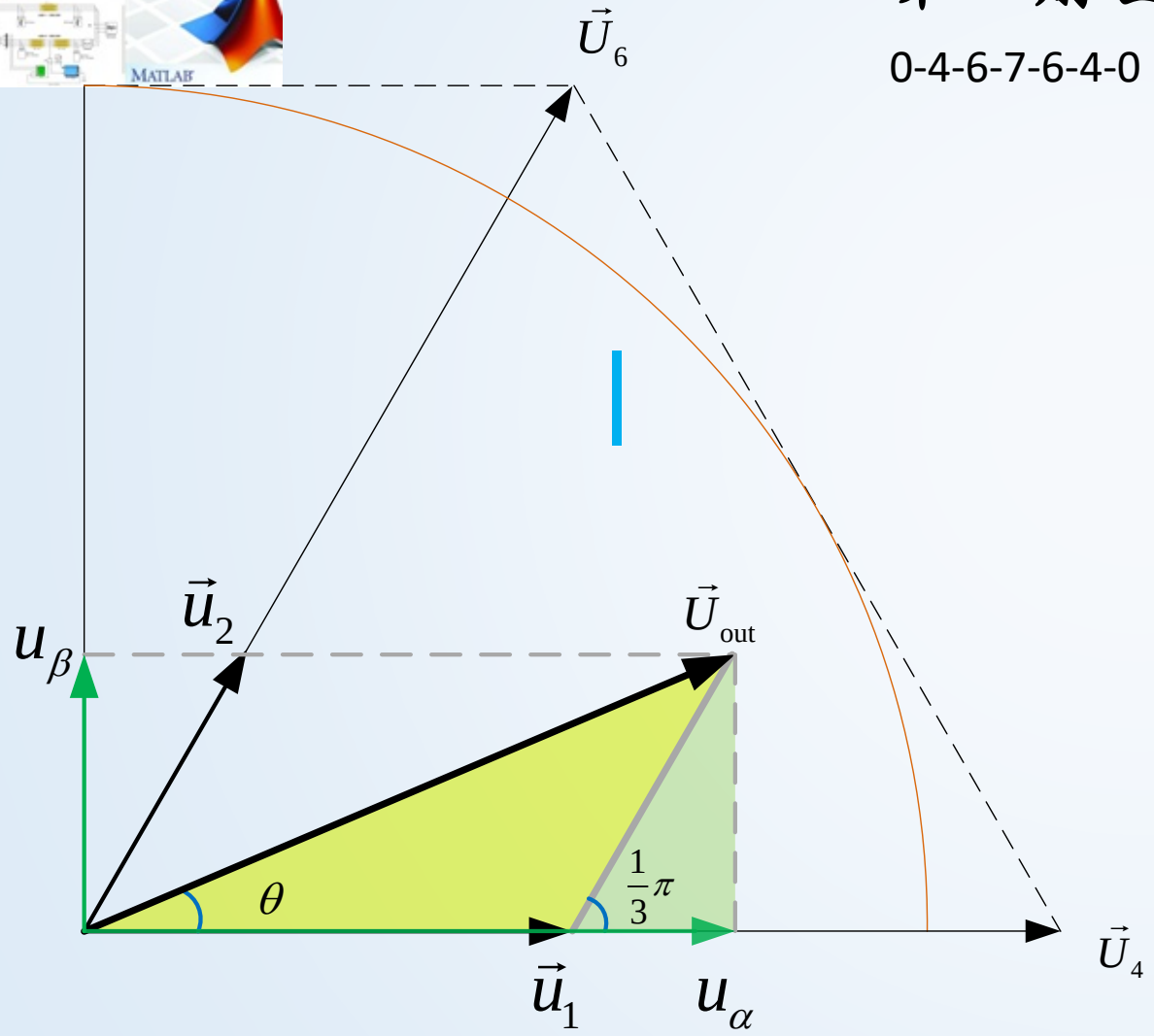
MATLAB教学——SVPWM篇（中）

第Ⅰ扇区

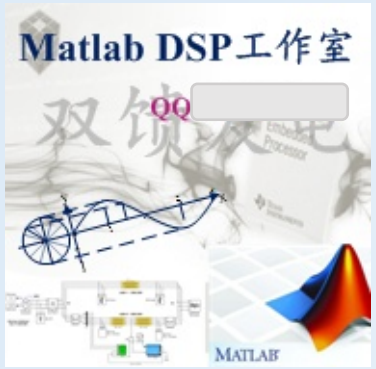
0-4-6-7-6-4-0



$$\begin{cases} u_\alpha = \dfrac{T_1}{T_{pwm}}\left|\vec{U}_4\right| + \dfrac{T_2}{T_{pwm}}\left|\vec{U}_6\right|\cos\dfrac{\pi}{3} \\ u_\beta = \dfrac{T_2}{T_{pwm}}\left|\vec{U}_6\right|\sin\dfrac{\pi}{3} \end{cases}$$

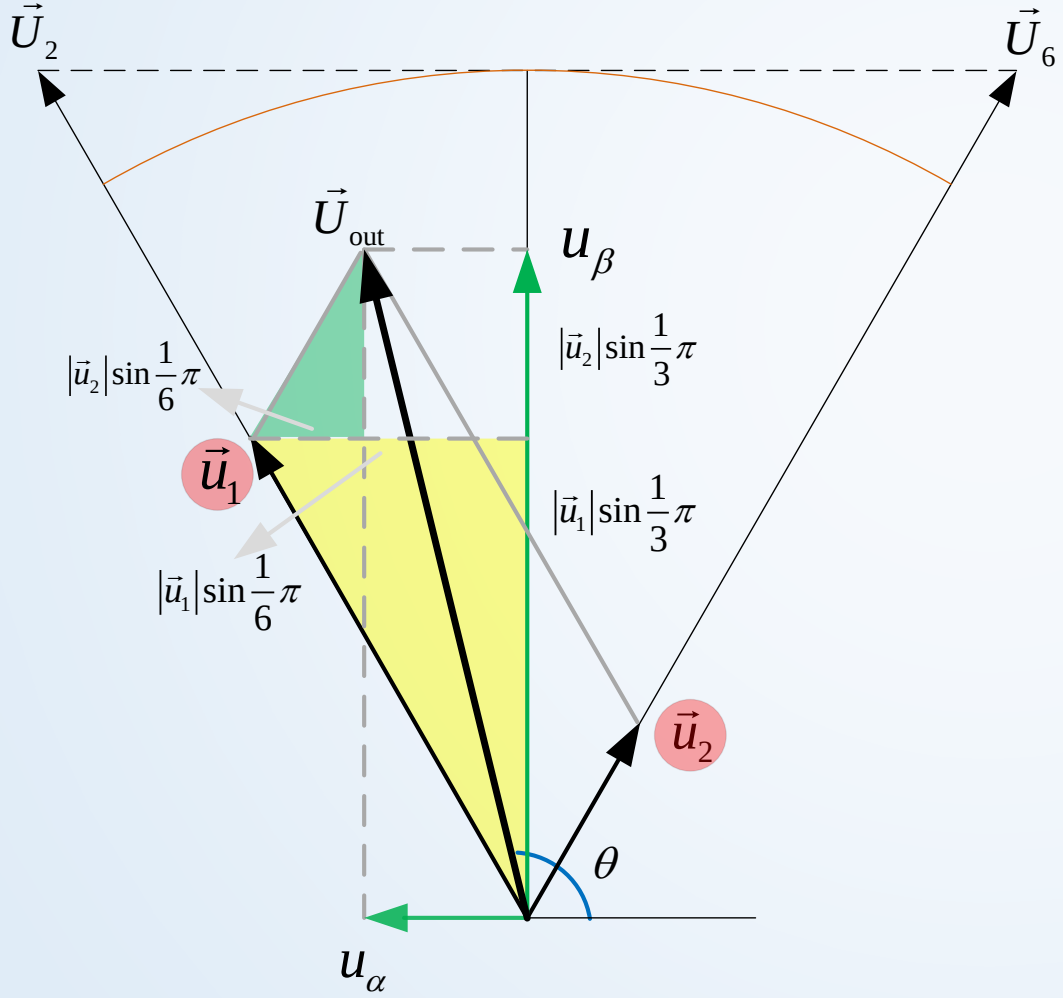
得出：

$$\begin{cases} T_1 = \dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(\sqrt{3}u_\alpha - u_\beta\right) \\ T_2 = \dfrac{\sqrt{3}T_{pwm}}{U_{dc}}u_\beta \end{cases}$$



第 II 扇区

0-2-6-7-6-2-0

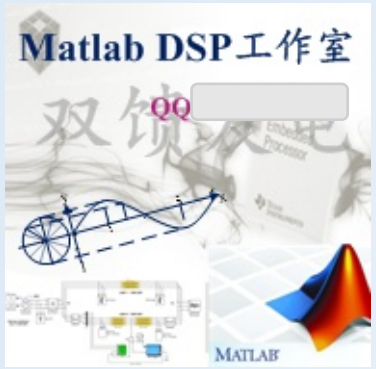


右半部分不带负号

$$\begin{cases} u_\alpha = -\left(\dfrac{T_1}{T_{pwm}}\left|\vec{U}_2\right| \cdot 0.5 - \dfrac{T_2}{T_{pwm}}\left|\vec{U}_6\right| \cdot 0.5 \right) \\ u_\beta = \dfrac{T_1}{T_{pwm}}\left|\vec{U}_2\right| \sin\dfrac{\pi}{3} + \dfrac{T_2}{T_{pwm}}\left|\vec{U}_6\right| \sin\dfrac{\pi}{3} \end{cases}$$

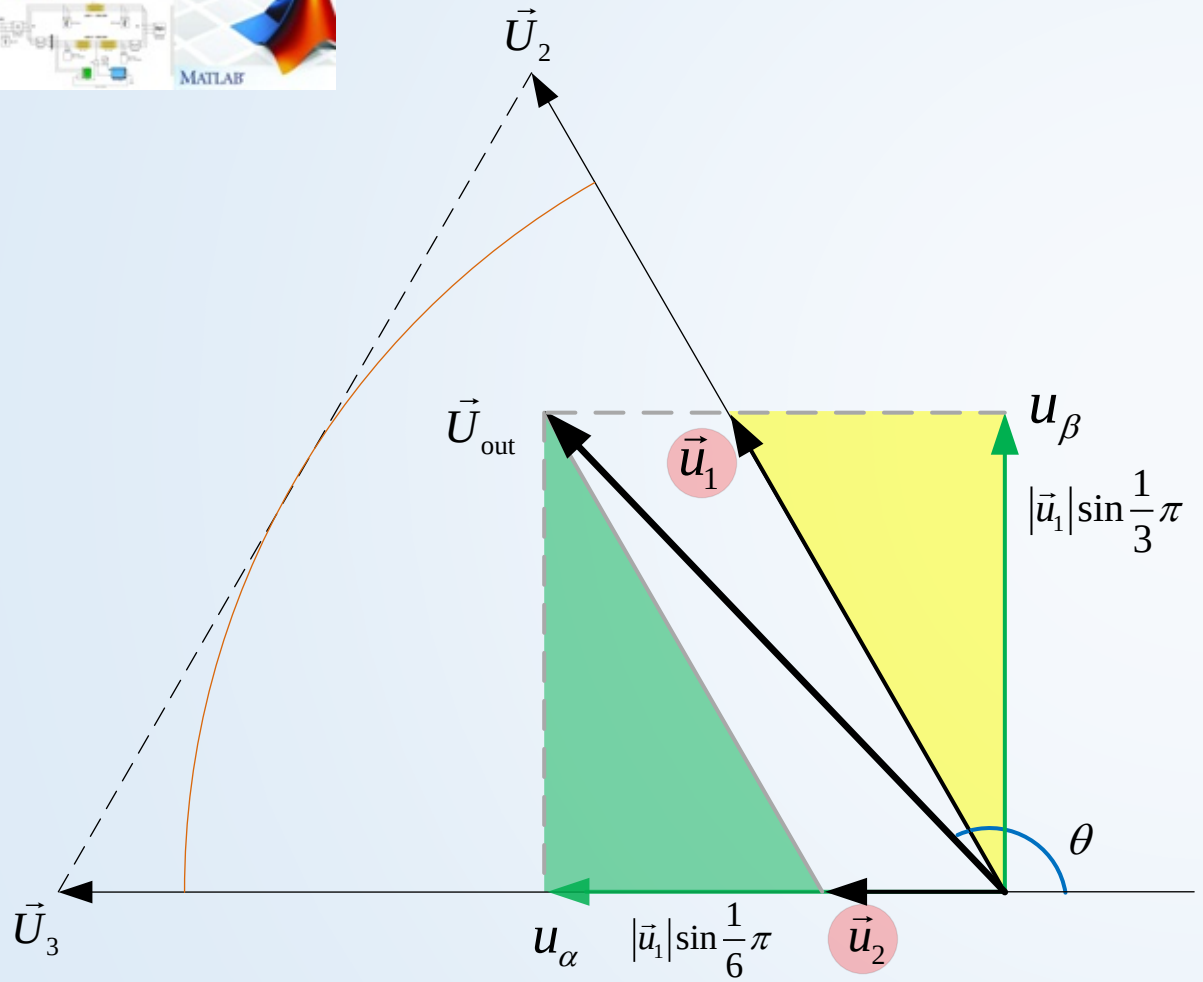
得出：

$$\begin{cases} T_1 = \dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(-\sqrt{3}u_\alpha + u_\beta\right) \\ T_2 = \dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(\sqrt{3}u_\alpha + u_\beta\right) \end{cases}$$



第 III 扇区

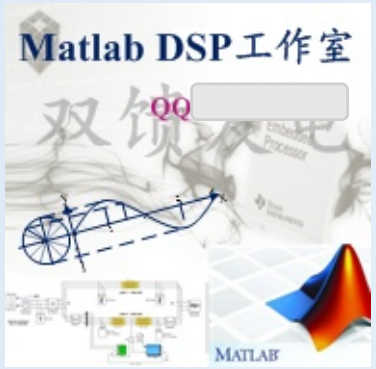
0-2-3-7-3-2-0



$$\begin{cases} u_\alpha = -\left(\dfrac{T_2}{T_{pwm}}\left|\vec{U}_3\right| + \dfrac{T_1}{T_{pwm}}\left|\vec{U}_2\right|\cos\dfrac{\pi}{3} \right) \\ u_\beta = \dfrac{T_1}{T_{pwm}}\left|\vec{U}_2\right|\sin\dfrac{\pi}{3} \end{cases}$$

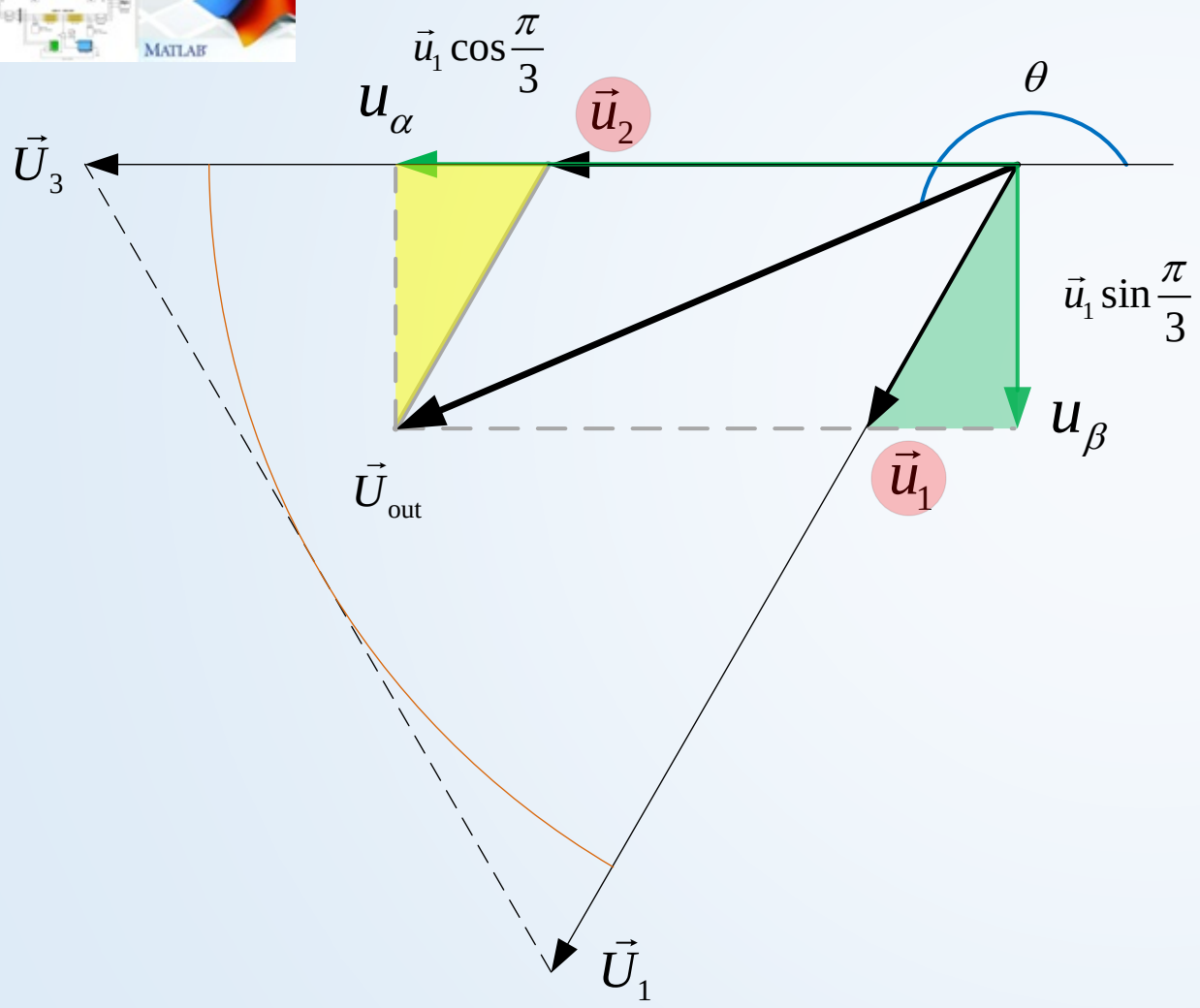
得出：

$$\begin{cases} T_1 = \dfrac{\sqrt{3}T_{pwm}}{U_{dc}}u_\beta \\ T_2 = -\dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(\sqrt{3}u_\alpha + u_\beta\right) \end{cases}$$



第Ⅳ扇区

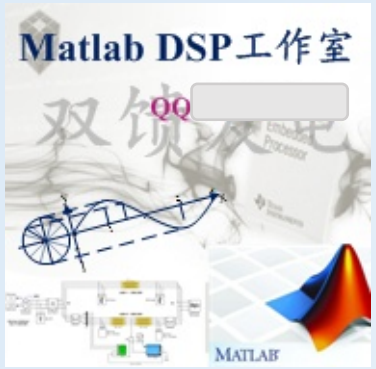
0-1-3-7-3-1-0



$$\begin{cases} u_\alpha = -\left(\dfrac{T_2}{T_{pwm}}\left|\vec{U}_3\right| + \dfrac{T_1}{T_{pwm}}\left|\vec{U}_1\right|\cos\dfrac{\pi}{3} \right) \\ u_\beta = -\dfrac{T_1}{T_{pwm}}\left|\vec{U}_1\right|\sin\dfrac{\pi}{3} \end{cases}$$

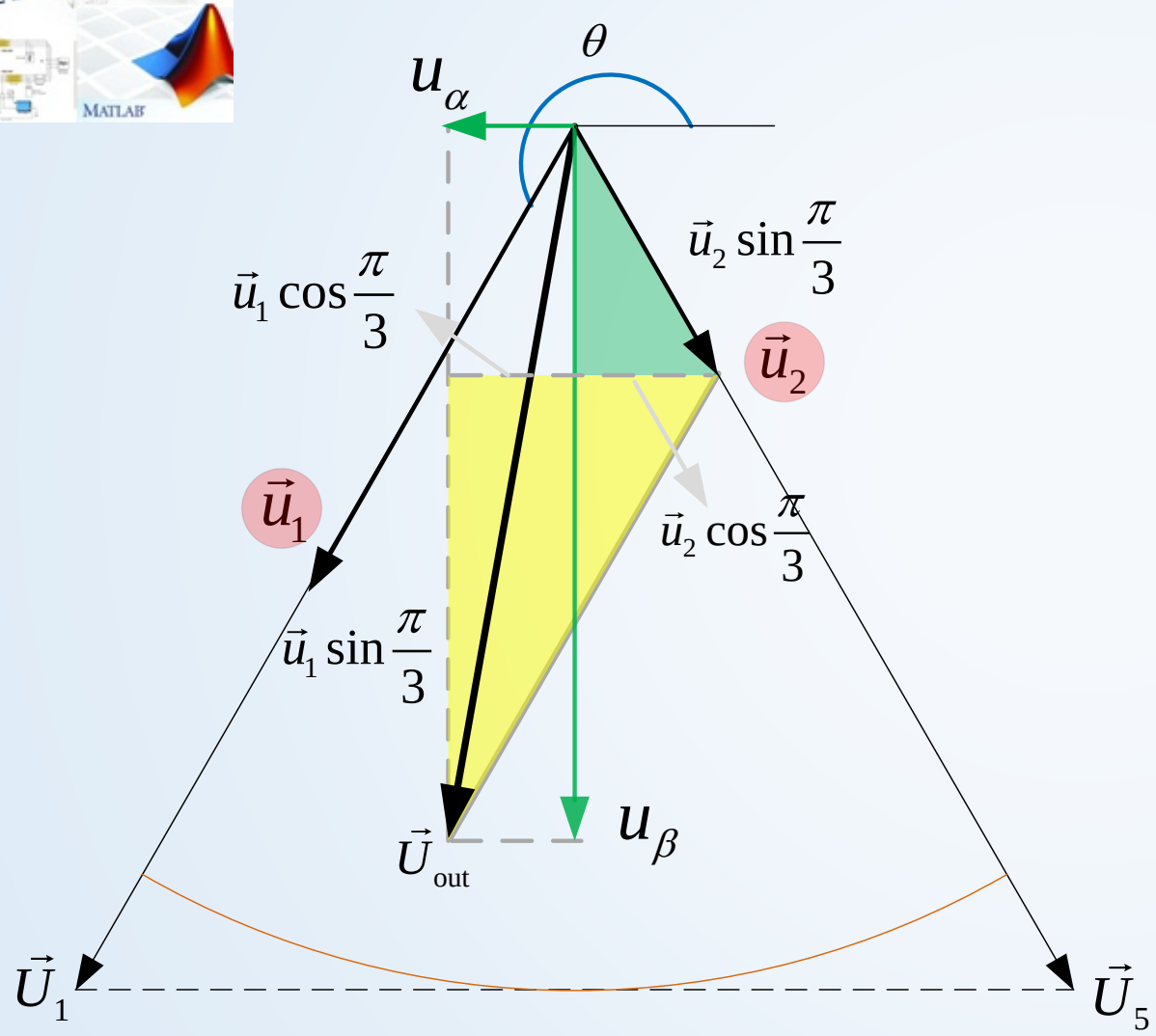
得出：

$$\begin{cases} T_1 = -\dfrac{\sqrt{3}T_{pwm}}{U_{dc}}u_\beta \\ T_2 = \dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(-\sqrt{3}u_\alpha + u_\beta\right) \end{cases}$$



第Ⅴ扇区

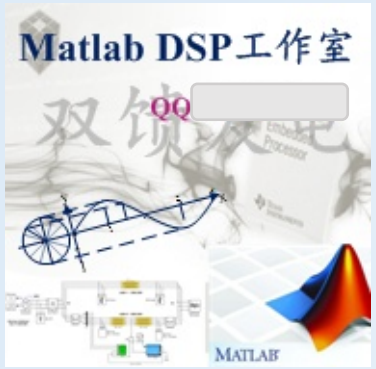
0-1-5-7-5-1-0



$$\begin{cases} u_\alpha = -\left(\dfrac{T_1}{T_{pwm}} \left|\vec{U}_1\right| \cos\dfrac{\pi}{3} - \dfrac{T_2}{T_{pwm}} \left|\vec{U}_5\right| \cos\dfrac{\pi}{3} \right) \\ u_\beta = -\left(\dfrac{T_1}{T_{pwm}} \left|\vec{U}_1\right| \sin\dfrac{\pi}{3} + \dfrac{T_2}{T_{pwm}} \left|\vec{U}_5\right| \sin\dfrac{\pi}{3} \right) \end{cases}$$

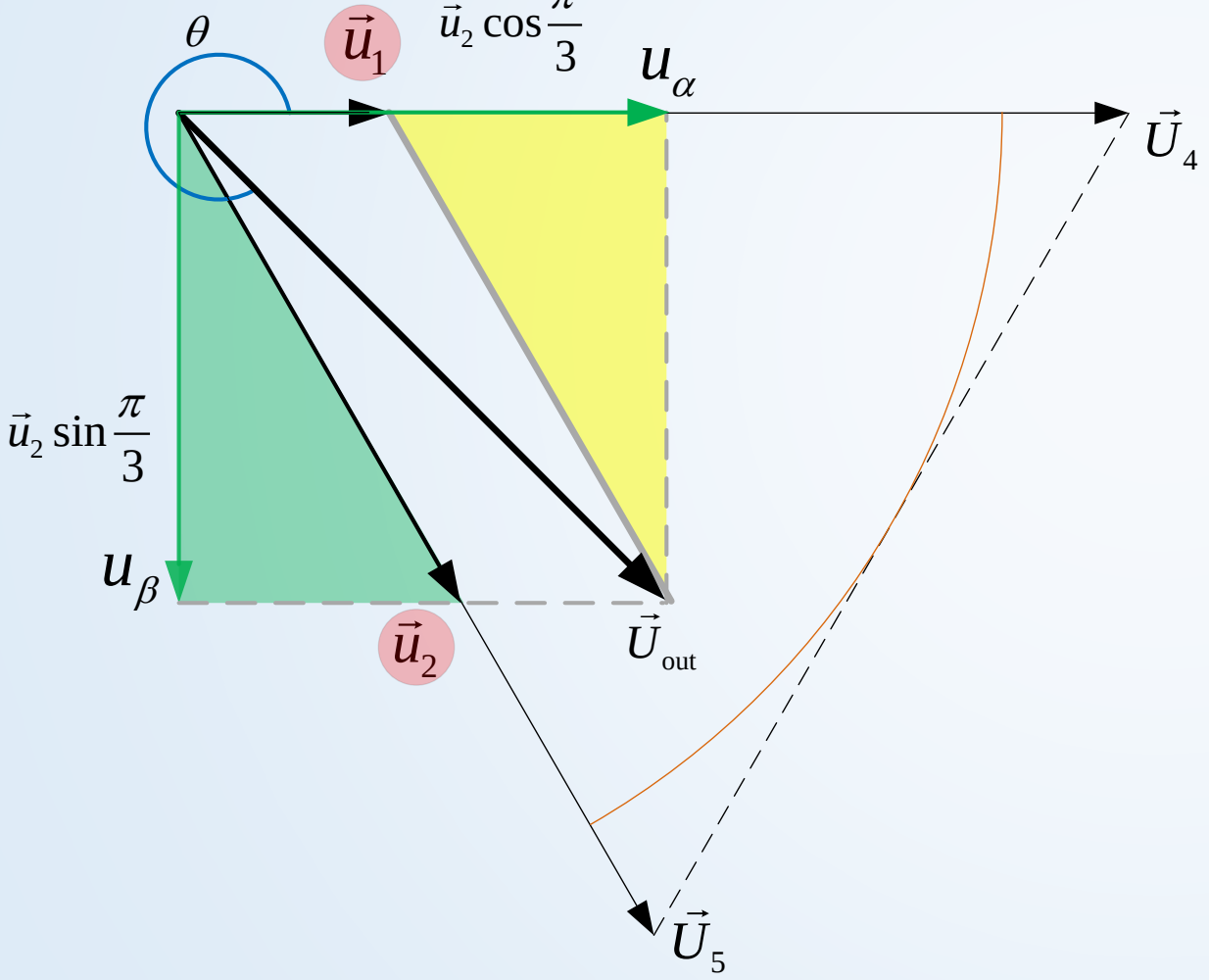
得出：

$$\begin{cases} T_1 = -\dfrac{\sqrt{3}T_{pwm}}{2U_{dc}} \left(\sqrt{3}u_\alpha + u_\beta \right) \\ T_2 = -\dfrac{\sqrt{3}T_{pwm}}{2U_{dc}} \left(-\sqrt{3}u_\alpha + u_\beta \right) \end{cases}$$



第 VI 扇区

0-4-5-7-5-4-0



$$\begin{cases} u_\alpha = \dfrac{T_1}{T_{pwm}}\left|\vec{U}_4\right| + \dfrac{T_2}{T_{pwm}}\left|\vec{U}_5\right|\cos\dfrac{\pi}{3} \\ u_\beta = -\left(\dfrac{T_2}{T_{pwm}}\left|\vec{U}_5\right|\sin\dfrac{\pi}{3}\right) \end{cases}$$

得出：

$$\begin{cases} T_1 = \dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(\sqrt{3}u_\alpha + u_\beta\right) \\ T_2 = -\dfrac{\sqrt{3}T_{pwm}}{U_{dc}}u_\beta \end{cases}$$

第Ⅰ扇区

$$\begin{cases} T_1 = \dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(\sqrt{3}u_\alpha - u_\beta\right) \\ T_2 = \dfrac{\sqrt{3}T_{pwm}}{U_{dc}}u_\beta \end{cases}$$

X

第Ⅱ扇区

Z

$$\begin{cases} T_1 = \dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(-\sqrt{3}u_\alpha + u_\beta\right) \\ T_2 = \dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(\sqrt{3}u_\alpha + u_\beta\right) \end{cases}$$

Y

第Ⅲ扇区

$$\begin{cases} T_1 = \dfrac{\sqrt{3}T_{pwm}}{U_{dc}}u_\beta \\ T_2 = -\dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(\sqrt{3}u_\alpha + u_\beta\right) \end{cases}$$

第Ⅳ扇区

$$\begin{cases} T_1 = -\dfrac{\sqrt{3}T_{pwm}}{U_{dc}}u_\beta \\ T_2 = \dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(-\sqrt{3}u_\alpha + u_\beta\right) \end{cases}$$

第Ⅴ扇区

$$\begin{cases} T_1 = -\dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(\sqrt{3}u_\alpha + u_\beta\right) \\ T_2 = -\dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(-\sqrt{3}u_\alpha + u_\beta\right) \end{cases}$$

第Ⅵ扇区

$$\begin{cases} T_1 = \dfrac{\sqrt{3}T_{pwm}}{2U_{dc}}\left(\sqrt{3}u_\alpha + u_\beta\right) \\ T_2 = -\dfrac{\sqrt{3}T_{pwm}}{U_{dc}}u_\beta \end{cases}$$

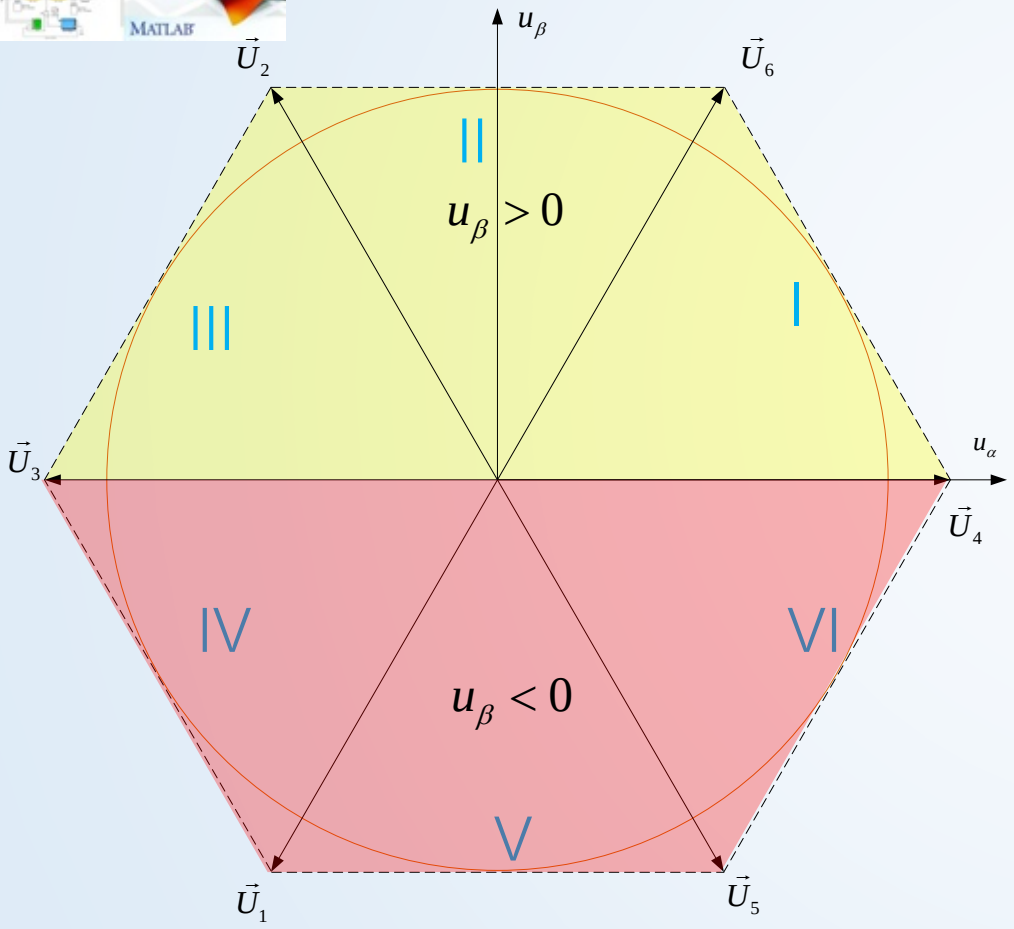
扇区	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ
N	3	1	5	4	6	2
T_1	-Z	Z	X	-X	-Y	Y
T_2	X	Y	-Y	Z	-Z	-X

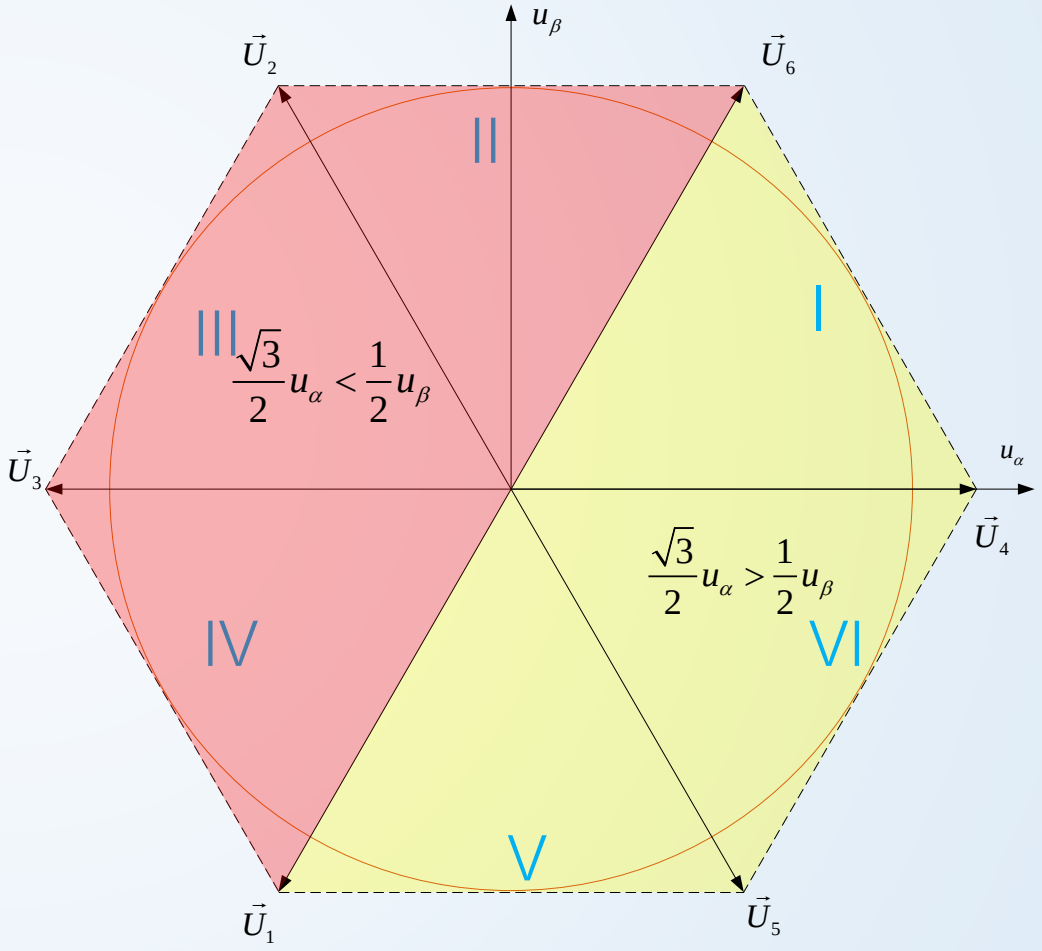
过调制处理

当 $T_1+T_2>T_{pwm}$ ，需要进行如下的过调制处理

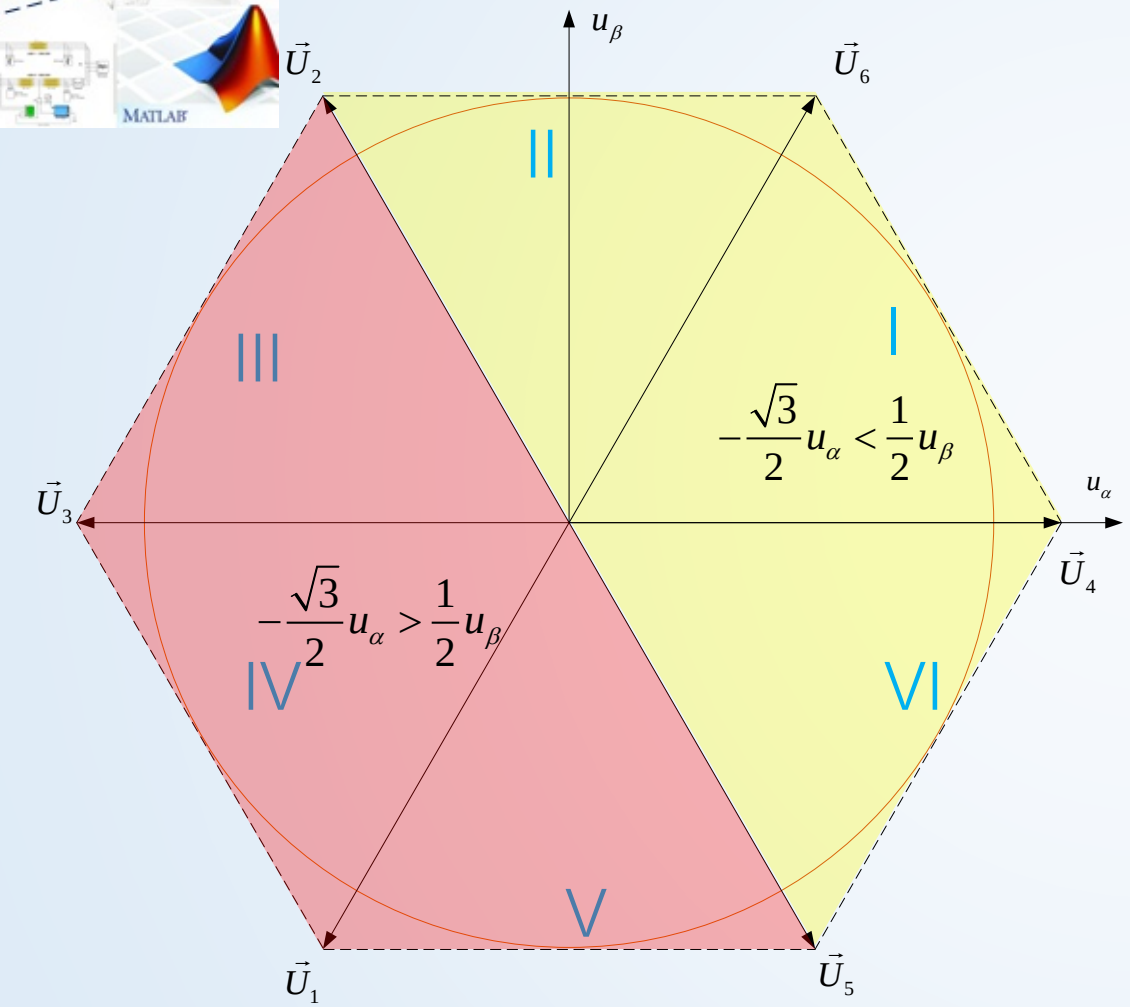
$$\begin{cases} T_1=\dfrac{T_1}{T_1+T_2}T_{pwm} \\ T_2=\dfrac{T_2}{T_1+T_2}T_{pwm} \end{cases}$$

扇区判断





扇区判断



当 $u_\beta > 0$，令A=1，否则A=0；

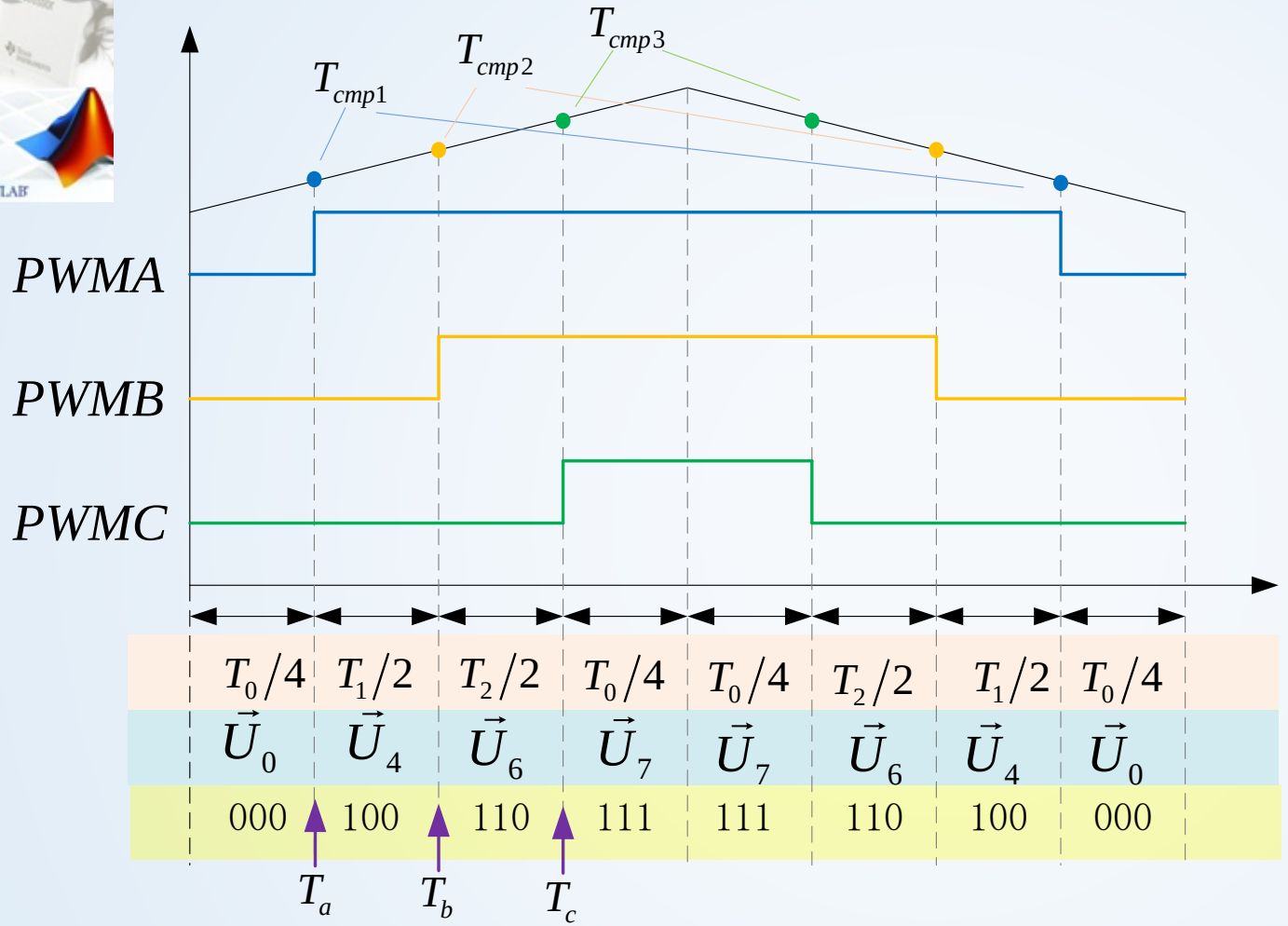
当 $\frac{\sqrt{3}}{2}u_\alpha - \frac{1}{2}u_\beta > 0$，令B=1，否则B=0；

当 $-\frac{\sqrt{3}}{2}u_\alpha - \frac{1}{2}u_\beta > 0$，令C=1，否则C=0；

$$N = 4C + 2B + A$$

I	A=1	B=1	C=0	N=3
II	A=1	B=0	C=0	N=1
III	A=1	B=0	C=1	N=5
IV	A=0	B=0	C=1	N=4
V	A=0	B=1	C=1	N=6
VI	A=0	B=1	C=0	N=2

切换点的时间计算



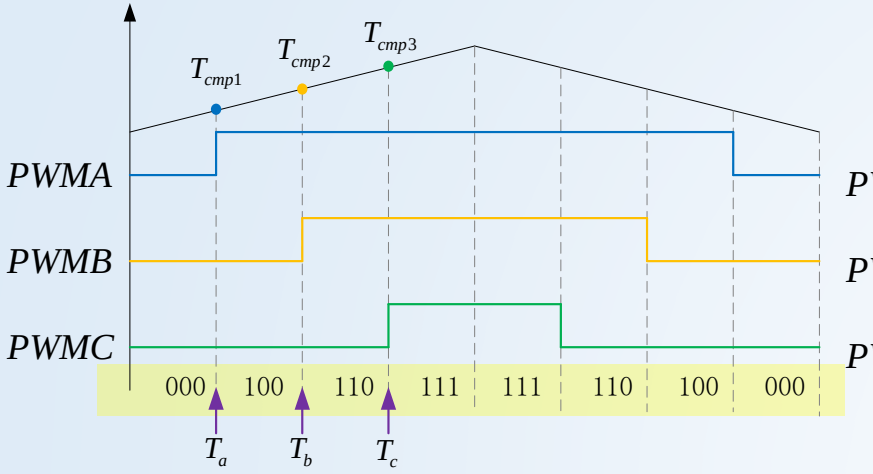
$$\begin{cases} T_a = \left(T_{pwm} - T_1 - T_2\right)/4 \\ T_b = T_a + T_1/2 \\ T_c = T_b + T_2/2 \end{cases}$$

第Ⅰ扇区

0-4-6-7-6-4-0

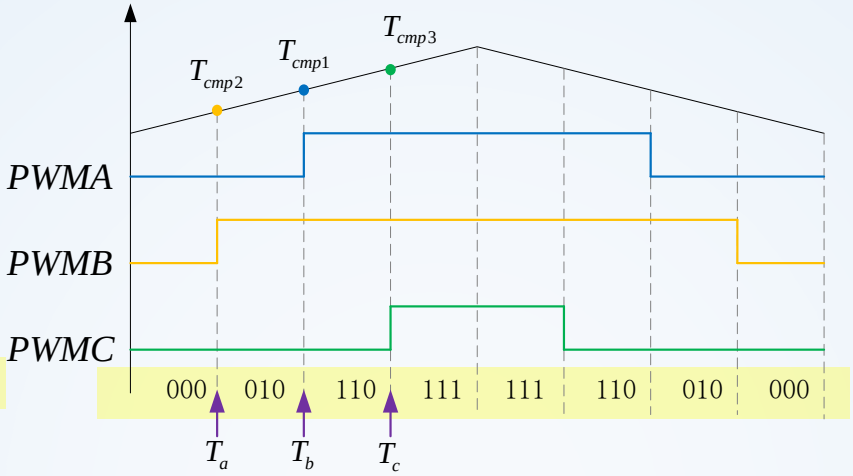
第Ⅰ扇区

0-4-6-7-6-4-0



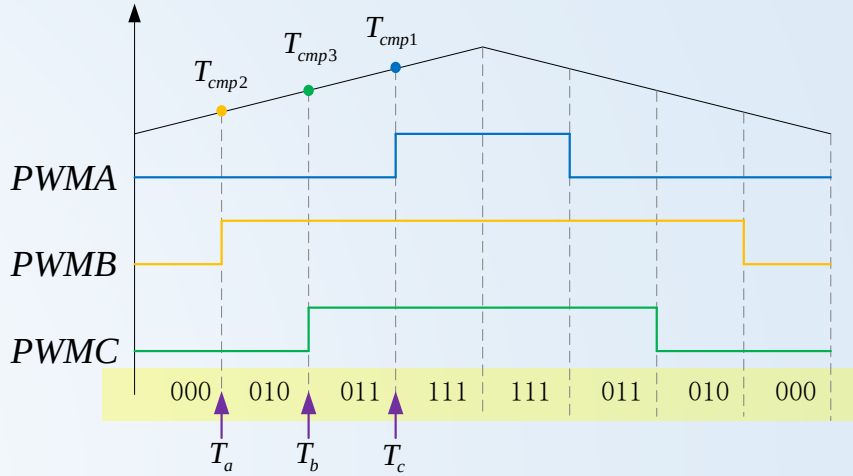
第Ⅱ扇区

0-2-6-7-6-2-0



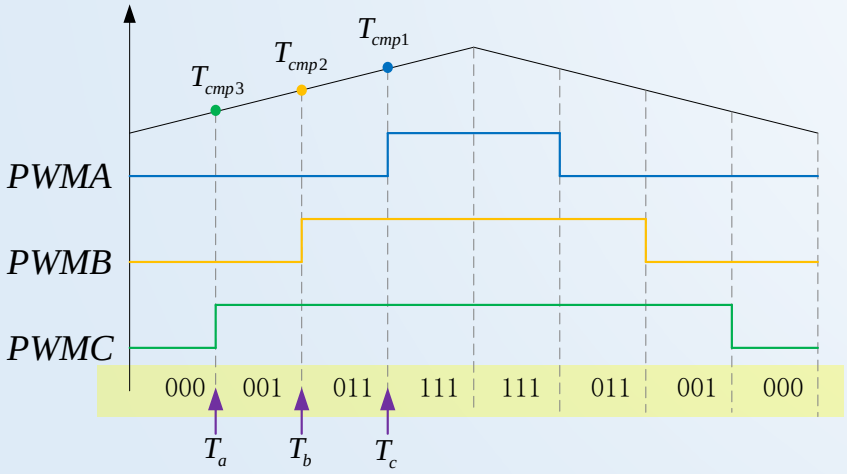
第Ⅲ扇区

0-2-3-7-3-2-0



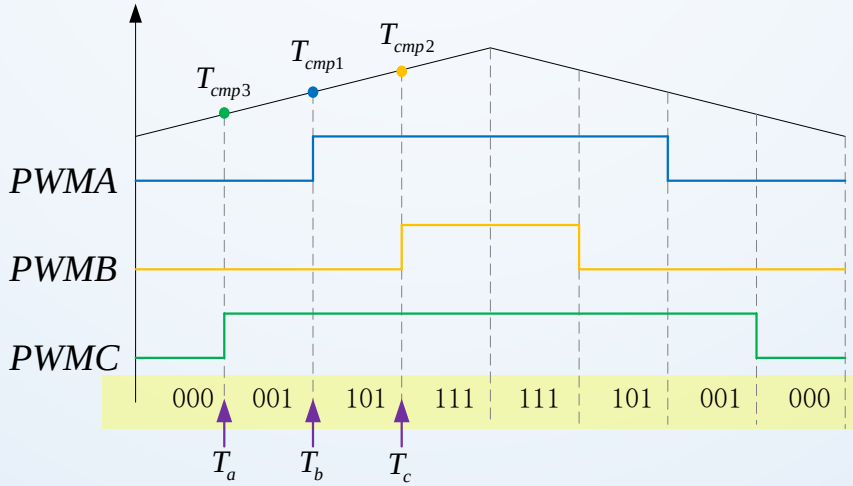
第Ⅳ扇区

0-1-3-7-3-1-0



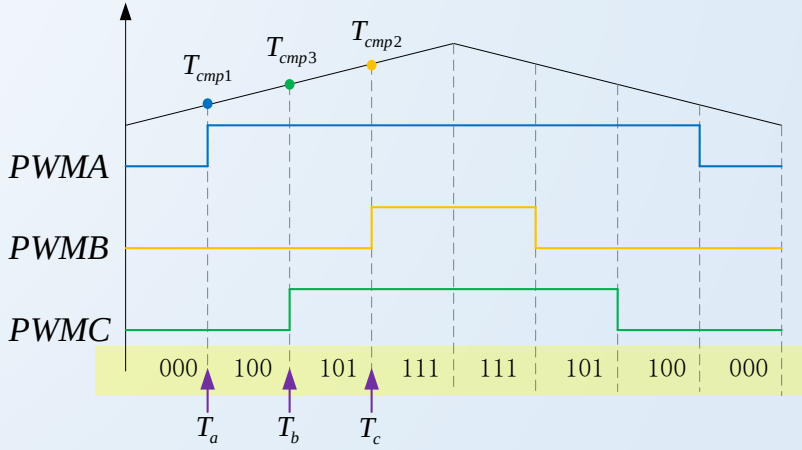
第Ⅴ扇区

0-1-5-7-5-1-0



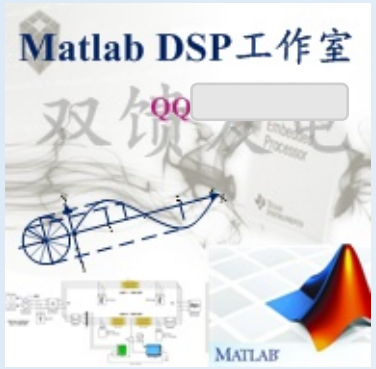
第Ⅵ扇区

0-4-5-7-5-4-0



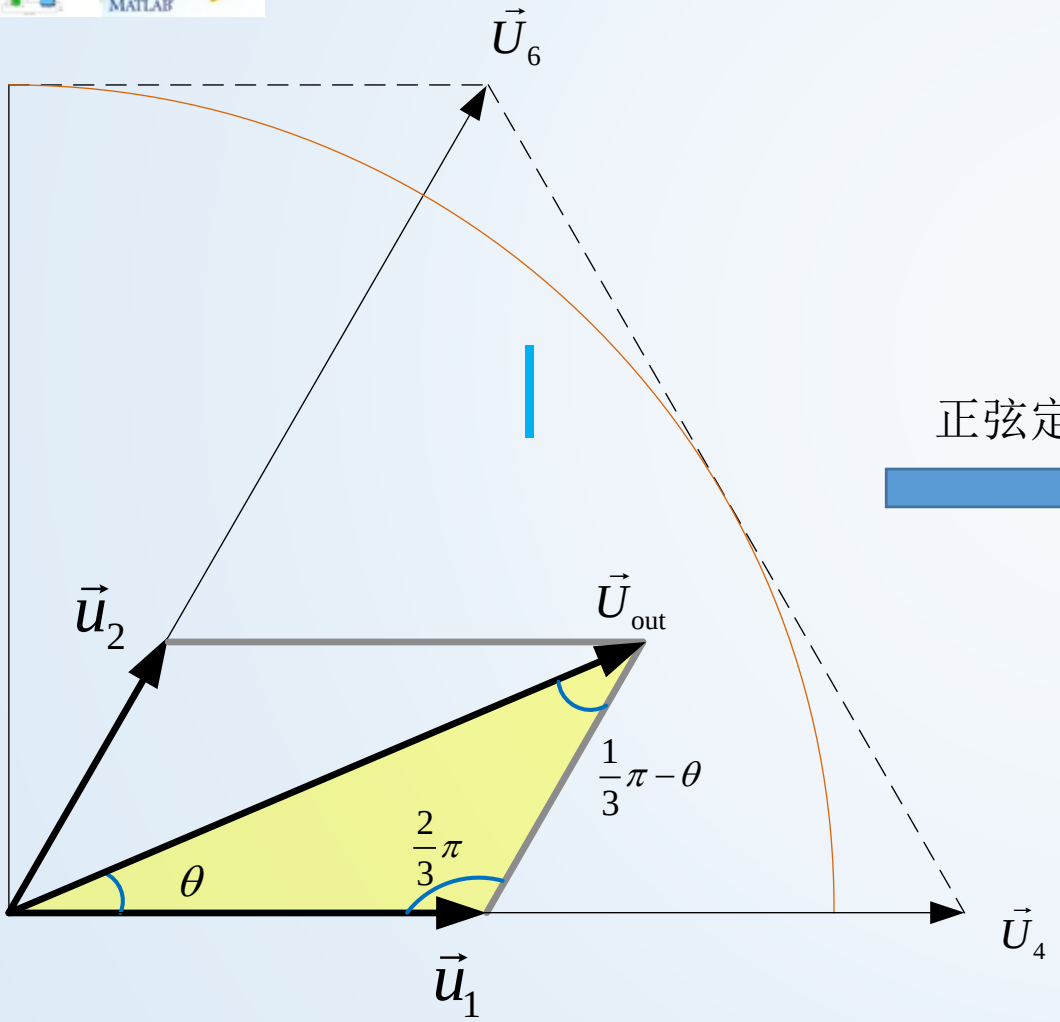
各个扇区的切换点

扇区	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ
N	3	1	5	4	6	2
T_{cmp1}	**Ta**	**Tb**	**Tc**	**Tc**	**Tb**	**Ta**
T_{cmp2}	**Tb**	**Ta**	**Ta**	**Tb**	**Tc**	**Tc**
T_{cmp3}	**Tc**	**Tc**	**Tb**	**Ta**	**Ta**	**Tb**



MATLAB教学——SVPWM篇（下）

基本原理、U_{dc}与$\frac{2}{3}U_{dc}$问题、调制度、七段式与五段式



正弦定理

$$\begin{cases}\vec{u}_1=\dfrac{T_1}{T_{PWM}}\vec{U}_4\\ \vec{u}_2=\dfrac{T_2}{T_{PWM}}\vec{U}_6\end{cases}$$

代入

$$\frac{\vec{U}_{out}}{\sin\pi/3}=\frac{\vec{u}_1}{\sin(\pi/3-\theta)}=\frac{\vec{u}_2}{\sin\theta}$$

$$\begin{cases}T_1=\sqrt{3}\dfrac{U_m}{U_{dc}}T_{pwm}\sin\left(\dfrac{\pi}{3}-\theta\right)\\ T_2=\sqrt{3}\dfrac{U_m}{U_{dc}}T_{pwm}\sin(\theta)\\ T_0=T_{pwm}-T_1-T_2\end{cases}$$