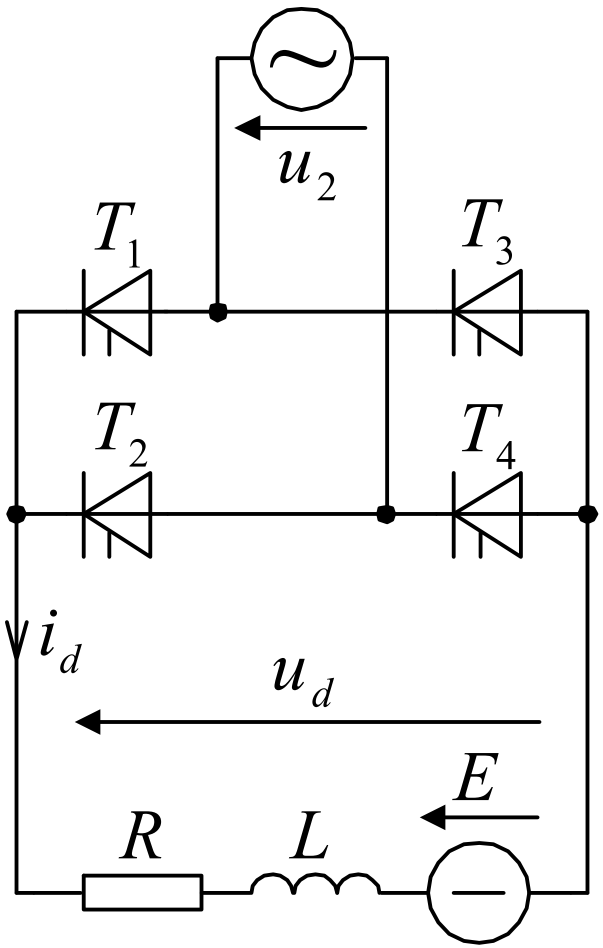
WYKŁAD 5

UKŁADY DWUKIERUNKOWE

Główna cecha charakterystyczna:

Dwukierunkowy (bez składowej stałej) przepływ prądu przez fazę źródła zasilania (lub fazę strony wtórnej transformatora)

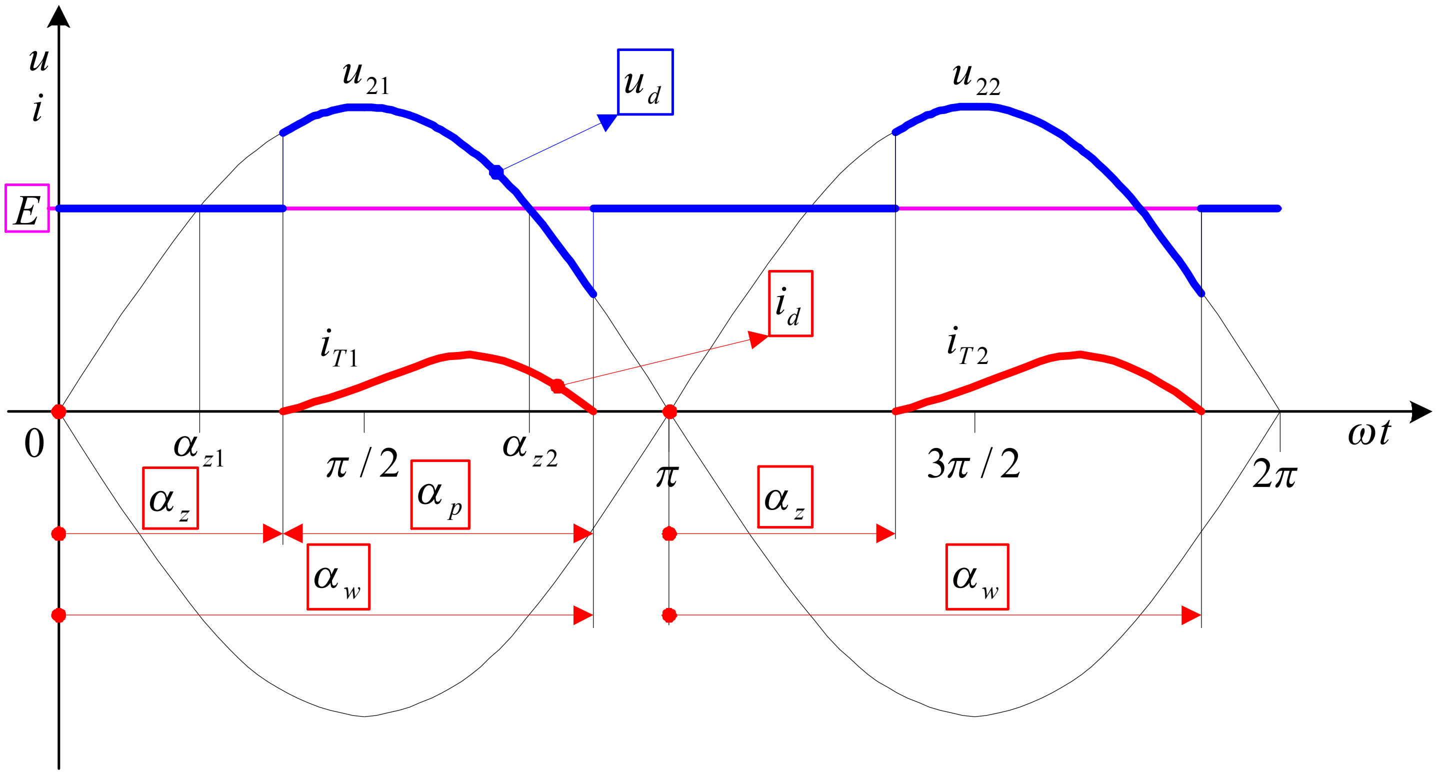
Układ dwukierunkowy dwupulsowy



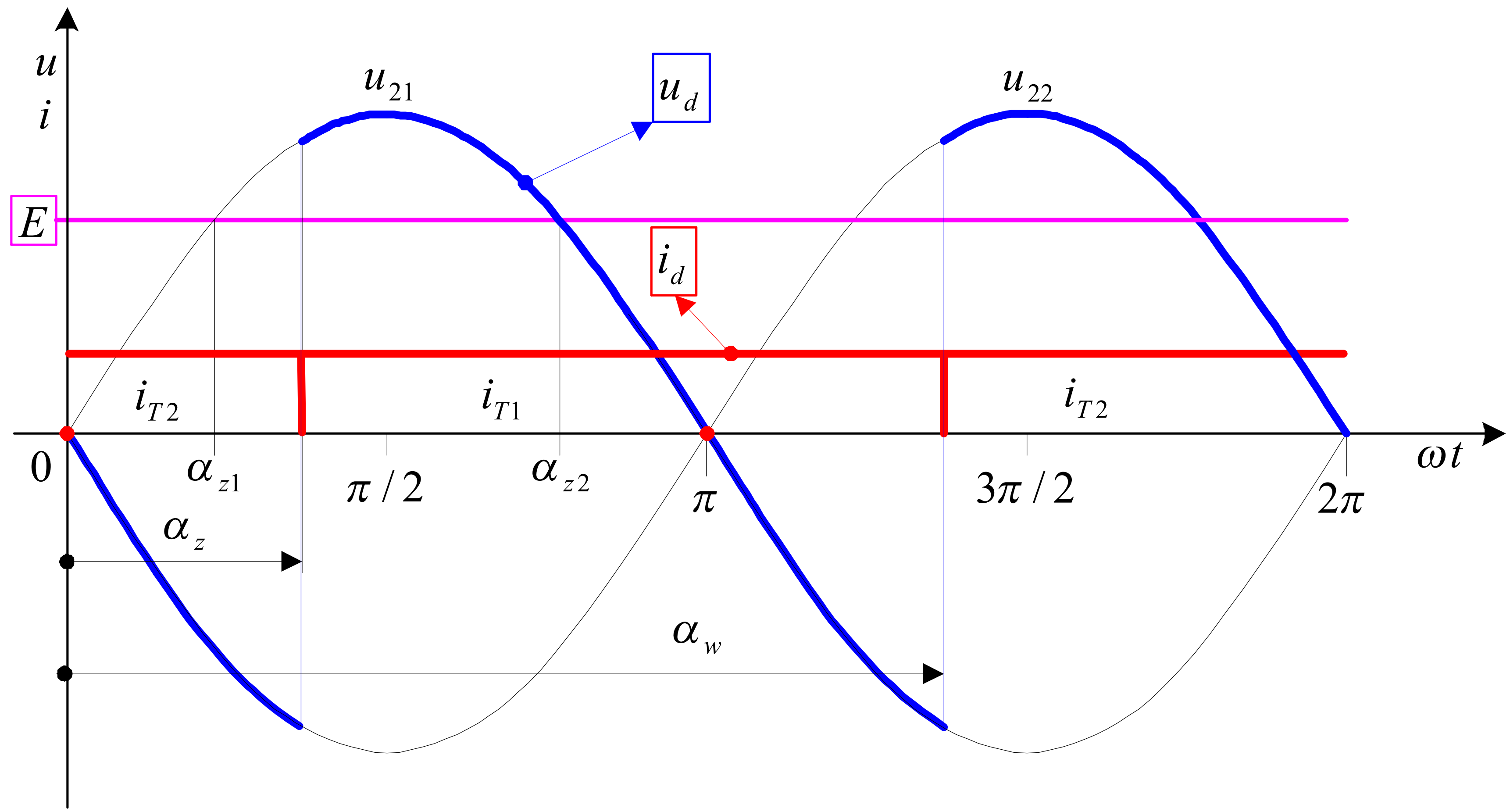
Sekwencja sterowania

T_1 - T_4

T_2 - T_3

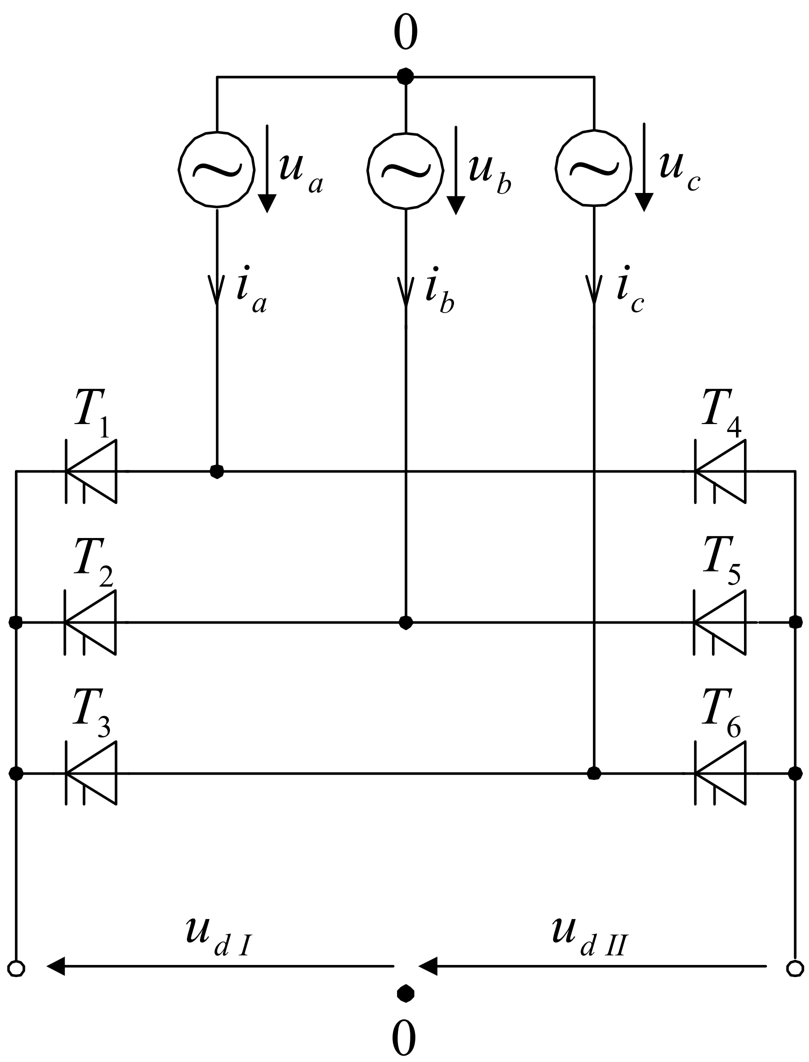


u
i
u_{21}
u_d
u_{22}
E
i_d
i_{T1}
i_{T2}
0
α_{z1}
$\pi / 2$
α_{z2}
π
$3\pi / 2$
2π
ωt
α_z
α_p
α_z
α_w
α_w

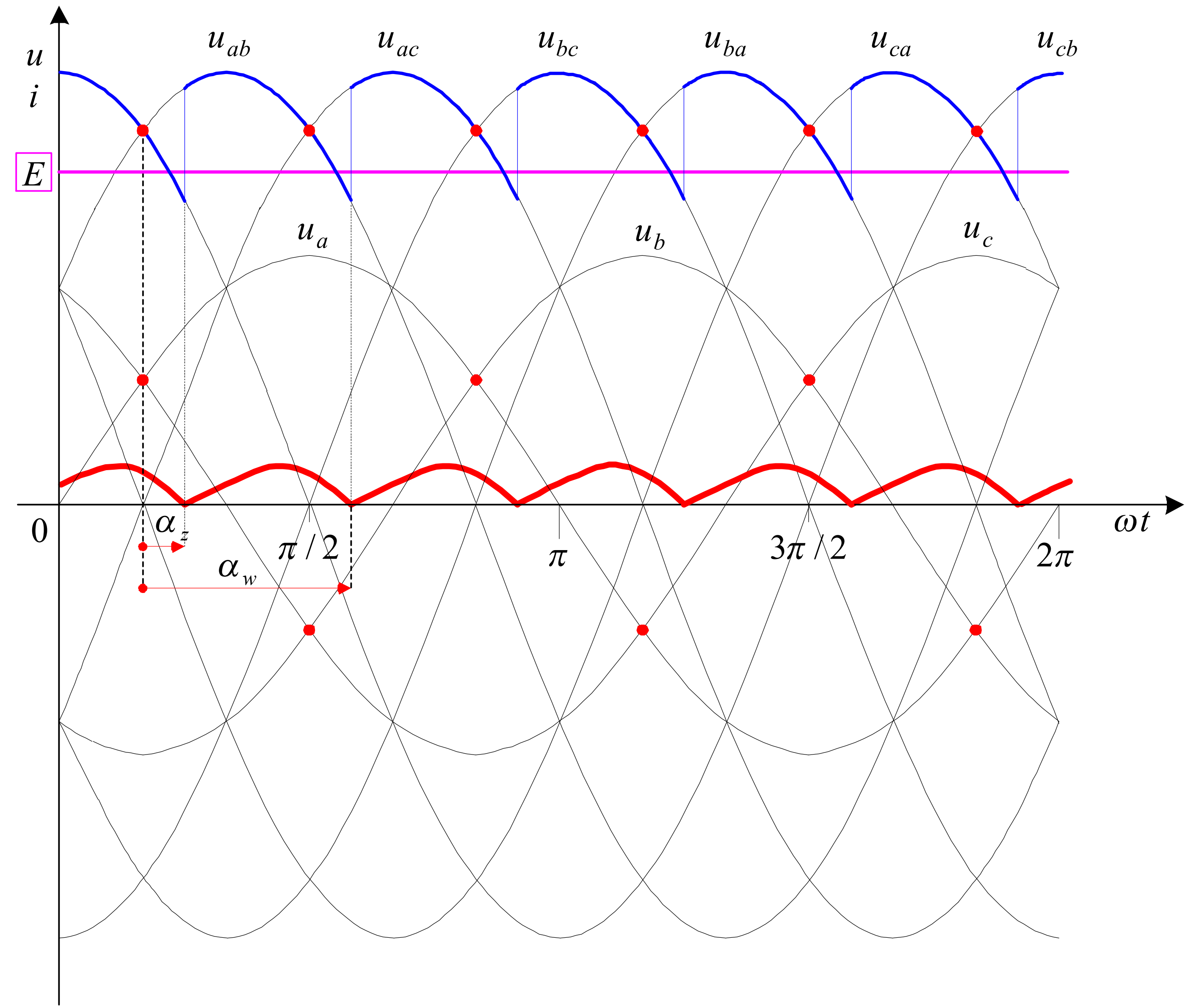


u
i
E
u_{21}
u_d
u_{22}
i_d
i_{T2}
i_{T1}
i_{T2}
0
α_{z1}
$\pi / 2$
α_{z2}
π
$3\pi / 2$
2π
ωt
α_z
α_w

Układ dwukierunkowy sześciopulsowy
Mostek trójfazowy



$$u_d = u_{d\ I} + u_{d\ II}$$



u
i
E
u_{ab}
u_{ac}
u_{bc}
u_{ba}
u_{ca}
u_{cb}
u_a
u_b
u_c
0
α_z
α_w
$\pi / 2$
π
$3\pi / 2$
2π
ωt

$$U_d = U_{d\,I} + U_{d\,II}$$

$$U_{d\,I} = U_{d\,II} = U_{2m} \frac{3}{\pi} \sin\frac{\pi}{3} \cos\alpha_z$$

$$U_{d0I} = U_{d0II} = U_{2m} \frac{3}{\pi} \sin\frac{\pi}{3} = \frac{3\sqrt{3}}{2\pi} U_{2m}$$

$$U_d = \frac{3}{\pi} U_{2mp} \cos\alpha_z$$

Sekwencja sterowania

$$a - b \rightarrow T_1 - T_5$$

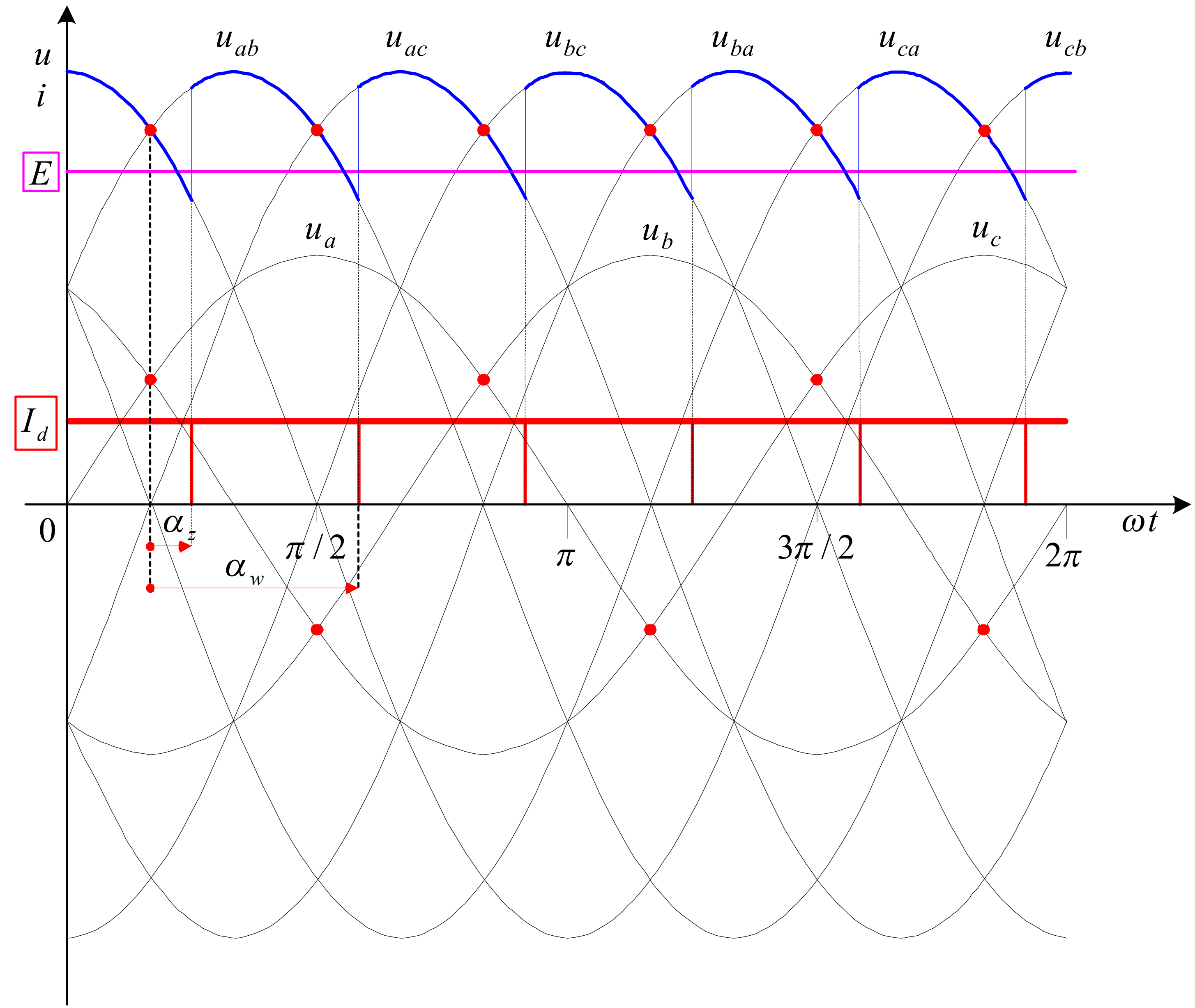
$$a - c \rightarrow T_1 - T_6$$

$$b - c \rightarrow T_2 - T_6$$

$$b - a \rightarrow T_2 - T_4$$

$$c - a \rightarrow T_3 - T_4$$

$$c - b \rightarrow T_3 - T_5$$



u
i
u_{ab}
u_{ac}
u_{bc}
u_{ba}
u_{ca}
u_{cb}
E
u_a
u_b
u_c
I_d
0
α_z
$\pi / 2$
α_w
π
$3\pi / 2$
2π
ωt

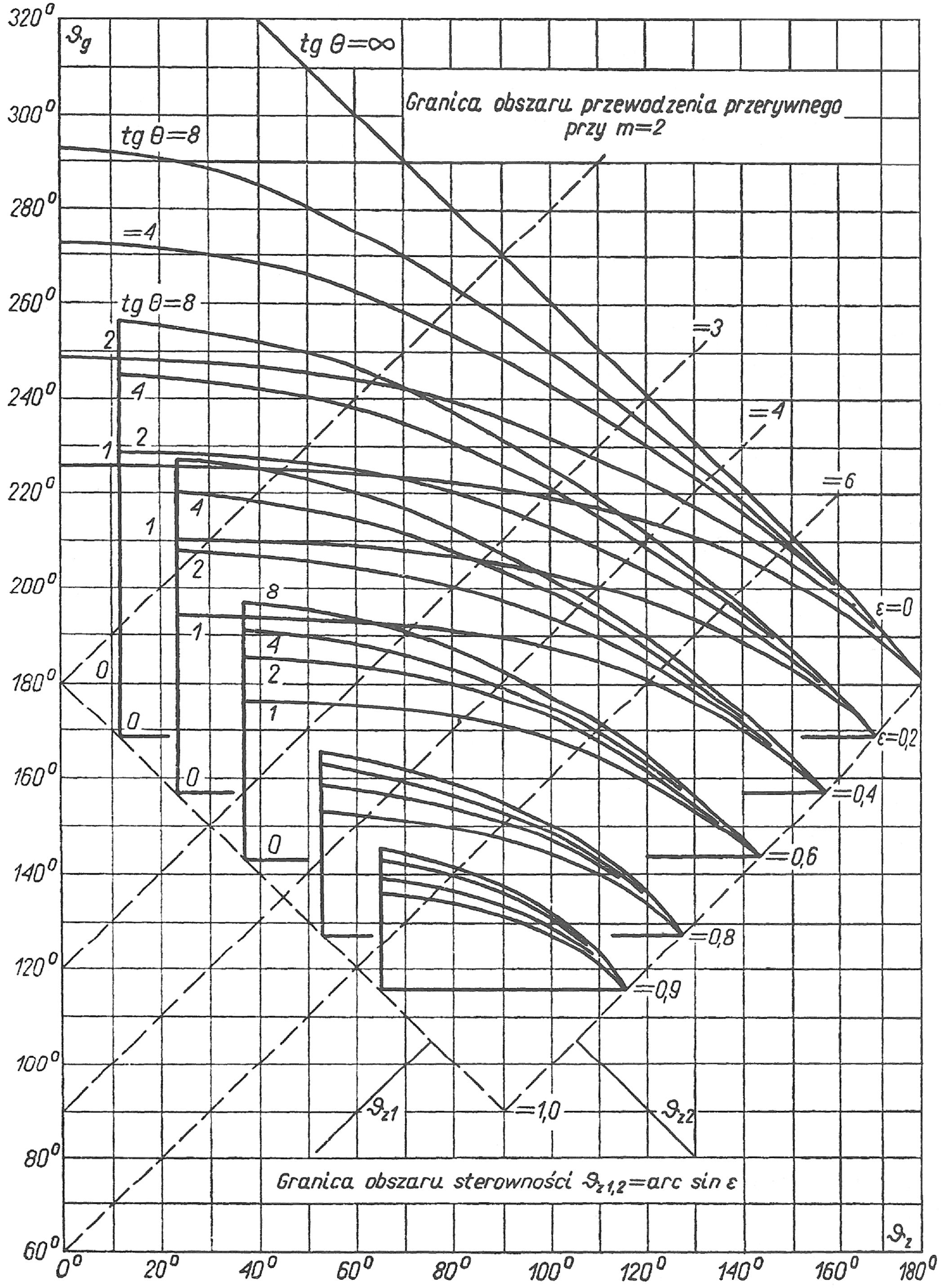
Charakterystyka sterowania

$$U_d = f(\alpha_z)$$

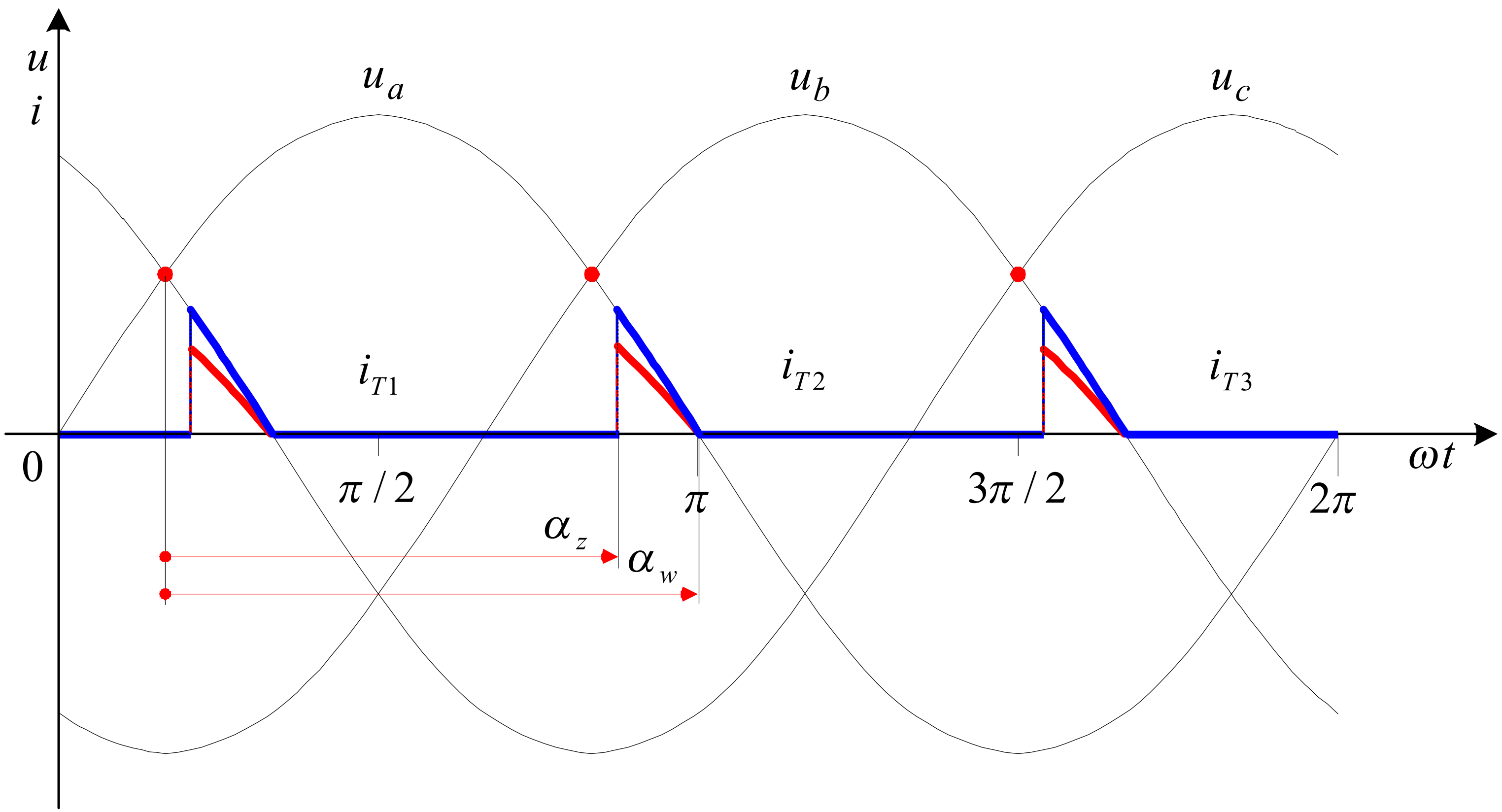
$$U_\mathrm{d} = \frac{p}{2\pi} U_{2m} \left[\cos\left(\frac{\pi}{2} - \frac{\pi}{p} + \alpha_\mathrm{z} \right) - \cos\left(\frac{\pi}{2} - \frac{\pi}{p} + \alpha_\mathrm{w} \right) + E^\mathrm{w} \left(\frac{2\pi}{p} - \alpha_\mathrm{p} \right) \right]$$

$$\alpha_w = f(\alpha_z, E^w, tg\varphi)$$

$$U_d = U_{2m} \frac{p}{\pi} \sin\frac{\pi}{p} \cos\alpha_z = U_{d0} \cos\alpha_z$$

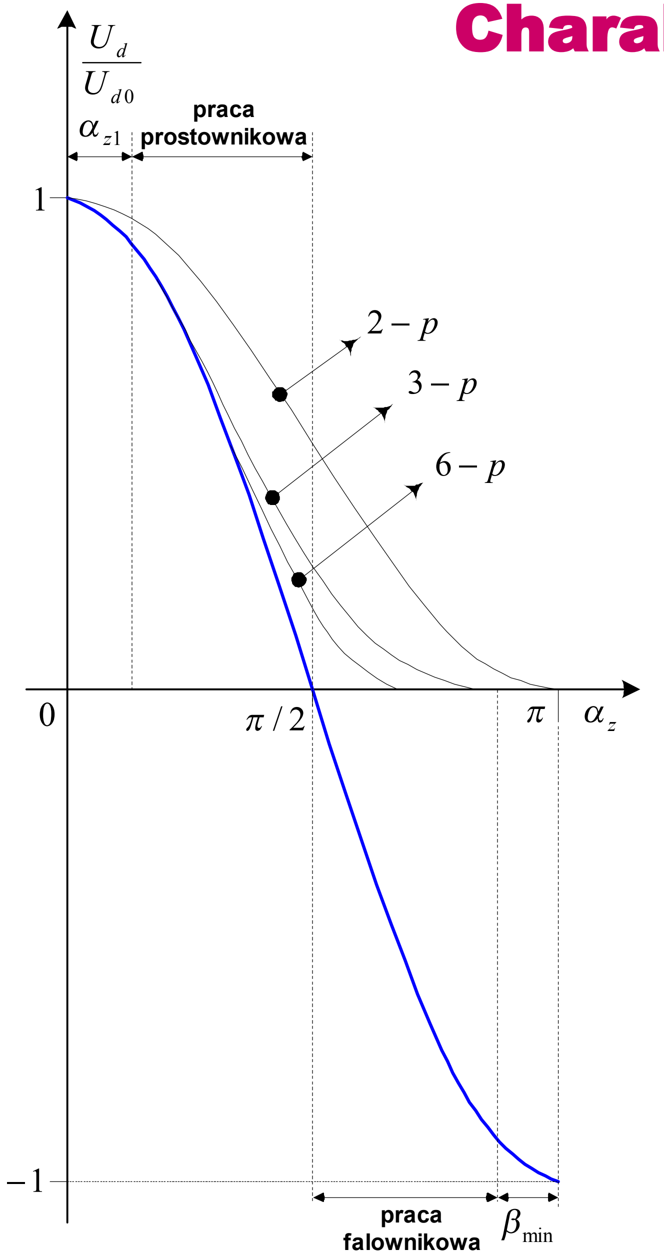


ϑ_g
tg θ=∞
Granica obszaru przewodzenia przerywnego przy m=2
tg θ=8
=4
tg θ=8
=3
=4
=6
ε=0
ε=0,2
=0,4
=0,6
=0,8
=0,9
=1,0
ϑ_{z1}
ϑ_{z2}
Granica obszaru sterowności $\vartheta_{z1,2}$=arc sin ε
ϑ_z
320°
300°
280°
260°
240°
220°
200°
180°
160°
140°
120°
100°
80°
60°
0°
20°
40°
60°
80°
100°
120°
140°
160°
180°



$$U_{\mathrm{d}} = \frac{p}{2\pi} U_{2m} \left[\cos\left(\frac{\pi}{2} - \frac{\pi}{p} + \alpha_{\mathrm{z}} \right) - \cos\left(\frac{\pi}{2} - \frac{\pi}{p} + \frac{5\pi}{6} \right) \right]$$

Charakterystyka sterowania



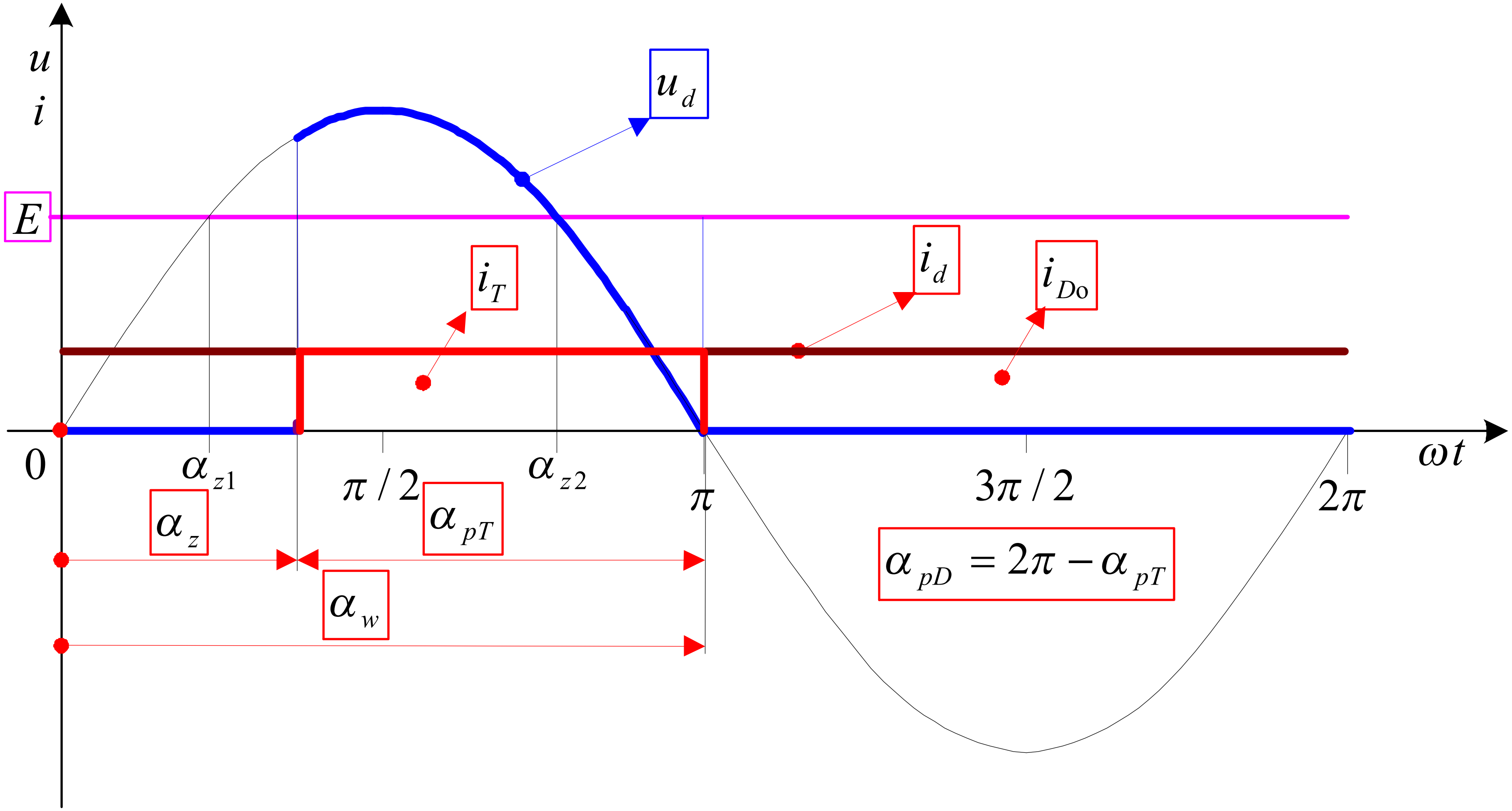
$$U_d = U_{2m}\frac{p}{\pi}\sin\frac{\pi}{p}\cos\alpha_z = U_{d0}\cos\alpha_z$$

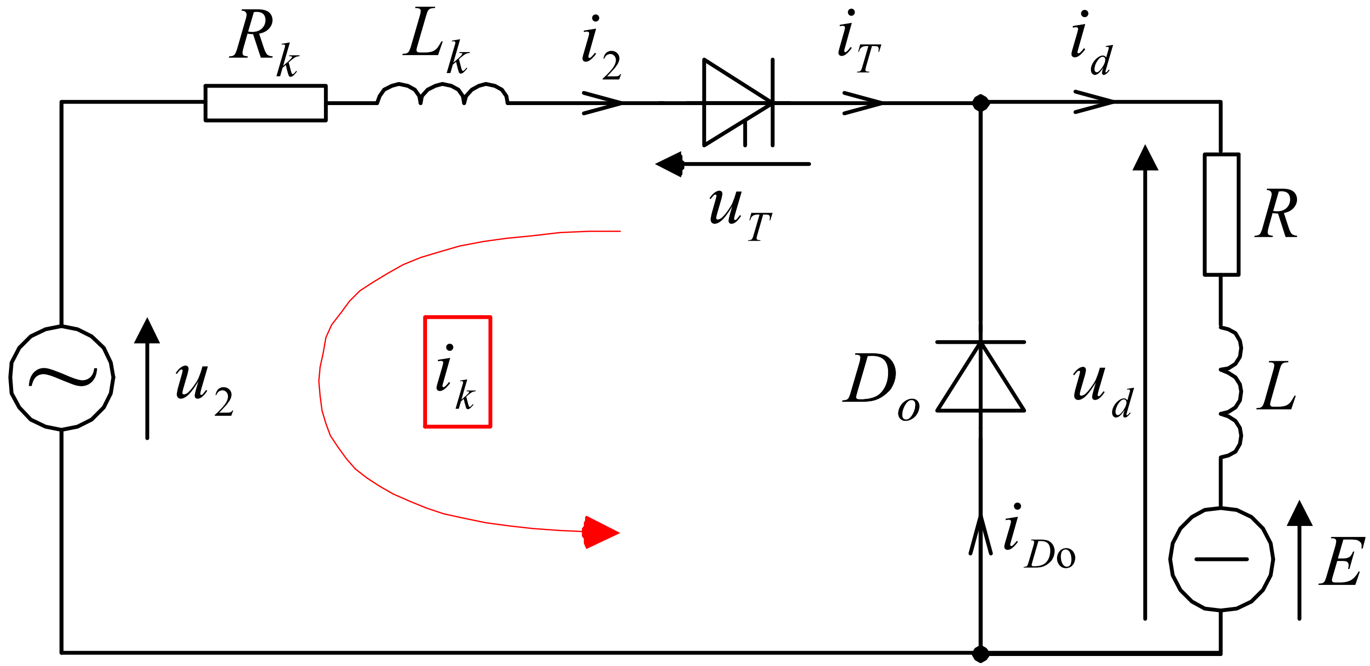
$$\frac{U_d}{U_{d0}} = \cos\alpha_z$$

Zjawisko komutacji w układach o komutacji sieciowej

Charakterystyka zewnętrzna

$$U_d = f(I_d) \quad \text{dla} \quad \alpha_z = const$$

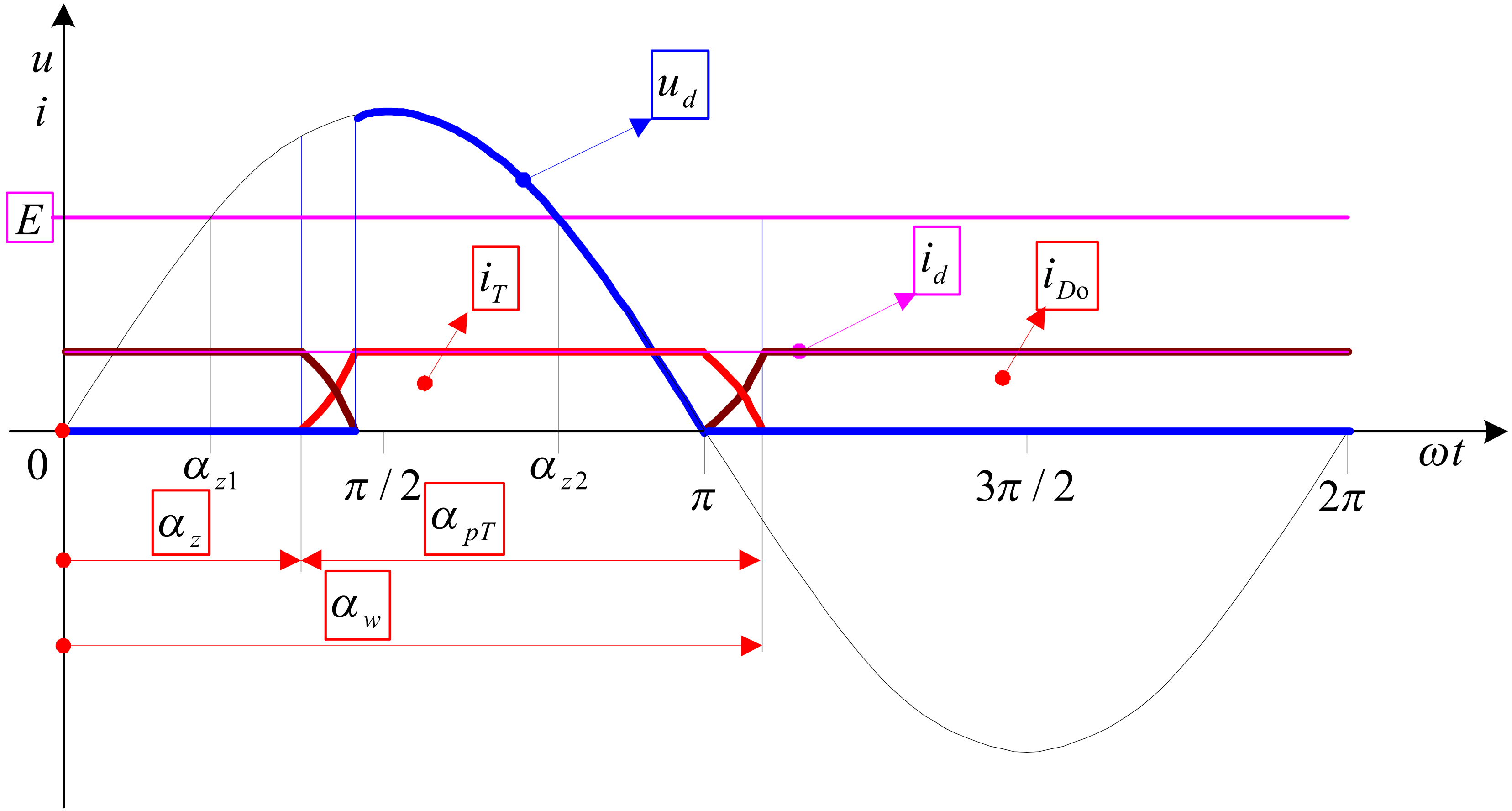




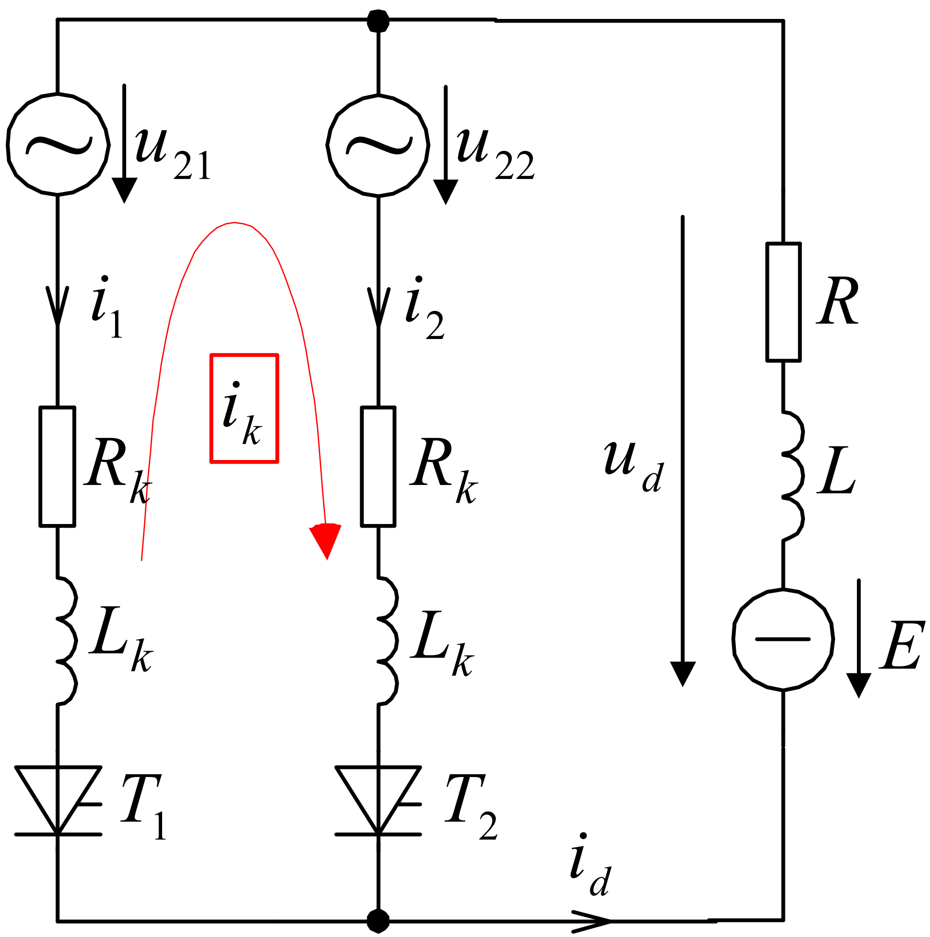
$$L_k \frac{di_k(t)}{dt} = U_{2m} \sin(\omega t + \alpha_z) \qquad i_k(0) = 0$$

$$i_k(t) = \frac{U_{2m}}{\omega L_k}\left(\cos\alpha_z - \cos(\omega t + \alpha_z)\right)$$

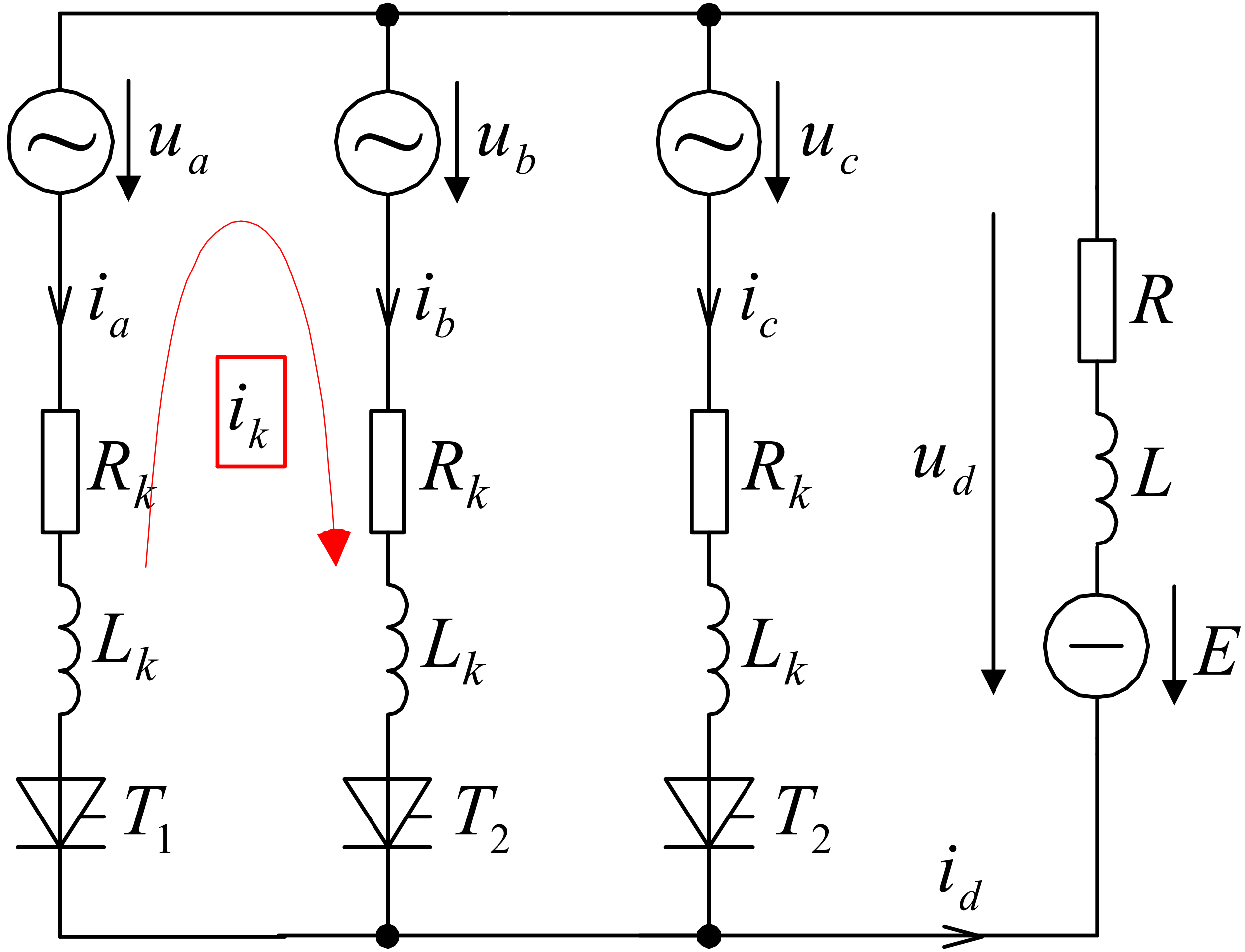
$$i_T(t) = I_d - i_k(t) \qquad i_{D_0}(t) = i_k(t)$$



u
i
u_d
E
i_T
i_d
i_{Do}
0
α_{z1}
$\pi / 2$
α_{z2}
π
$3\pi / 2$
2π
ωt
α_z
α_{pT}
α_w



u_{21}
u_{22}
i_1
i_2
i_k
R_k
R_k
R
u_d
L
L_k
L_k
E
T_1
T_2
i_d



u_a
u_b
u_c
i_a
i_b
i_c
i_k
R_k
R_k
R_k
L_k
L_k
L_k
T_1
T_2
T_2
u_d
R
L
E
i_d

$$u_{2a} = U_{2m} \sin(\omega t)$$

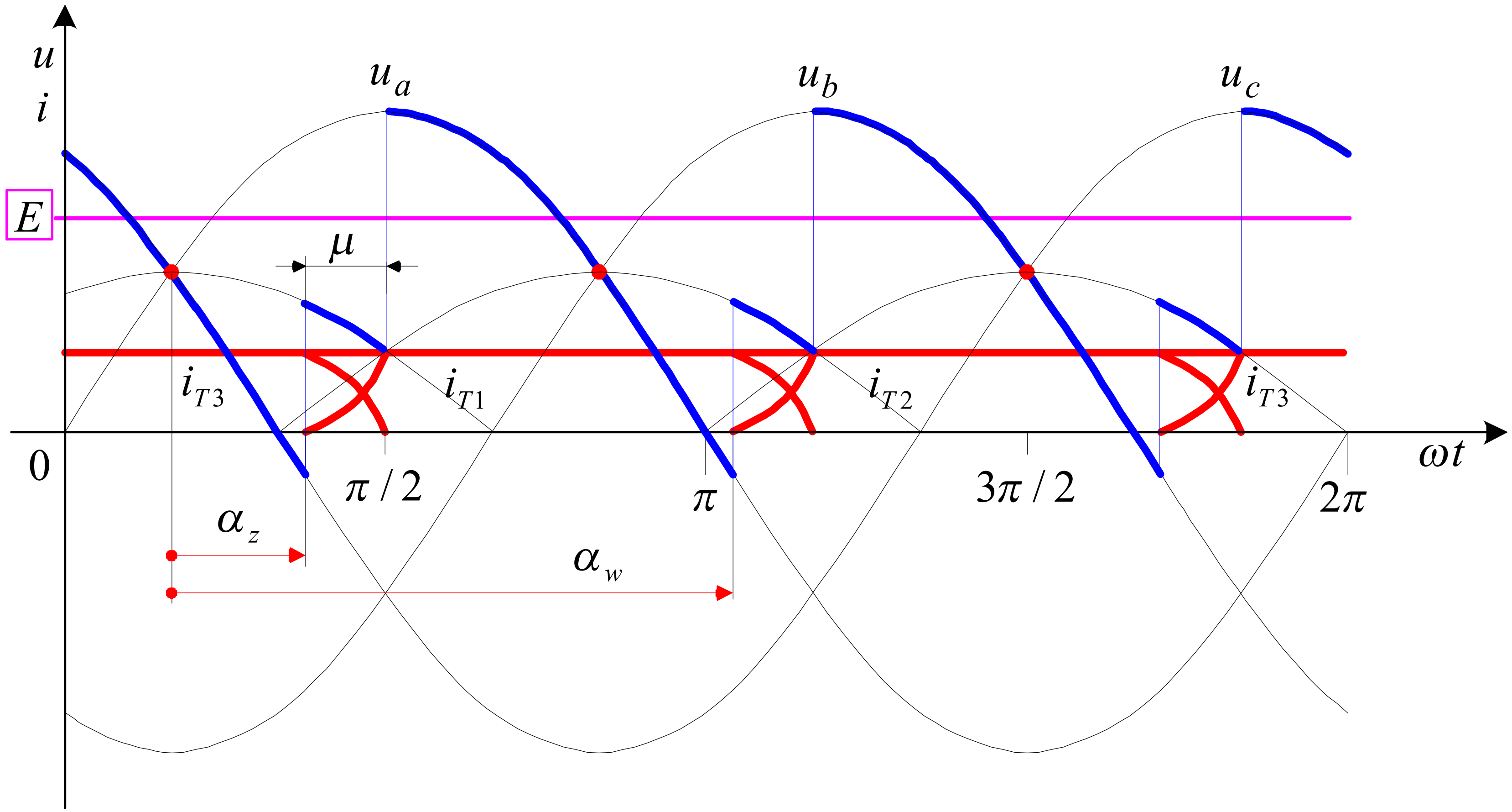
$$u_{2b} = U_{2m} \sin(\omega t - 2\pi / 3)$$

$$L_k \frac{di_k}{dt} = \frac{1}{2}(u_{2b} - u_{2a}) \qquad i_k(0) = 0$$

$$i_k(t) = \frac{U_{2m}}{\omega L_k} \sin\frac{\pi}{p}\left(\cos\alpha_z - \cos(\omega t + \alpha_z)\right)$$

$$i_{2a}(t) = I_d - \frac{U_{2m}}{\omega L_k} \sin\frac{\pi}{p}\left(\cos\alpha_z - \cos(\omega t + \alpha_z)\right)$$

$$i_{2b}(t) = \frac{U_{2m}}{\omega L_k} \sin\frac{\pi}{p}\left(\cos\alpha_z - \cos(\omega t + \alpha_z)\right)$$



u
i
u_a
u_b
u_c
E
μ
i_{T3}
i_{T1}
i_{T2}
i_{T3}
0
$\pi / 2$
π
$3\pi / 2$
2π
ωt
α_z
α_w

$$\mu = \arccos\left(\cos\alpha_z - \frac{\omega L_k I_d}{U_{2m}\sin\frac{\pi}{p}}\right) - \alpha_z$$

$\alpha_z = \pi / 2$

$$\mu_{\min} = \arccos\left(-\frac{\omega L_k I_d}{U_{2m}\sin\frac{\pi}{p}}\right) - \frac{\pi}{2}$$

$\alpha_z = 0$

$$\mu_{\max} = \mu_0 = \arccos\left(1 - \frac{\omega L_k I_d}{U_{2m}\sin\frac{\pi}{p}}\right)$$

$$U_d = \frac{1}{\frac{2\pi}{p}} \left(\int_{\frac{\pi}{2}-\frac{\pi}{p}+\alpha_z}^{\frac{\pi}{2}+\frac{\pi}{p}+\alpha_z} u_{2a}\, d\omega t - \frac{1}{2} \int_{\frac{\pi}{2}-\frac{\pi}{p}+\alpha_z}^{\frac{\pi}{2}-\frac{\pi}{p}+\alpha_z+\mu} (u_{2a} + u_{2c})\, d\omega t \right)$$

$$U_d = U_{2m} \frac{p}{\pi} \sin\frac{\pi}{p} \left(\cos\alpha_z + \cos(\alpha_z + \mu) \right)$$

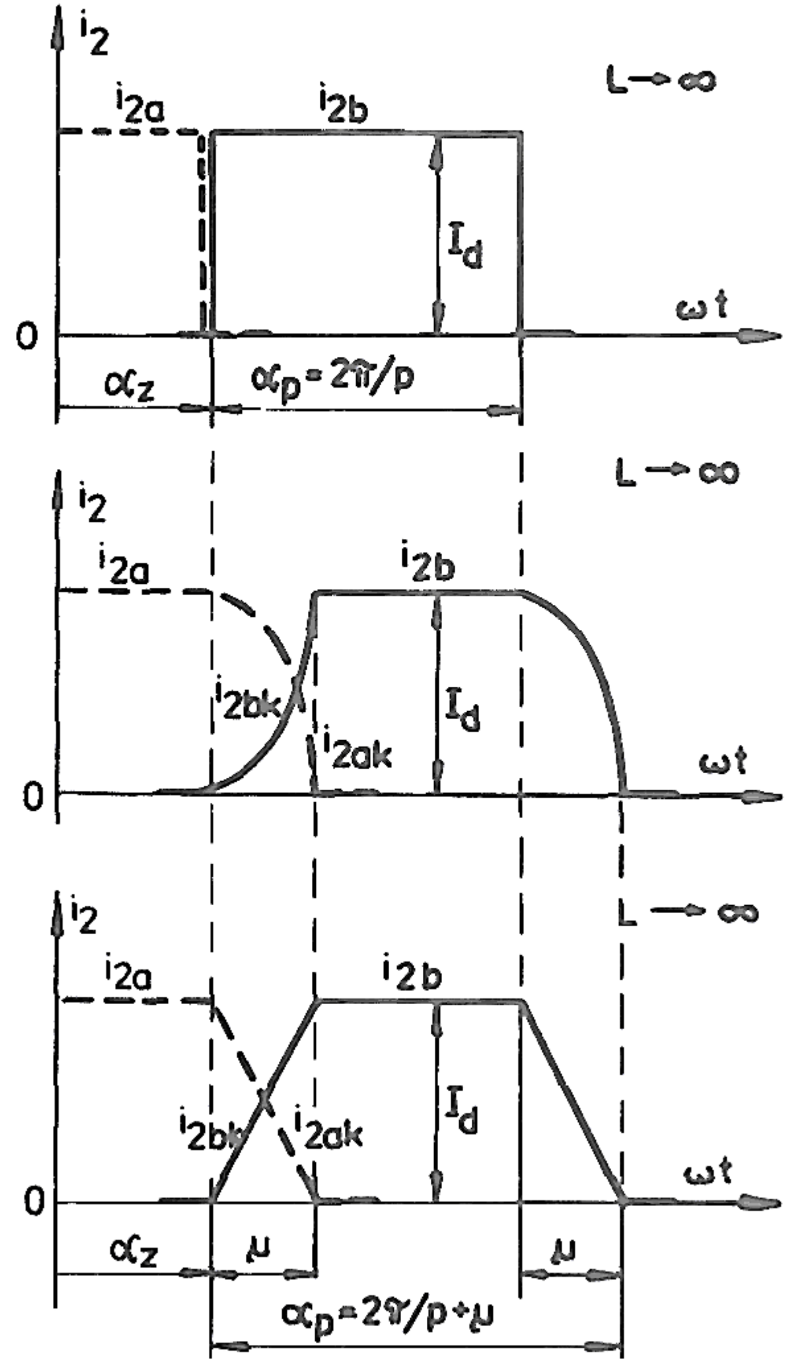
$$U_d = \frac{1}{2} U_{d0} \left(\cos\alpha_z + \cos(\alpha_z + \mu) \right)$$

$$U_d = U_{d0} \cos(\mu/2) \cos(\alpha_z + \mu/2)$$

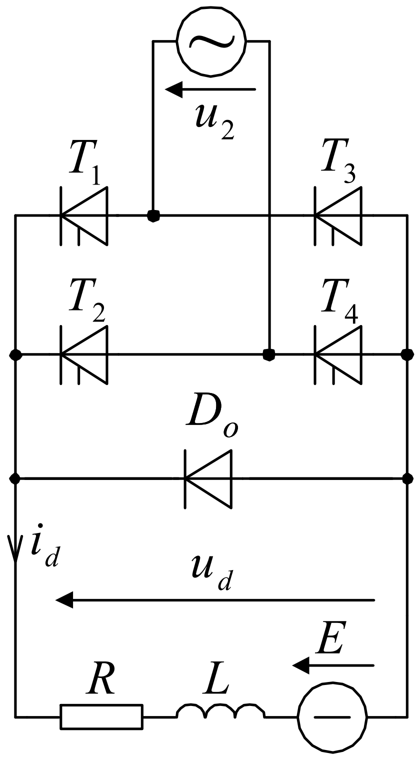
$$\cos\alpha_z - \cos(\alpha_z + \mu) = \frac{\omega L_k}{U_{2m} \sin\frac{\pi}{p}} I_d$$

$$\Delta U_{dk} = \frac{p}{2\pi} X_k I_d$$

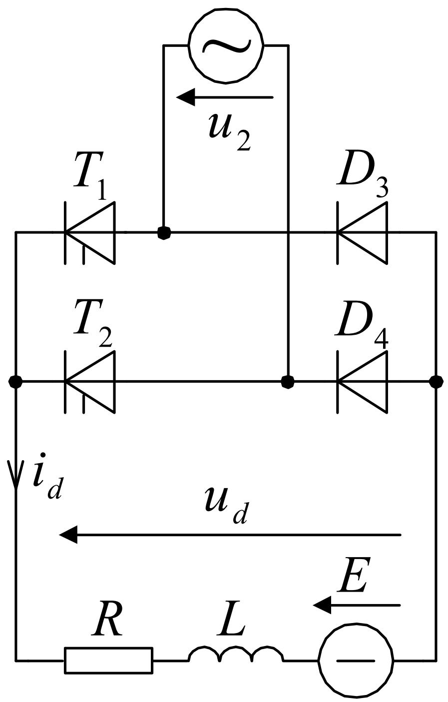
$$U_d = U_{2m} \frac{p}{\pi} \sin\frac{\pi}{p} \left(\cos\alpha_z \mp \frac{X_k I_d}{2U_{2m} \sin\frac{\pi}{p}} \right) = U_{d0} \cos\alpha_z \mp \Delta U_{dk}$$



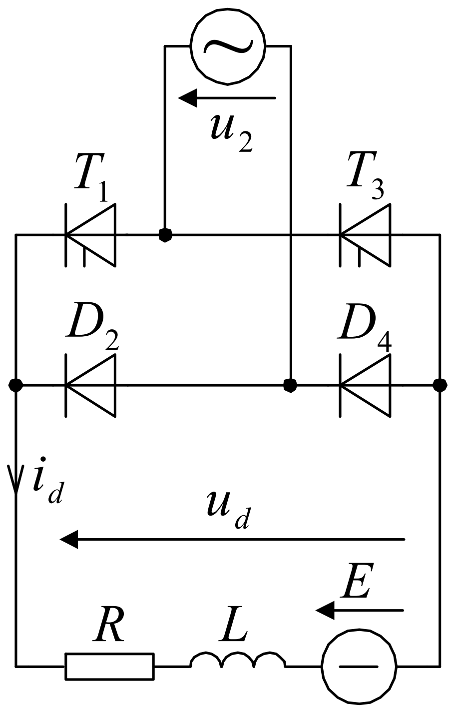
i2
L → ∞
i2a
i2b
Id
ωt
0
αz
αp = 2π/p
i2
L → ∞
i2a
i2b
i2bk
Id
i2ak
ωt
0
i2
L → ∞
i2a
i2b
Id
i2bk
i2ak
ωt
0
αz
μ
μ
αp = 2π/p + μ



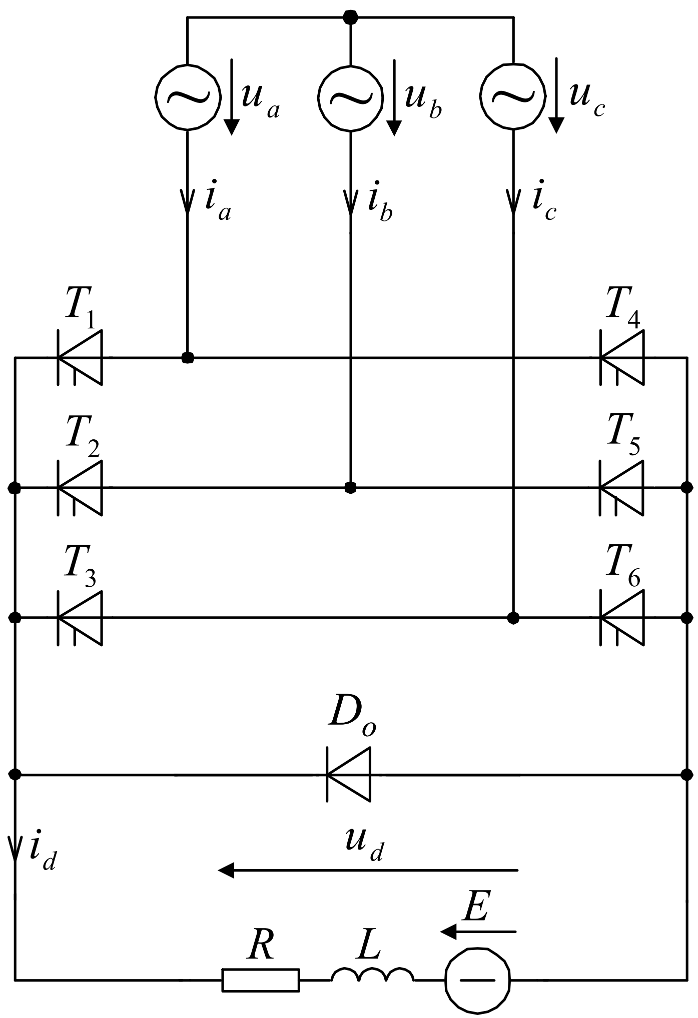
u_2
T_1
T_3
T_2
T_4
D_o
i_d
u_d
E
R
L



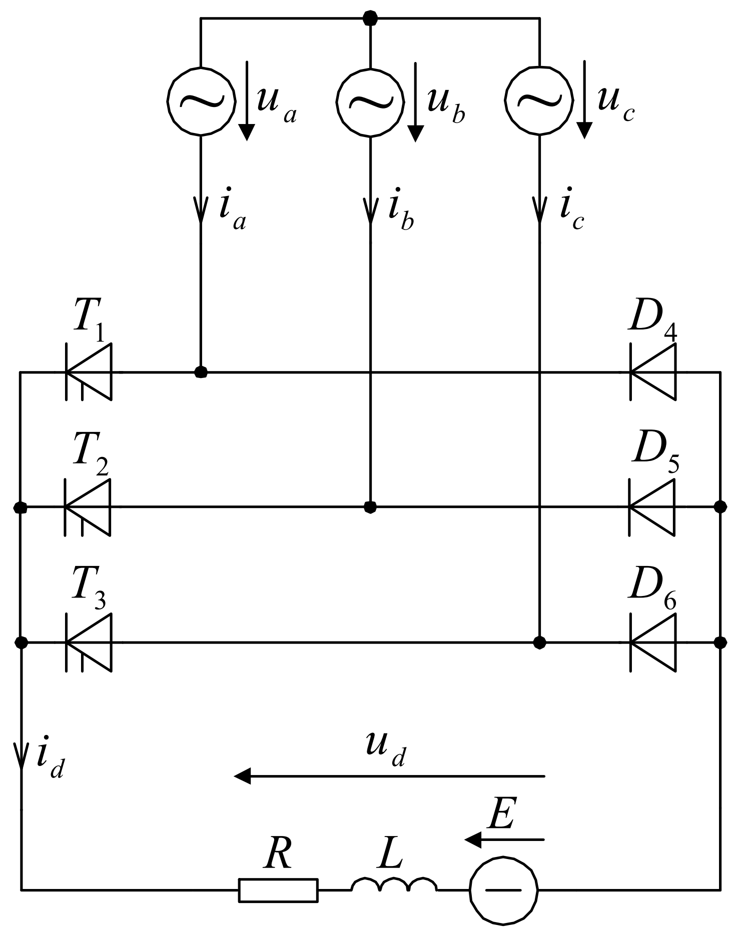
u_2
T_1
D_3
T_2
D_4
i_d
u_d
E
R
L



u_2
T_1
T_3
D_2
D_4
i_d
u_d
E
R
L



u_a
u_b
u_c
i_a
i_b
i_c
T_1
T_4
T_2
T_5
T_3
T_6
D_o
i_d
u_d
E
R
L



u_a
u_b
u_c
i_a
i_b
i_c
T_1
D_4
T_2
D_5
T_3
D_6
i_d
u_d
E
R
L