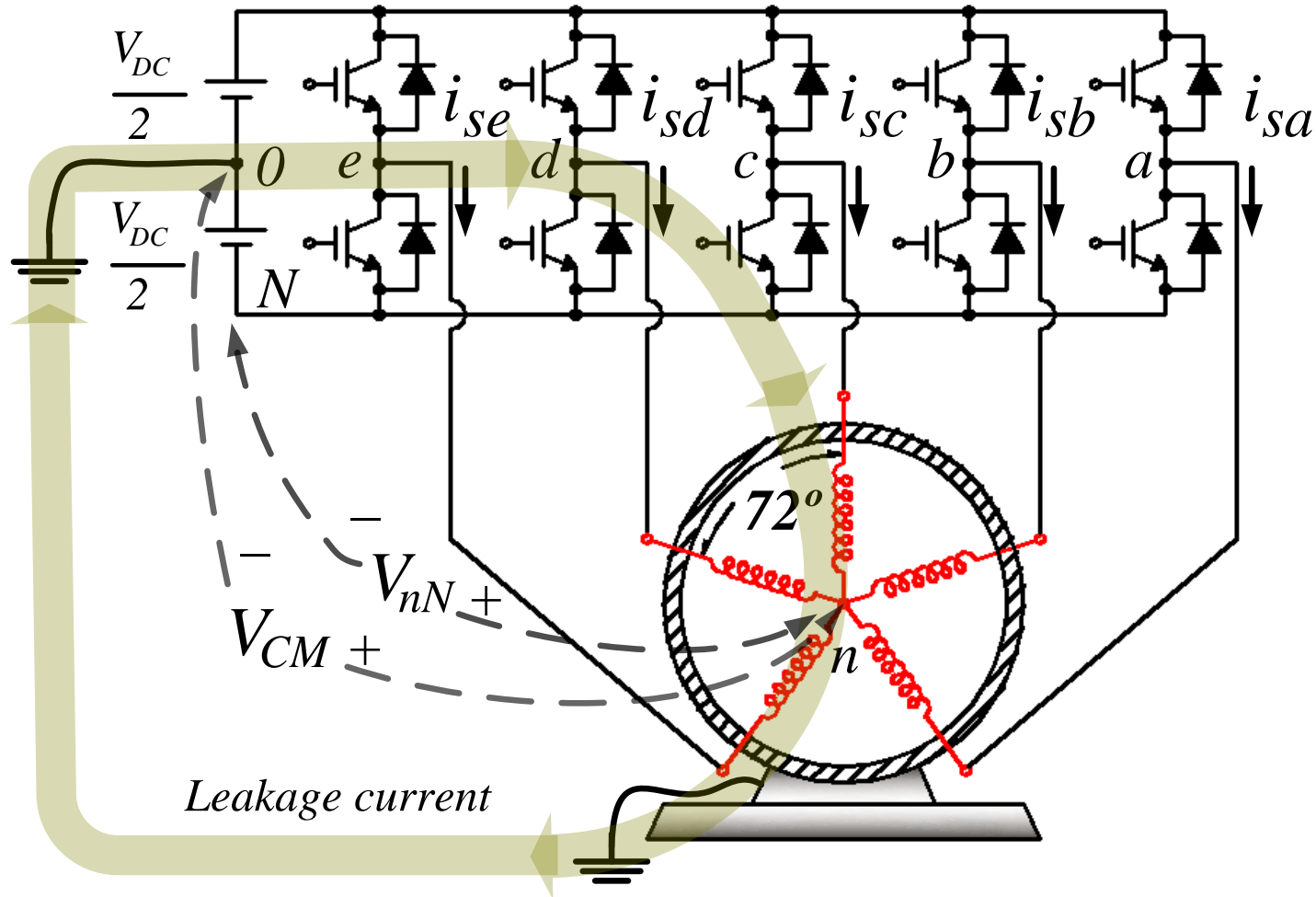
Técnicas PWM para convertidores multifasicos



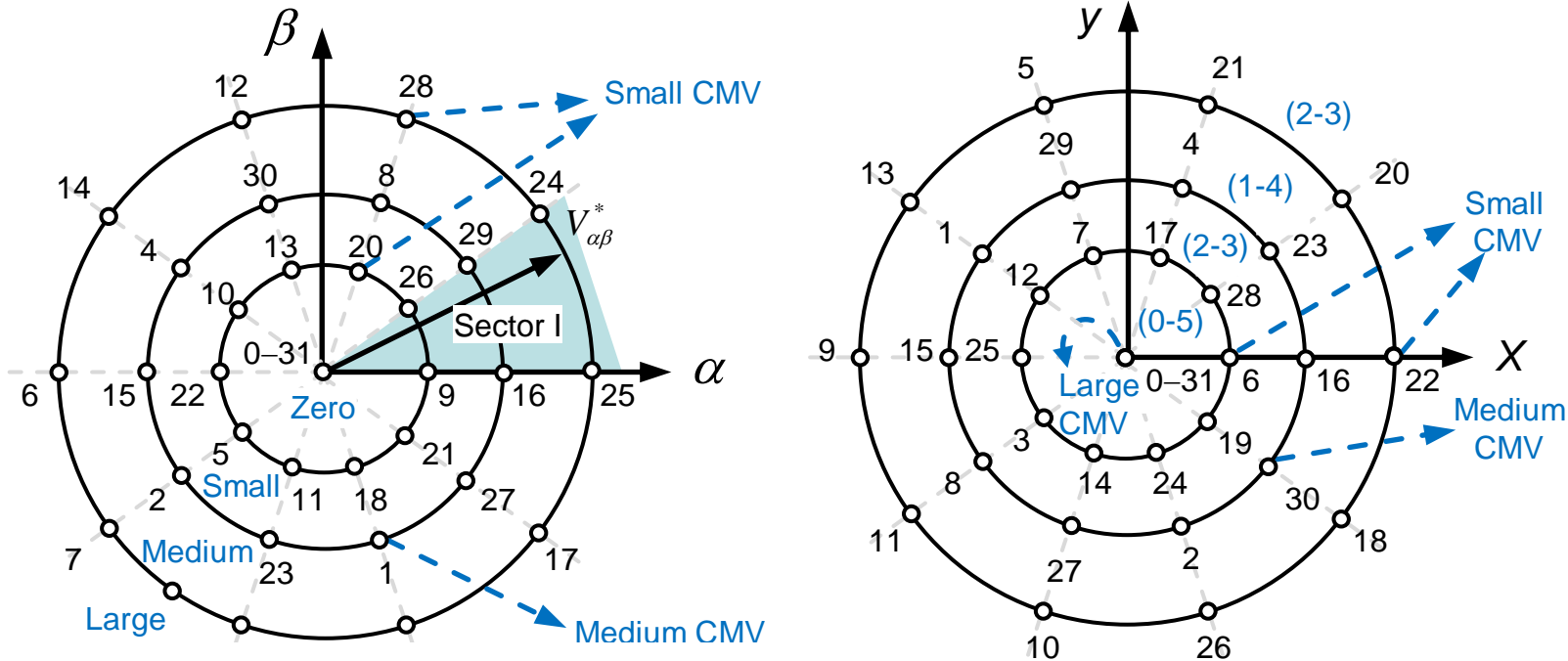
Indicadores de rendimiento



Common Mode Voltage Mitigation



Common-Mode Voltage Mitigation

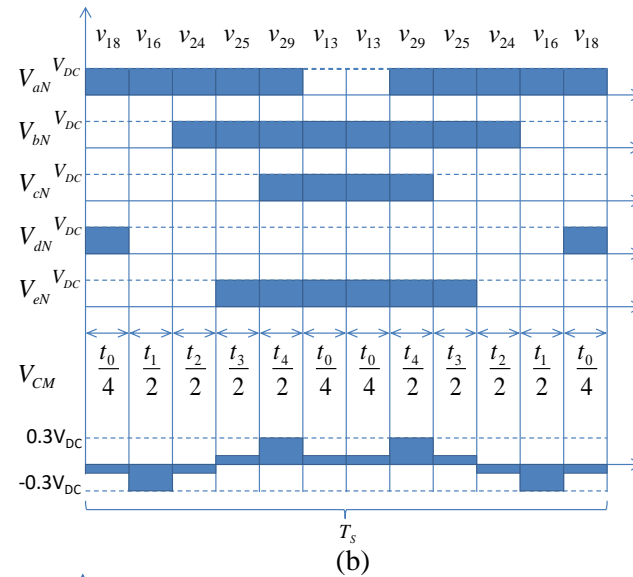
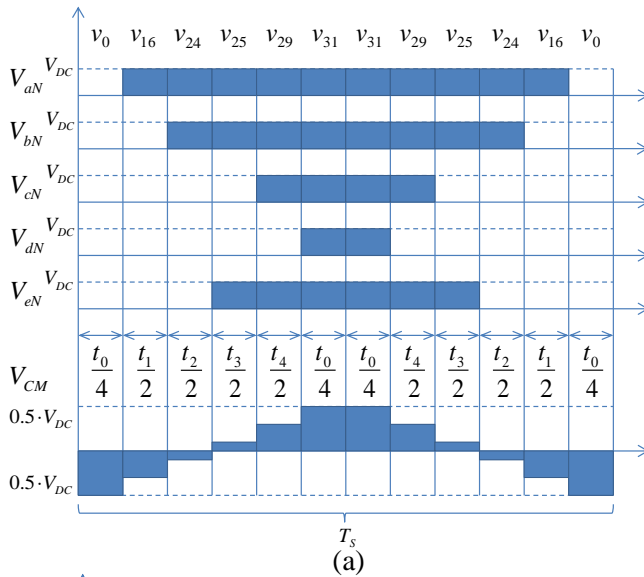


MAGNITUDE OF CMV ACCORDING TO THE SWITCHING STATES

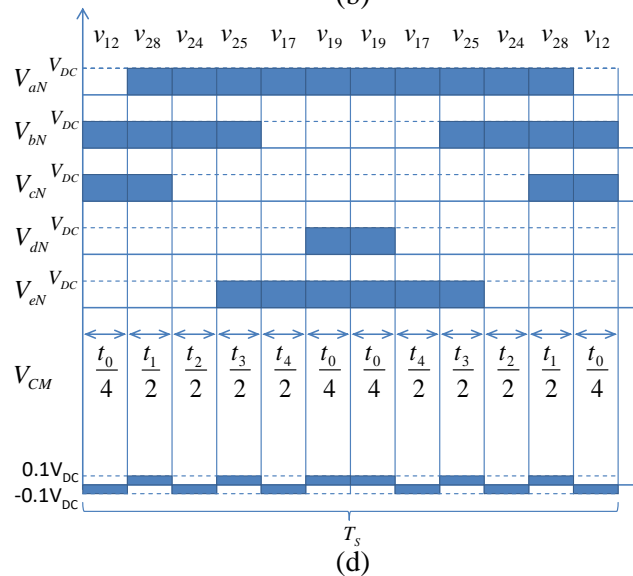
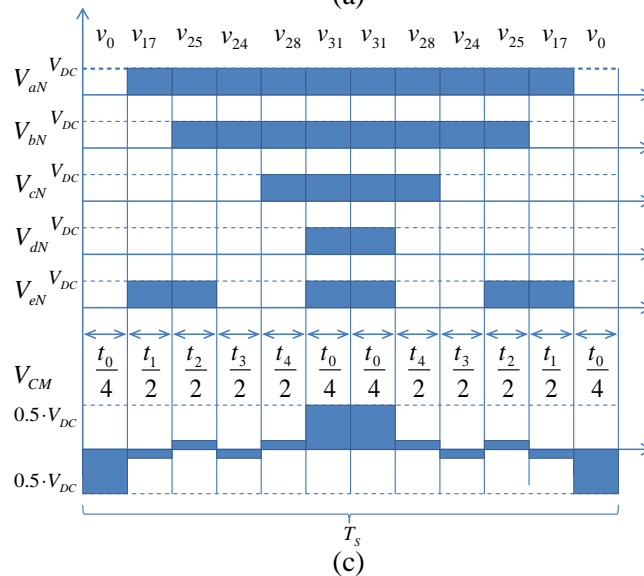
	Switching states	α - β Size	x - y Size	$ V_{CM} $
Large CMV (0-5)	{00000} {11111}	Z	Z	$0.5 \cdot V_{DC}$
Medium CMV (1-4)	{00001} {00010} {00100} {01000} {10000}	M	M	$0.3 \cdot V_{DC}$
	{11110} {11101} {11011} {10111} {01111}	M	M	
Small CMV (2-3)	{00011} {11001} {10001} {00110} {01100} {10100} {11000} {00111} {01110} {10011}	L	S	$0.1 \cdot V_{DC}$
	{00101} {11100} {11010} {10110} {10101} {01101} {01011} {01001} {01010} {10010}	S	L	

Common-Mode Voltage Mitigation

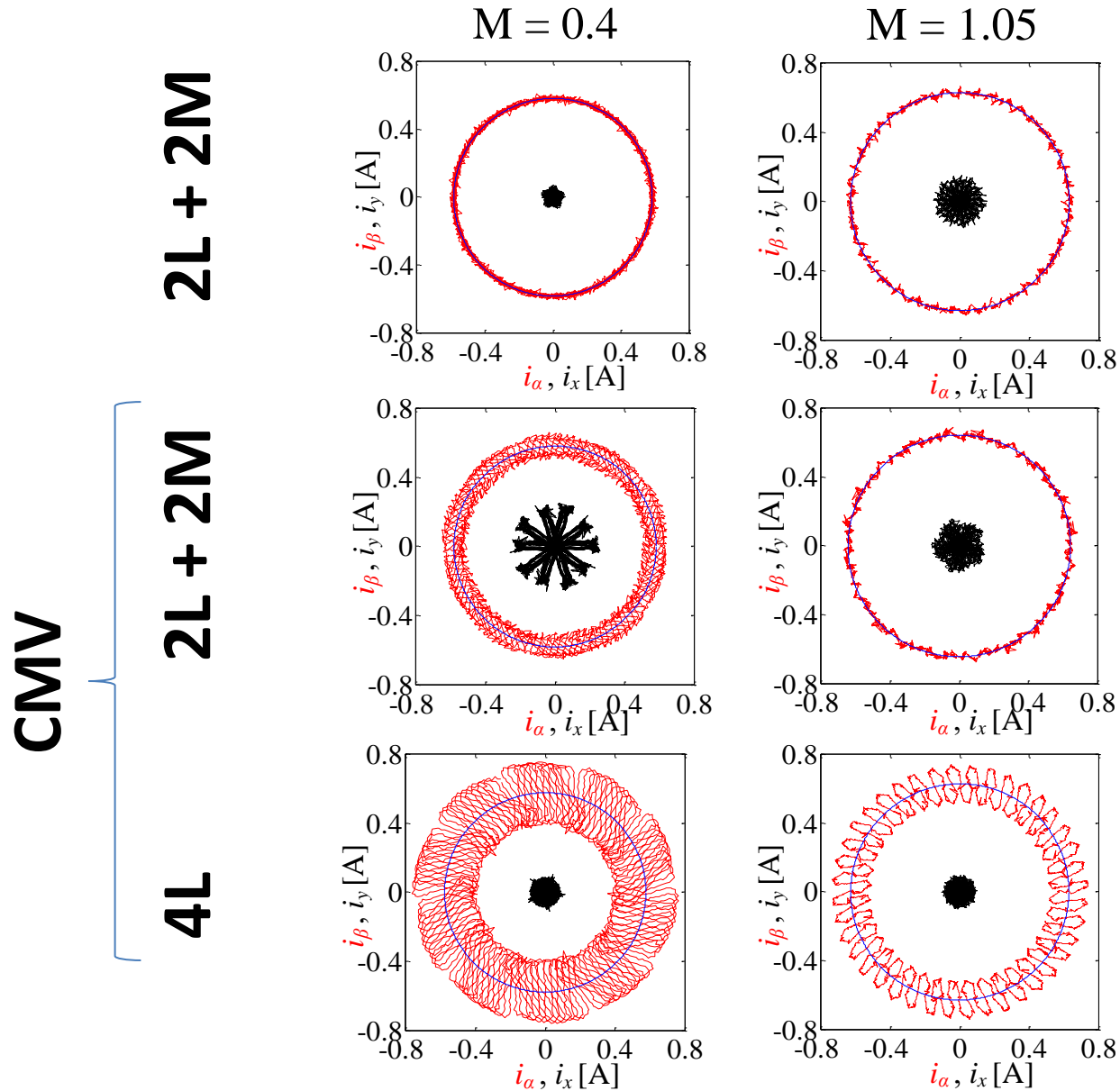
2L + 2M



4L

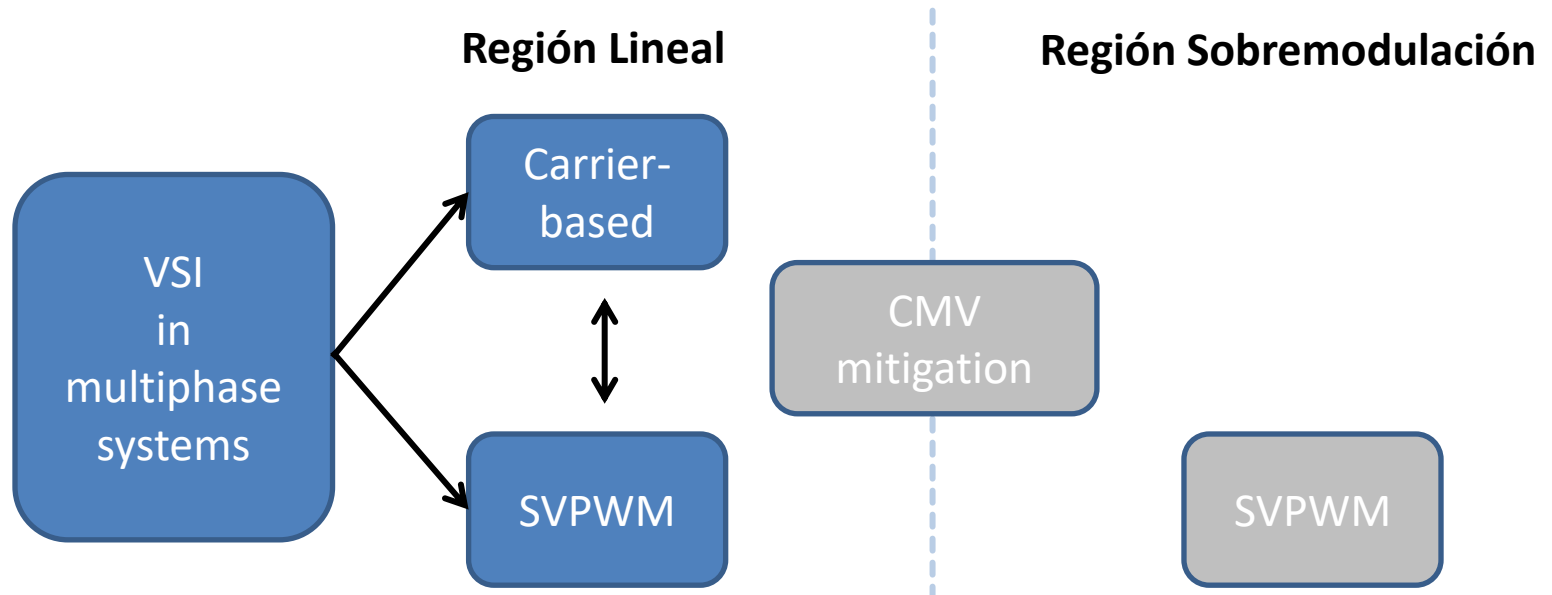


Common-Mode Voltage Mitigation

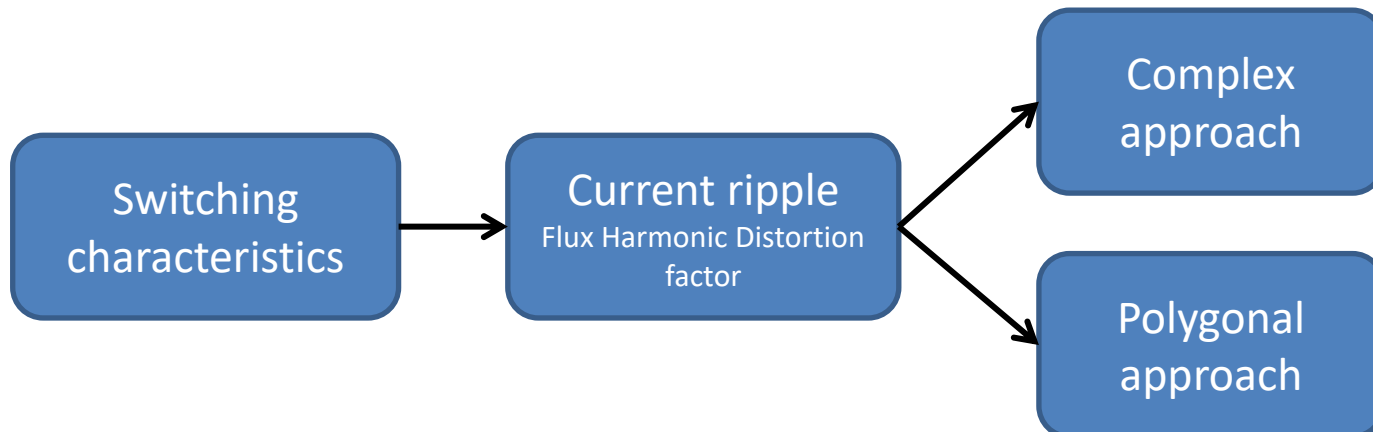


Dissertation Outline

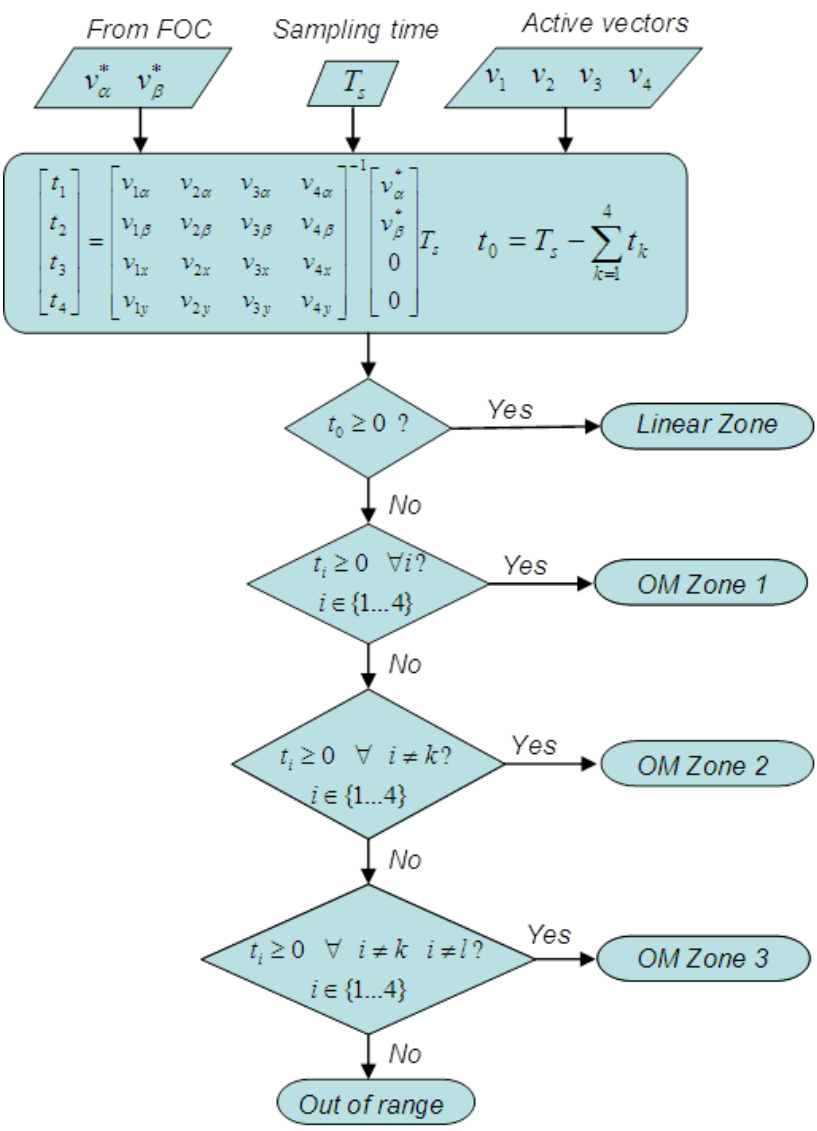
Técnicas PWM para convertidores multifasicos



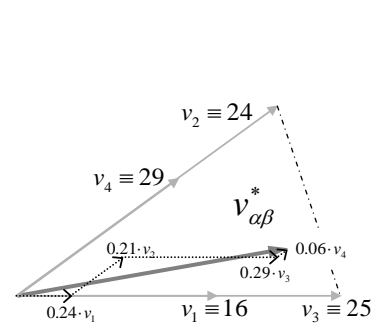
Indicadores de rendimiento



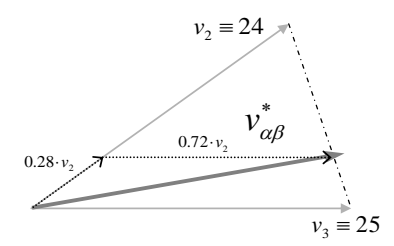
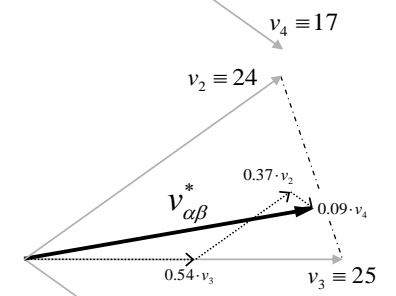
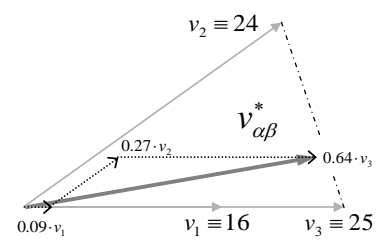
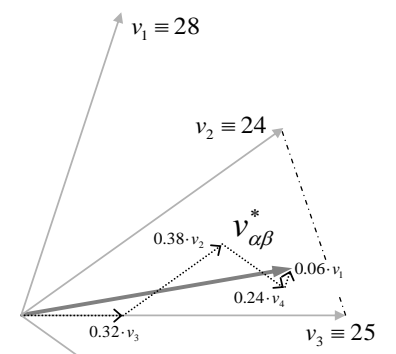
CMV in overmodulation zone



2L + 2M

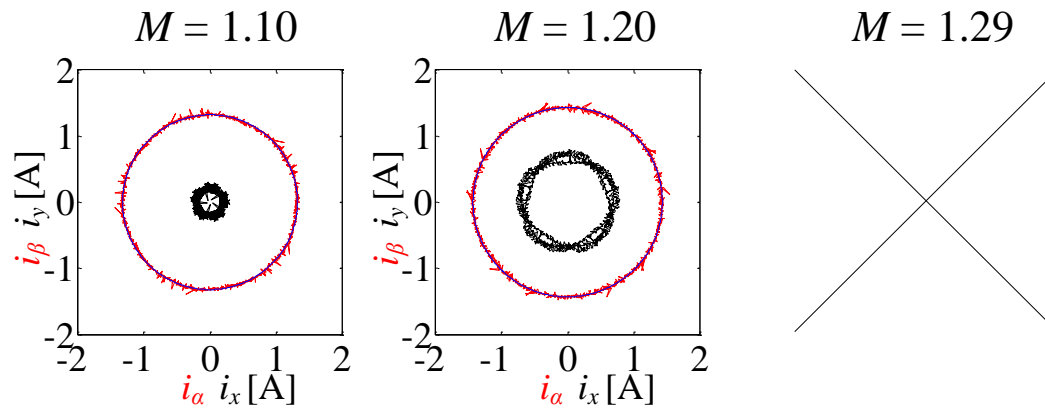


4L

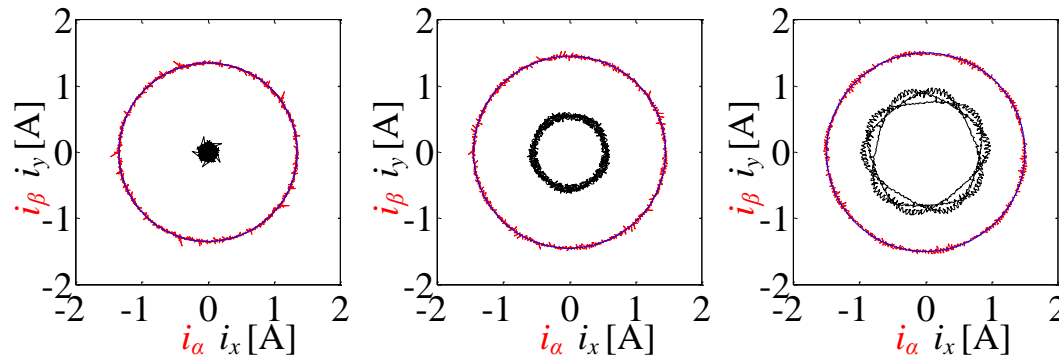


CMV in overmodulation zone

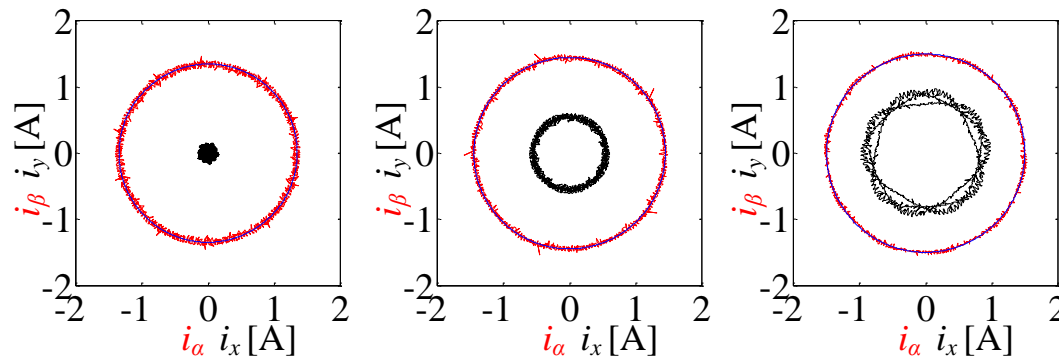
2L



2L + 2M



4L



- Introducción
- Objetivos
- Técnicas de modulación para accionamientos multifásicos
 - Continuos and Discontinuos
 - Análisis de rizado de corriente
 - Técnicas SVPWM para zona de sobremodulación
 - Mitigación de tensión de modo común
- **Conclusiones**

- Las técnicas de modulación basados en portadora y Space Vector para convertidores trifásicos fueron extendidos para su utilización en convertidores multifásicos
- Técnicas de modulación continuas y discontinuas fueron comparadas mediante indicadores de rendimiento
- Las técnicas de modulación analizadas incluyen la región de sobremodulación, además del análisis de la tensión del modo común.



PROGRAMA PARAGUAYO PARA EL DESARROLLO DE LA CIENCIA Y TECNOLOGÍA



Técnicas de modulación para accionamientos multifásicos

¿ PREGUNTAS ?
Gracias por su atención