Power converters AC/DC and DC/AC - MM2

Three phase rectifiers

Content MM2

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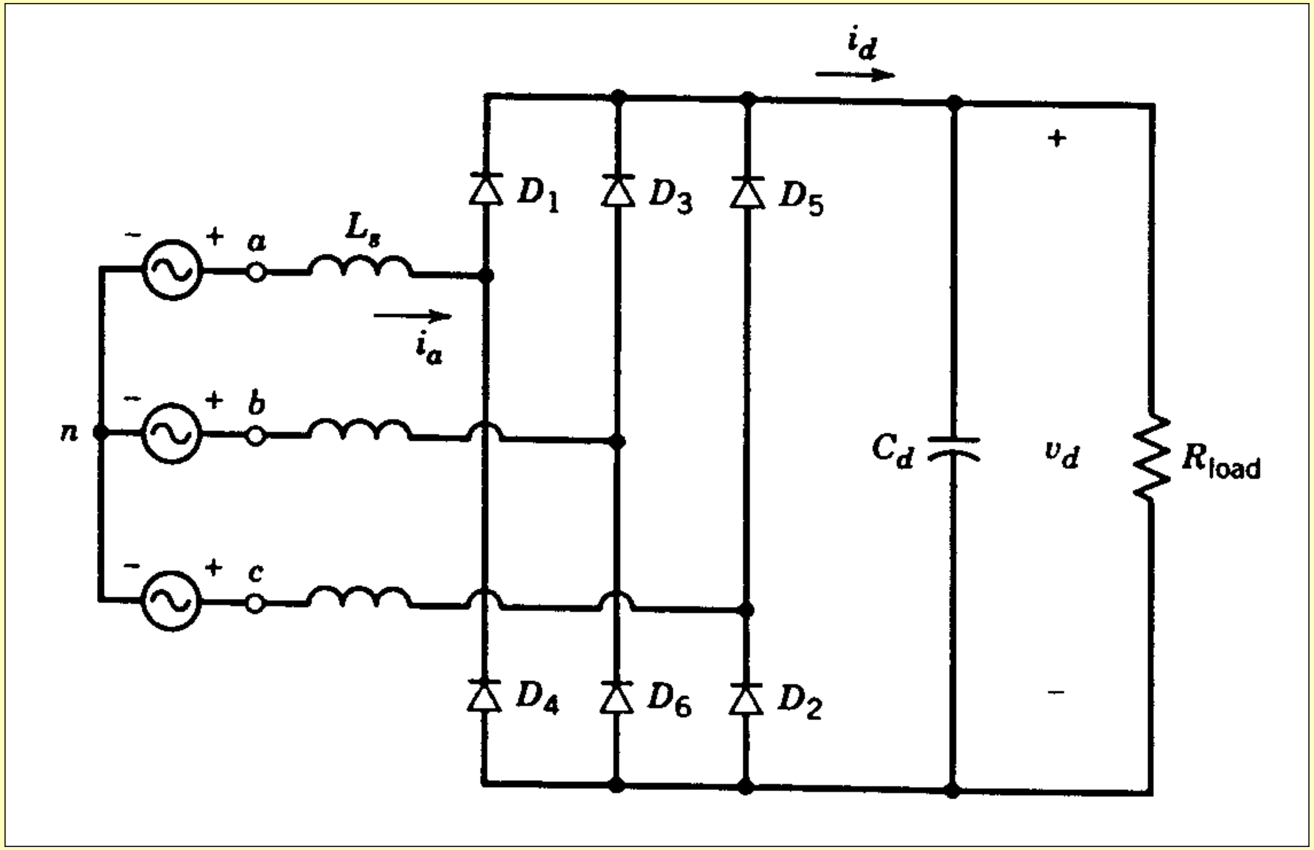
2. Three phase rectifier ($L_s = 0$)

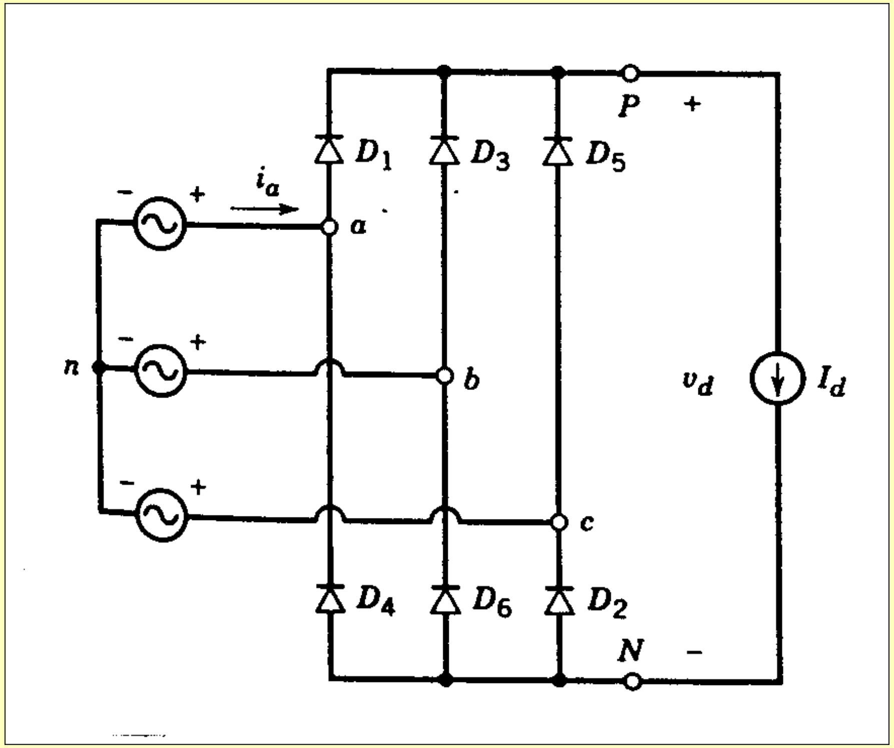


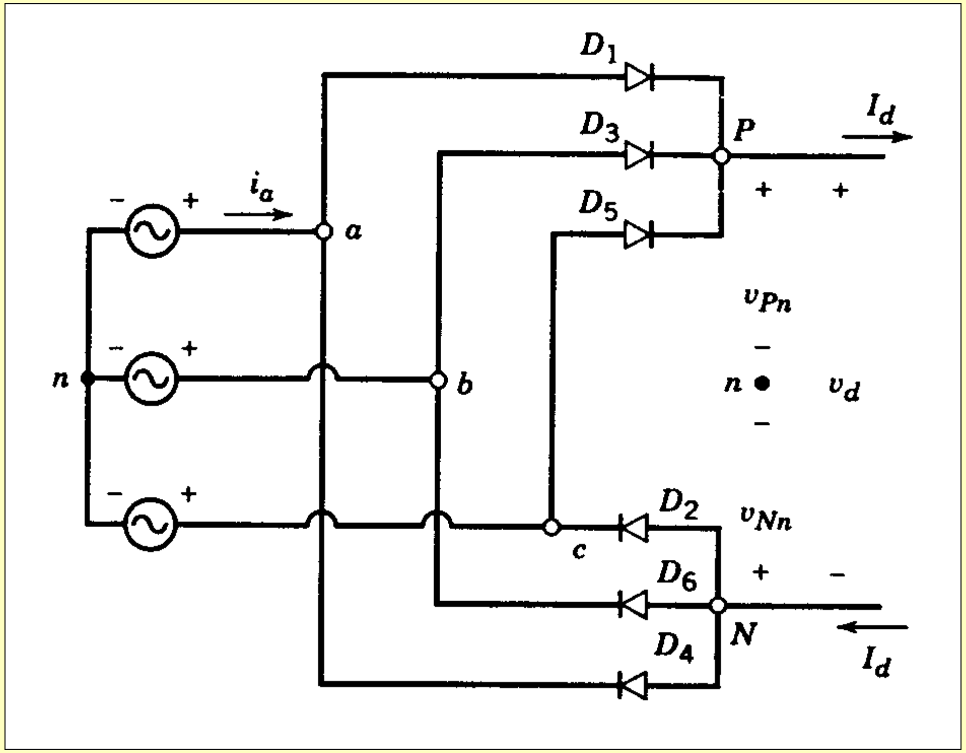
- Three phase line
- Larger power
- Higher voltage (V_d)
- Smaller filter
- Good properties

2. Three phase rectifier ($L_s = 0$)

Constant DC current

The highest voltage conduct

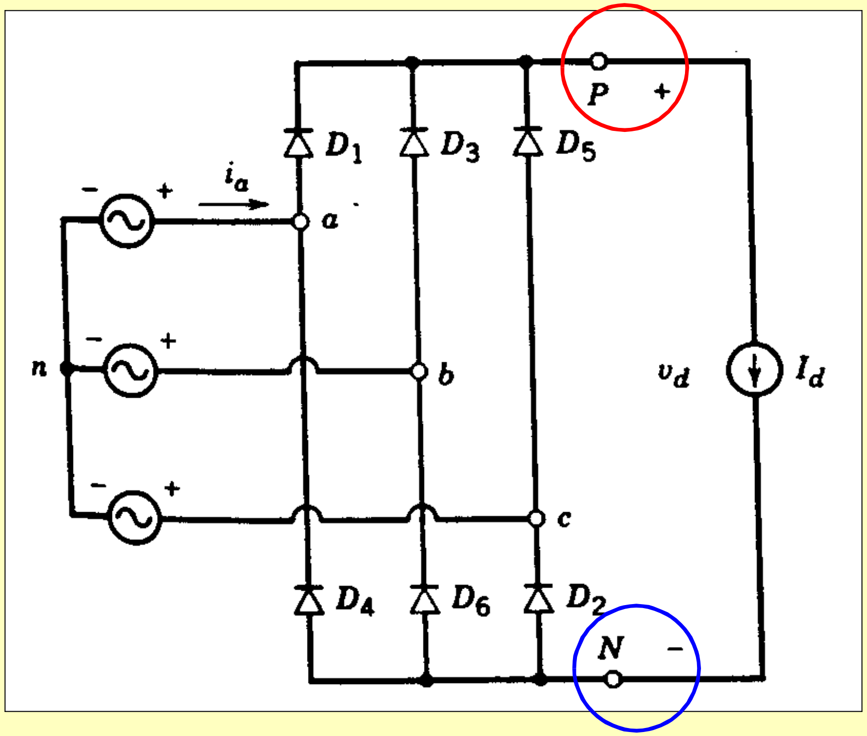


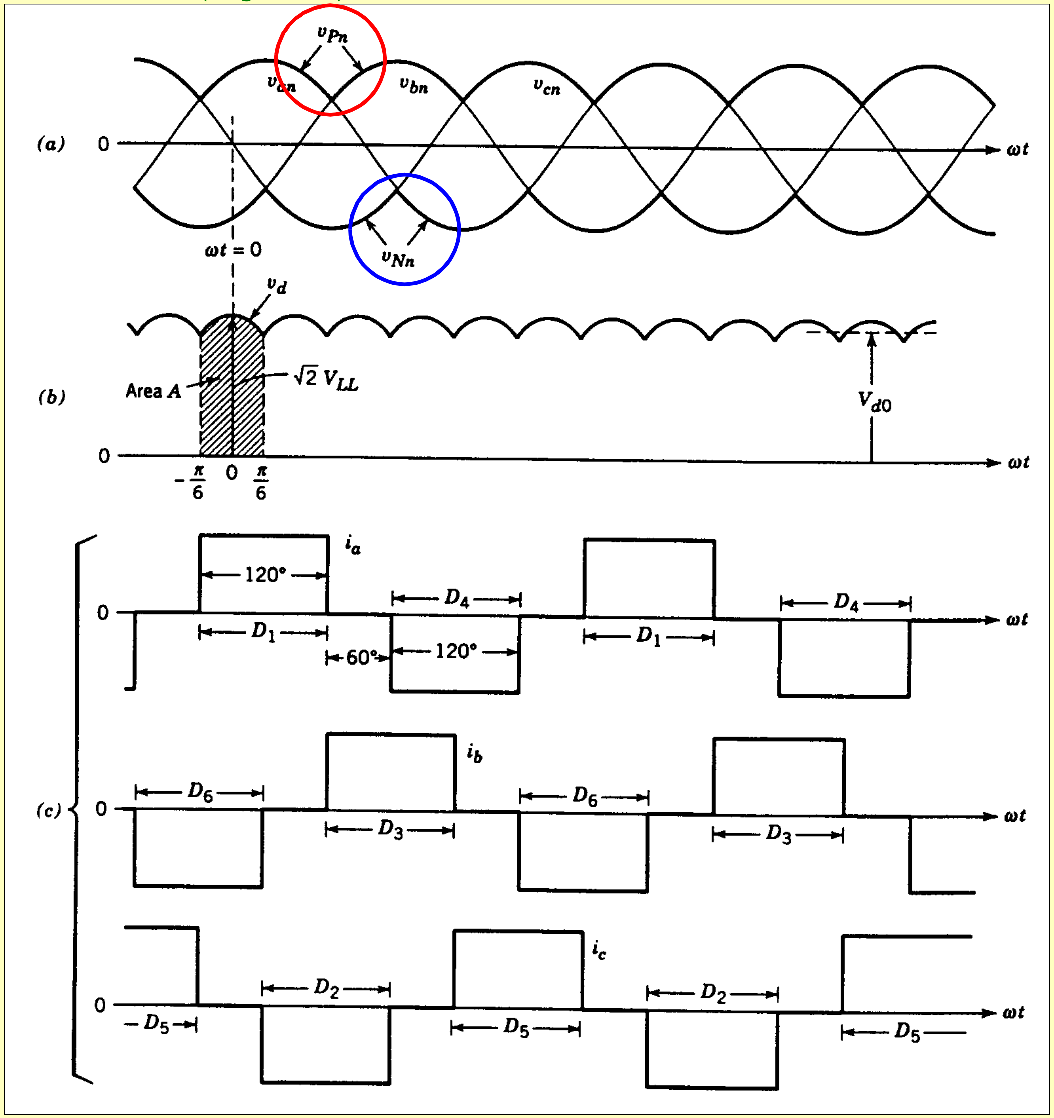


The lowest voltage conduct

2. Three phase rectifier (L_s = 0)

Constant DC-current

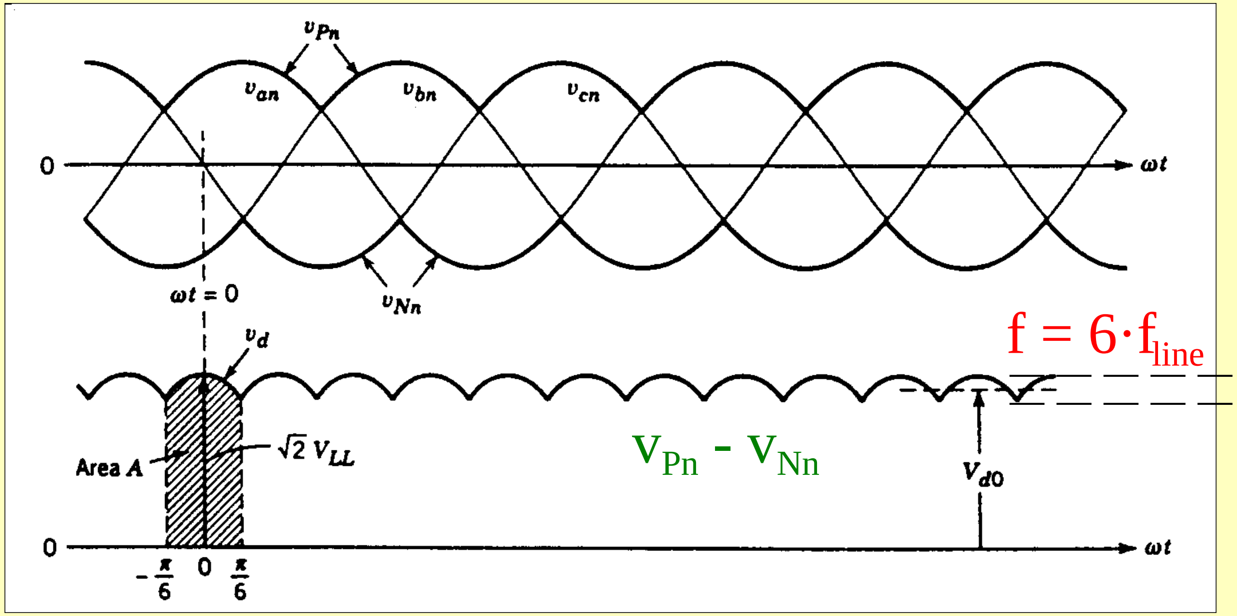




Current with resistive load ?

2. Three phase rectifier ($L_s = 0$)

Current/voltage



DC-link voltage

$$v_d = v_{ab} = \sqrt{2}V_{LL}\cos\omega t \qquad -\tfrac{1}{6}\pi < \omega t < \tfrac{1}{6}\pi$$

RMS current

$$I_s = \sqrt{\tfrac{2}{3}}I_d = 0.816 I_d$$

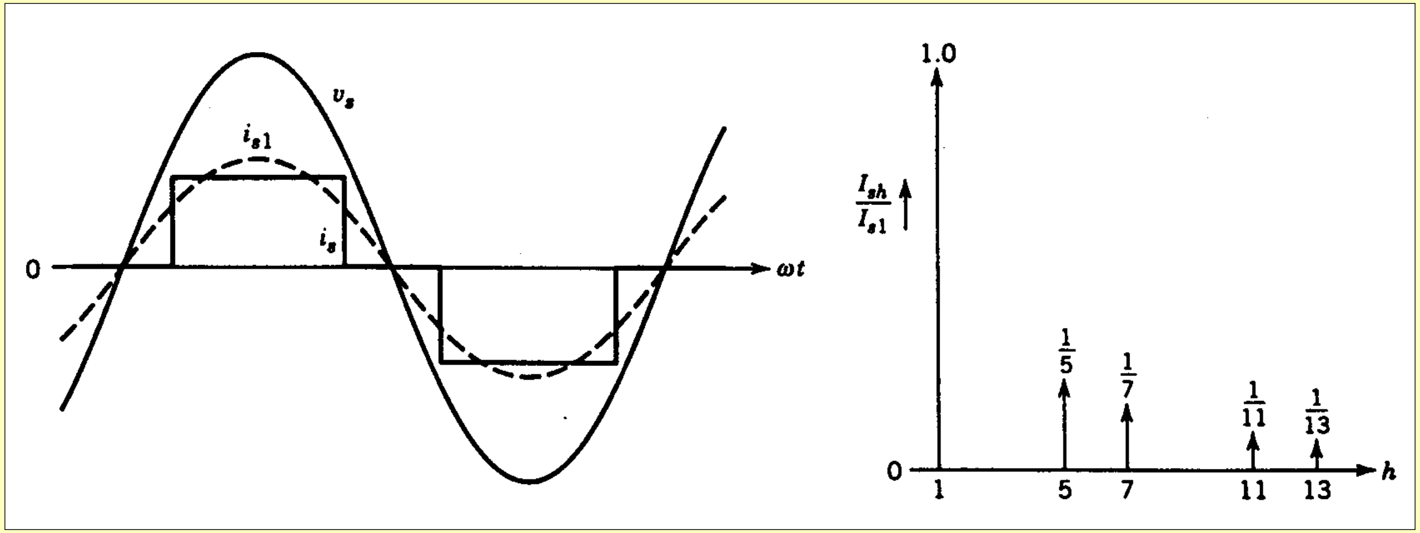
Average voltage

$$V_{do} = \frac{1}{\pi/3}\int_{-\pi/6}^{\pi/6}\sqrt{2}V_{LL}\cos\omega t\, d(\omega t) = \frac{3}{\pi}\sqrt{2}V_{LL} = 1.35V_{LL}$$

$v_{LL} = 400\ \text{VAC} \Rightarrow V_{d0} = 540\ \text{VDC}$

2. Three phase rectifier ($L_s = 0$)

Current



1. Harmonic current

$$I_{s1} = \frac{1}{\pi}\sqrt{6}I_d = 0.78I_d$$

DPF

$$DPF = 1.0$$

PF

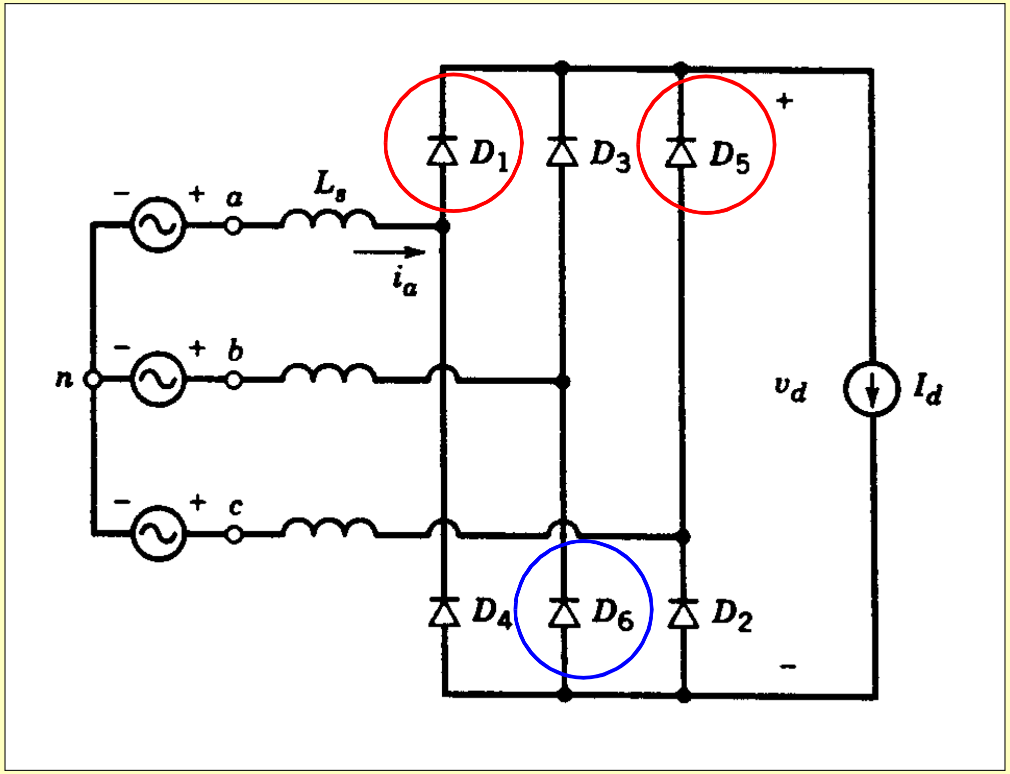
$$PF = \frac{3}{\pi} = 0.955$$

$$PF = DPF I_{s1} \rho vore I_s = \frac{\frac{1}{\pi}\sqrt{6}I_d}{\sqrt{\frac{2}{3}}I_d}$$

Smaller harmonics than the single phase rectifier (much smaller)

3. Three phase rectifier ($L_s \neq 0$)

Present 3 phase rectifier



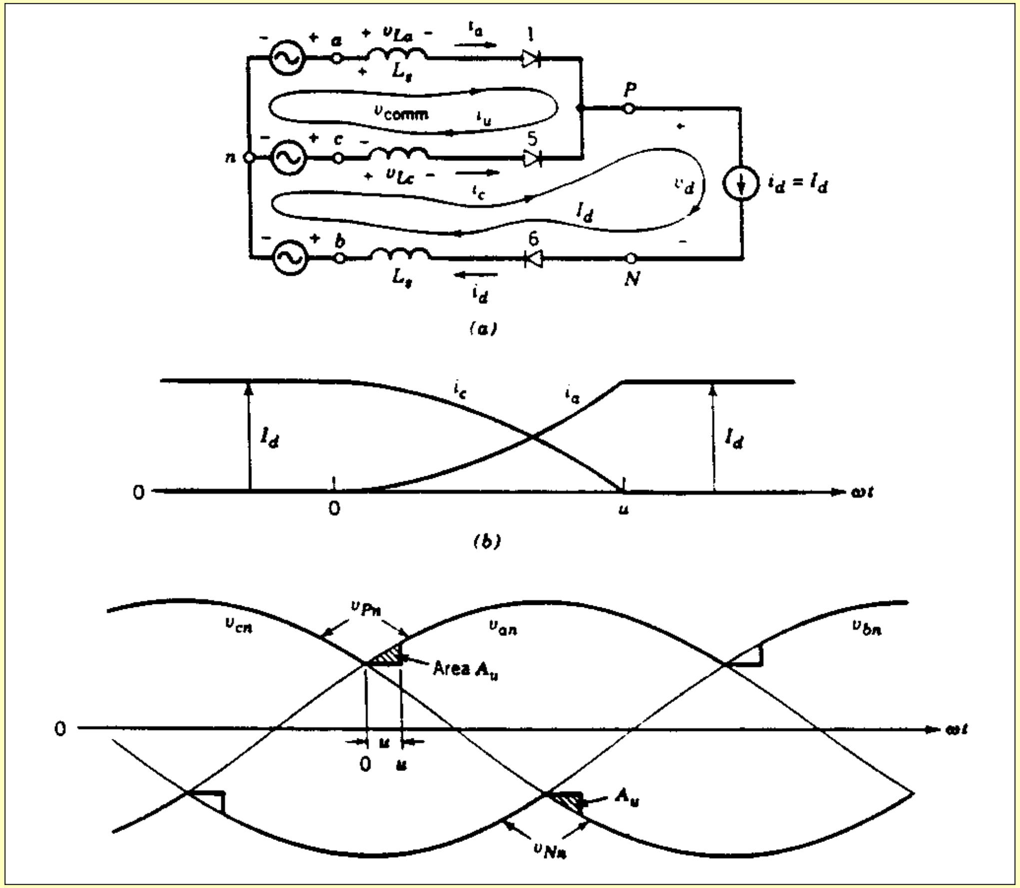
$D_5 + D_6 \rightarrow D_1 + D_6$

3 -phase rectifier

- Lower voltage due to voltage drop over L_s

3. Three phase rectifier ($L_s \neq 0$)

Real rectifier



A_u is loss of average DC-link voltage

Inductance voltage

$$v_{La} = L_s \frac{di_a}{dt} = L_s di_u/dt$$

$$v_{Lc} = L_s \frac{di_c}{dt} = -L_s \frac{di_u}{dt}$$

$$v_{comm} = v_{an} - v_{cn} = v_{La} - v_{Lc} = 2L_s \frac{di_u}{dt}$$

$$L_s \frac{di_u}{dt} = \frac{v_{an} - v_{cn}}{2}$$

Commutation interval

$$v_{an} - v_{cn} = \sqrt{2} V_{LL} \sin \omega t$$

$$\omega L_s \int_0^{I_d} di_u = \omega L_s I_d = \frac{\sqrt{2} V_{LL}(1 - \cos u)}{2}$$

$$\cos u = 1 - \frac{2\omega L_s I_d}{\sqrt{2} V_{LL}}$$

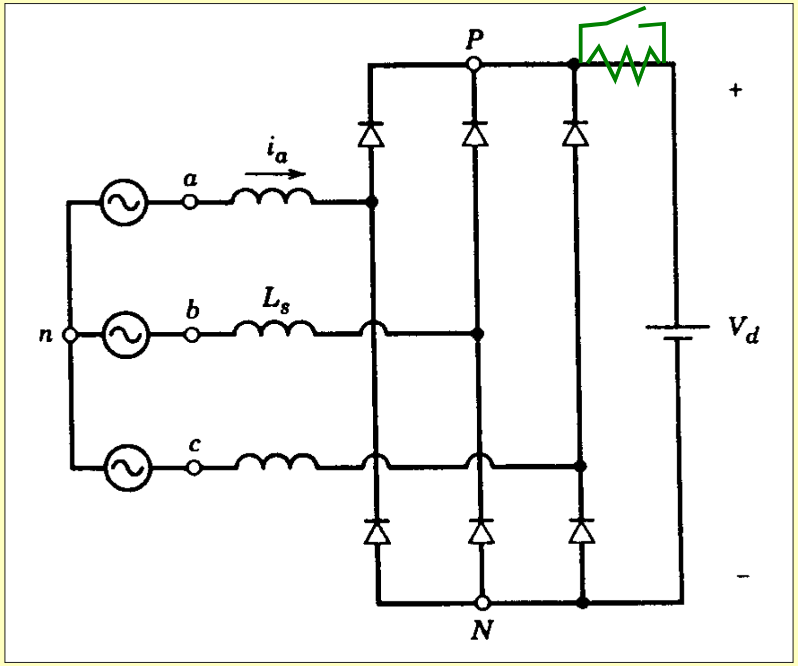
Corrected average DC-link voltage

$$V_d = V_{do} - \Delta V_d = 1.35 V_{LL} - \frac{3}{\pi} \omega L_s I_d$$

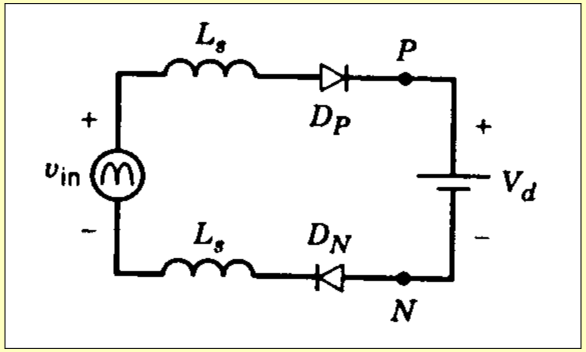
4. Constant DC-link voltage

Dis-continues current

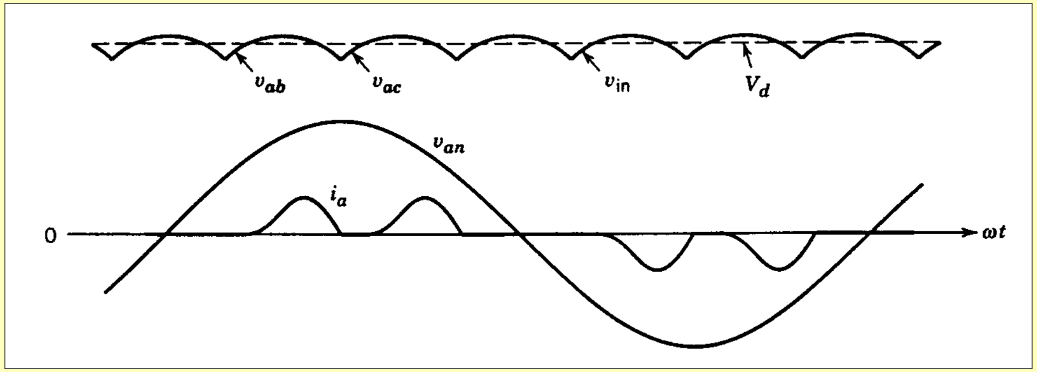
Inrush circuit



Simplified model

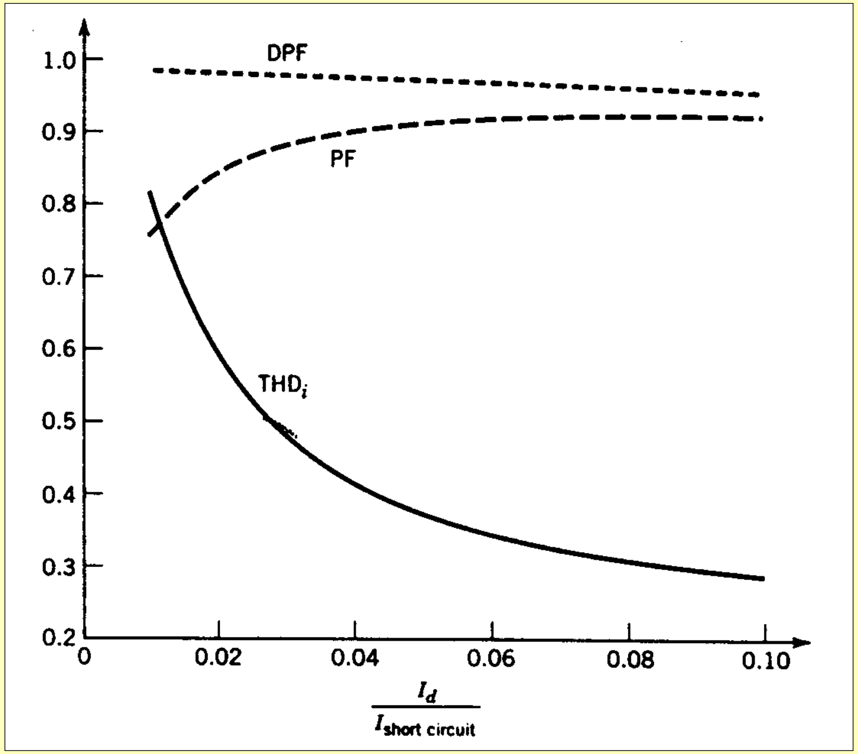


Line current

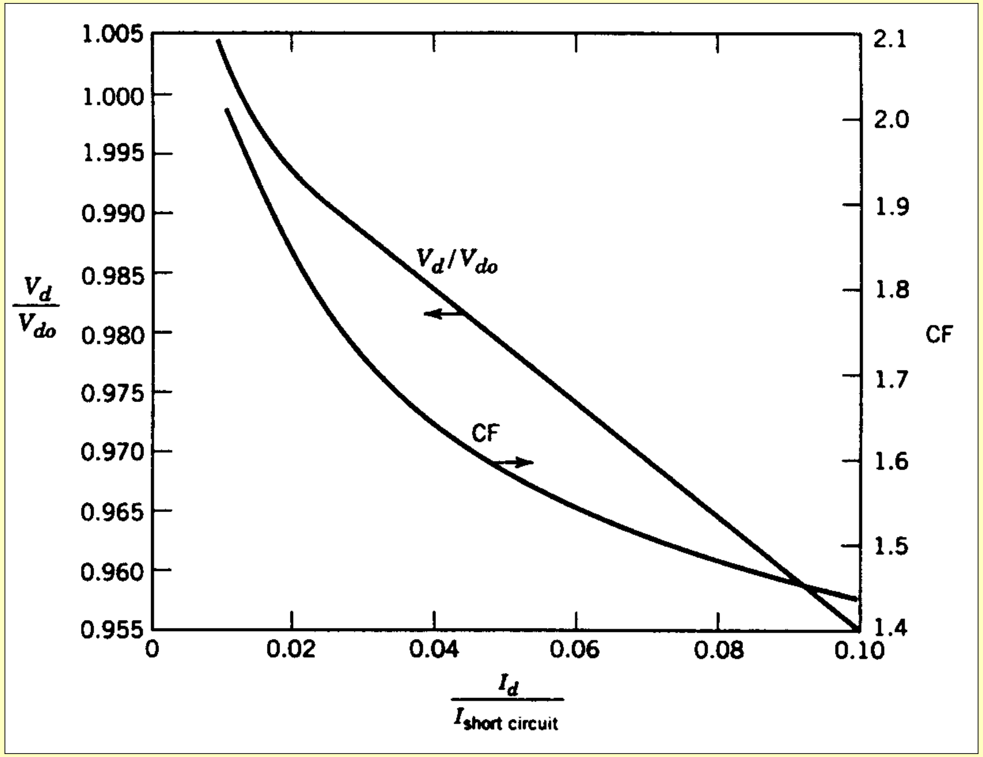


5. Charateristics

DPF, PF, THD$_i$



Voltage and Crest-factor



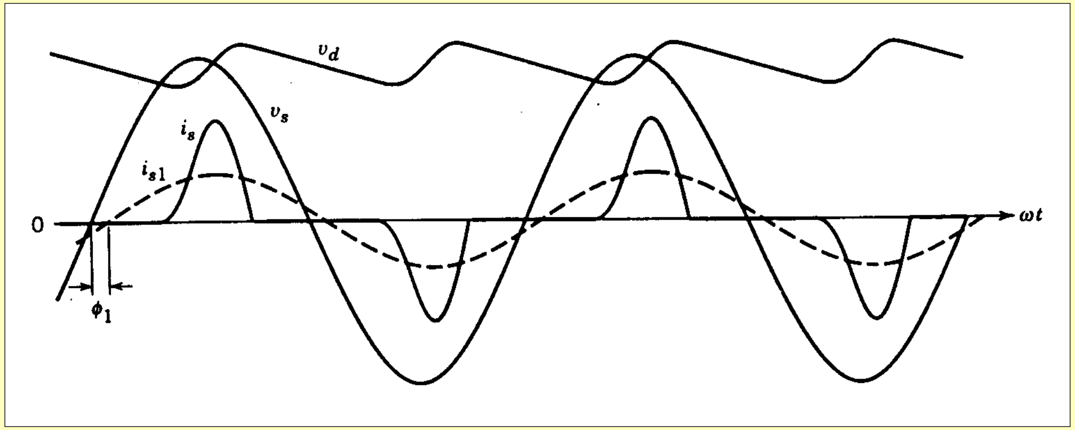
Short circuit current

$$I_{short\ circuit} = \frac{V_{LL}/\sqrt{3}}{\omega_1 L_s}$$

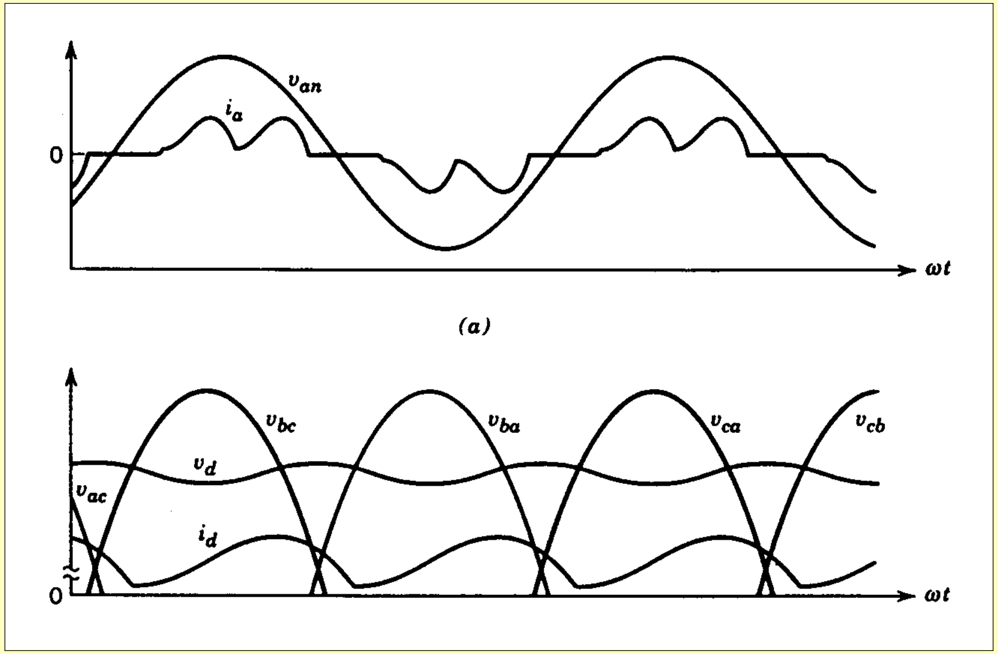
5. Charateristics

Comparison

Single phase



Three phase



6. Exercises

Exercise 7, PSpice-Simulation

Download from www.iet.auc.dk/~por/teaching/power/power.html