TSTE19 Power Electronics

- Lecture 12

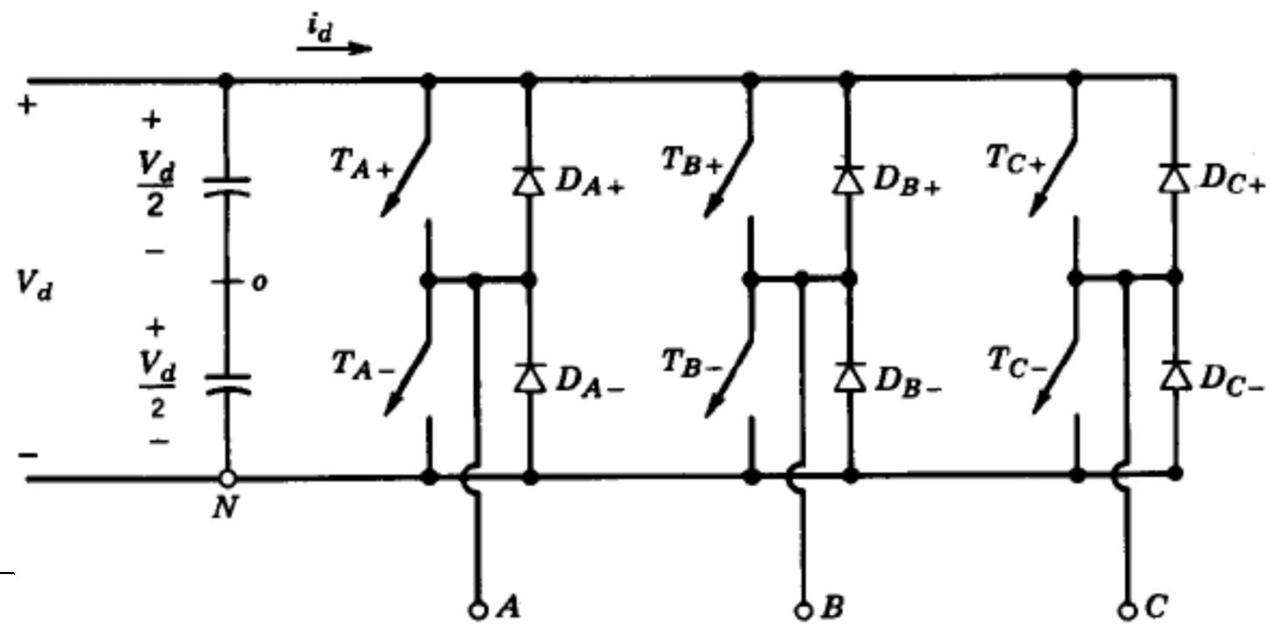
- Tomas Jonsson
- ISY/EKS

Outline

- DC-AC switching inverters
  - 3-phase inverter
  - Short circuit
  - Exercises

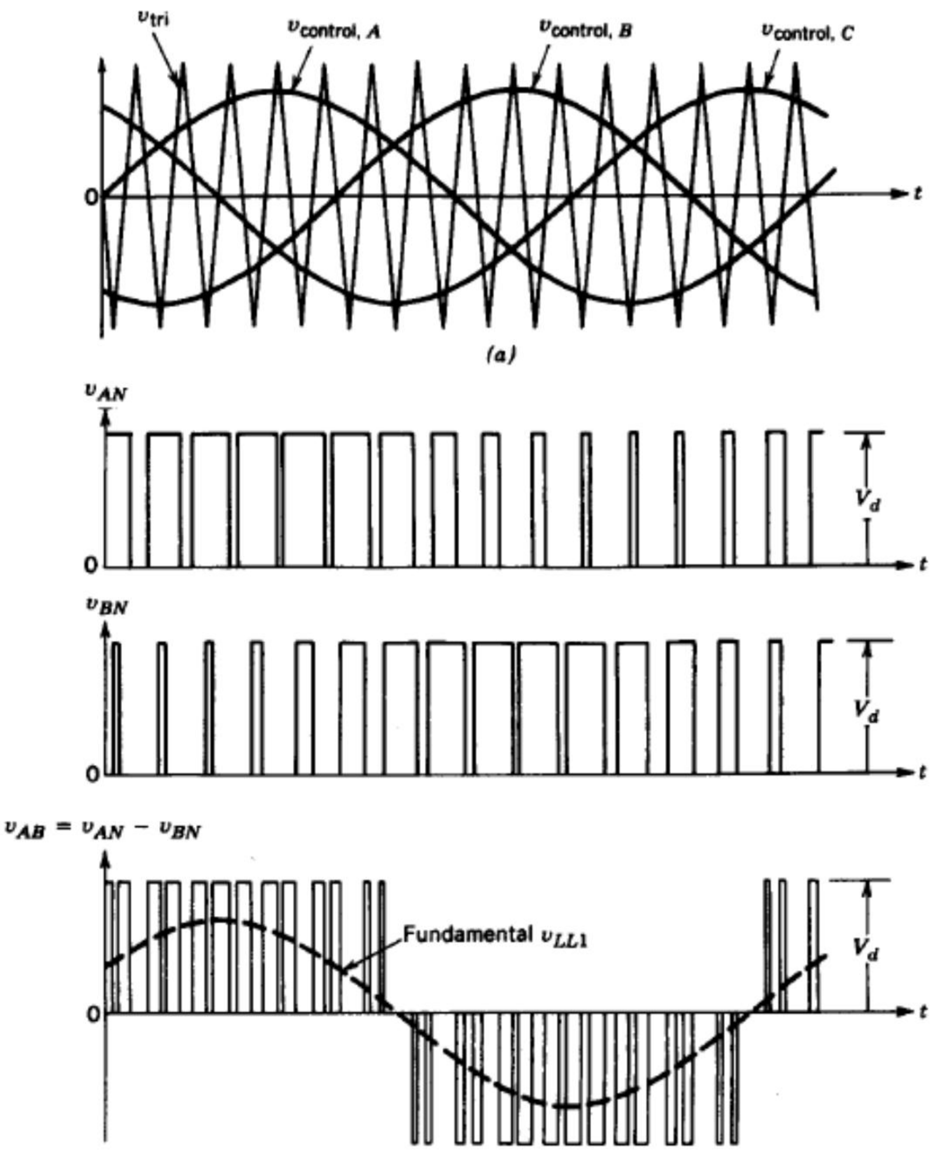
Three-phase inverters

- Three legs
- Controls phase shifted 120 °
- Midpoint not used



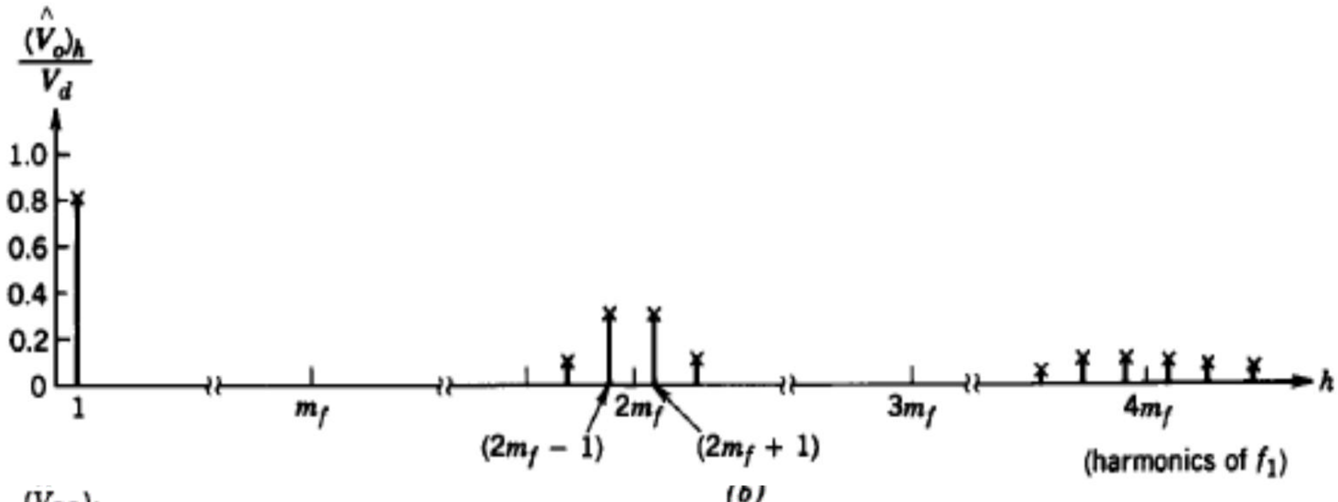
Three-phase inverter

- m_f odd multiple of 3
  - Reduce harmonics

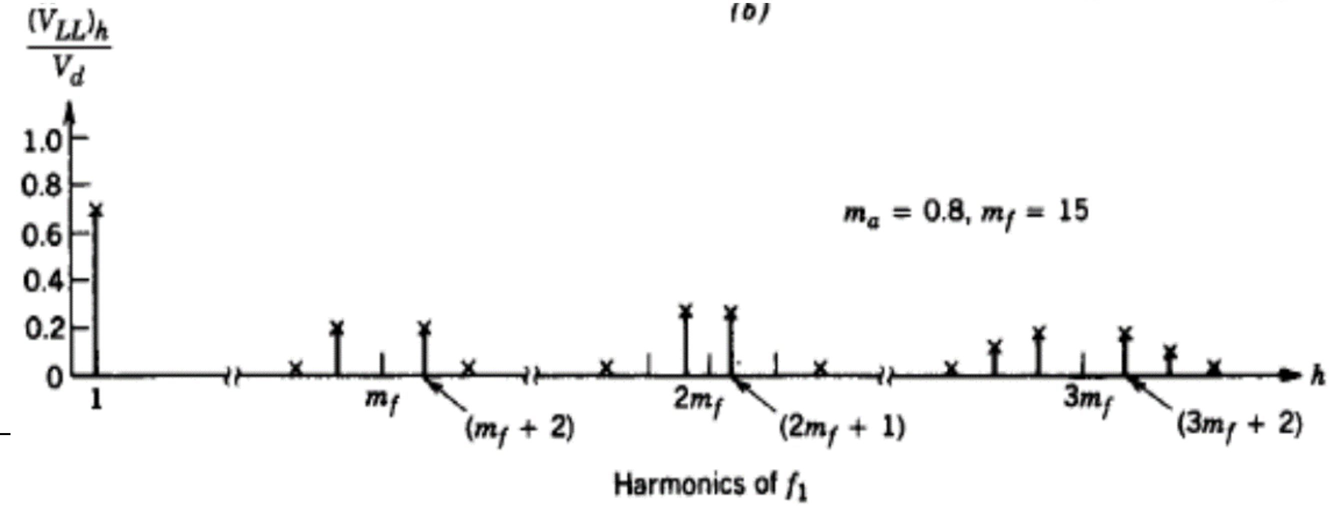


Harmonics of 3-ph vs 1-ph PWM

- 1-ph unipolar PWM



- 3-ph PWM



Three-phase inverter harmonics

Table 8-1 Generalized Harmonics of v_{Ao} for a Large m_f.

h \ m_a	0.2	0.4	0.6	0.8	1.0
1 Fundamental	0.2	0.4	0.6	0.8	1.0
m_f	1.242	1.15	1.006	0.818	0.601
$m_f \pm 2$	0.016	0.061	0.131	0.220	0.318
$m_f \pm 4$					0.018
$2m_f \pm 1$	0.190	0.326	0.370	0.314	0.181
$2m_f \pm 3$		0.024	0.071	0.139	0.212
$2m_f \pm 5$				0.013	0.033
$3m_f$	0.335	0.123	0.083	0.171	0.113
$3m_f \pm 2$	0.044	0.139	0.203	0.176	0.062
$3m_f \pm 4$		0.012	0.047	0.104	0.157
$3m_f \pm 6$				0.016	0.044
$4m_f \pm 1$	0.163	0.157	0.008	0.105	0.068
$4m_f \pm 3$	0.012	0.070	0.132	0.115	0.009
$4m_f \pm 5$			0.034	0.084	0.119
$4m_f \pm 7$				0.017	0.050

Note: $(\hat{V}_{Ao})_h/\frac{1}{2}V_d$ [$= (\hat{V}_{AN})_h/\frac{1}{2}V_d$] is tabulated as a function of m_a.

1-ph PWM

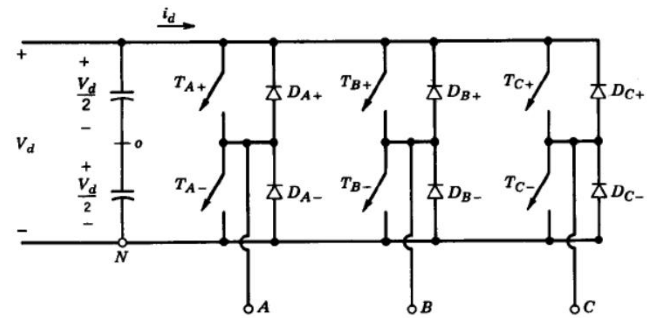
Table 8-2 Generalized Harmonics of v_{LL} for a Large and Odd m_f That Is a Multiple of 3.

h \ m_a	0.2	0.4	0.6	0.8	1.0
1	0.122	0.245	0.367	0.490	0.612
$m_f \pm 2$	0.010	0.037	0.080	0.135	0.195
$m_f \pm 4$				0.005	0.011
$2m_f \pm 1$	0.116	0.200	0.227	0.192	0.111
$2m_f \pm 5$				0.008	0.020
$3m_f \pm 2$	0.027	0.085	0.124	0.108	0.038
$3m_f \pm 4$		0.007	0.029	0.064	0.096
$4m_f \pm 1$	0.100	0.096	0.005	0.064	0.042
$4m_f \pm 5$			0.021	0.051	0.073
$4m_f \pm 7$				0.010	0.030

Note: $(V_{LL})_h/V_d$ are tabulated as a function of m_a where $(V_{LL})_h$ are the rms values of the harmonic voltages.

3-ph PWM

Output voltage magnitude

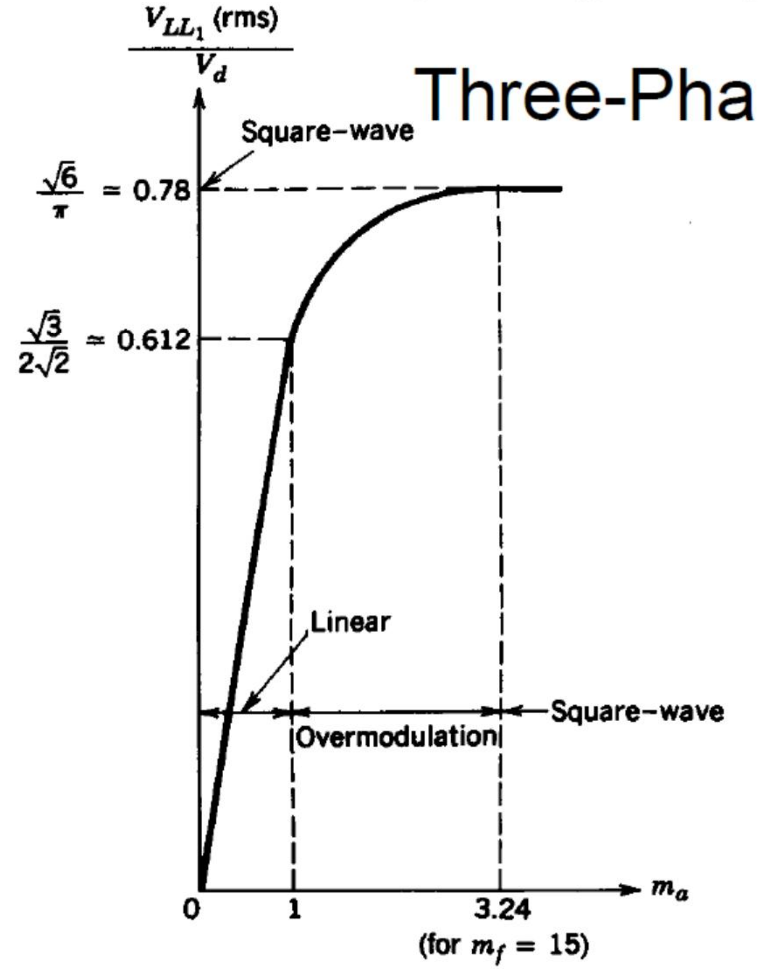


- Single phase ac-voltage:

$$\hat{V}_{AN1} = m_a \frac{V_d}{2}$$

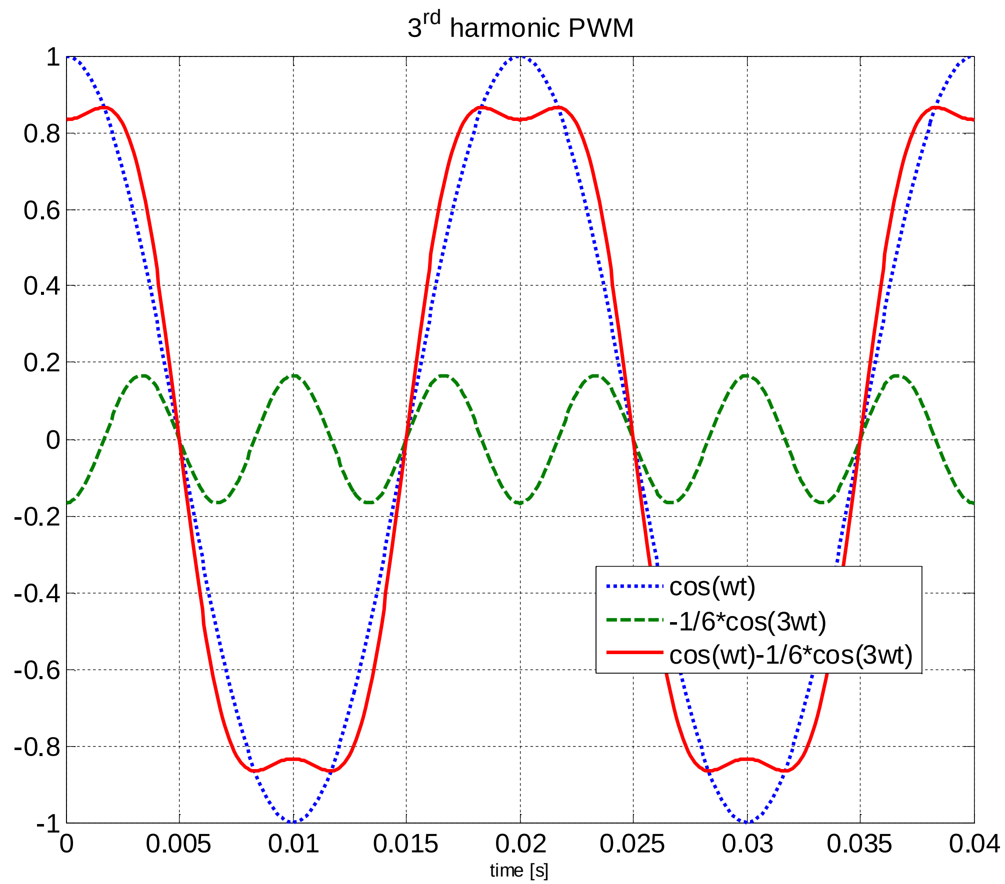
- Phase-phase (Line-Line):

$$\hat{V}_{LL1,rms} = m_a \frac{V_d}{2} \frac{\sqrt{3}}{\sqrt{2}}$$



3rd harmonic PWM

- $m_a = 1$
- Subtract a 3rd harmonic with magnitude 1/6
- Peak of total output voltage reduced to $87\% = \frac{\sqrt{3}}{2}$



3rd harmonic PWM, cont

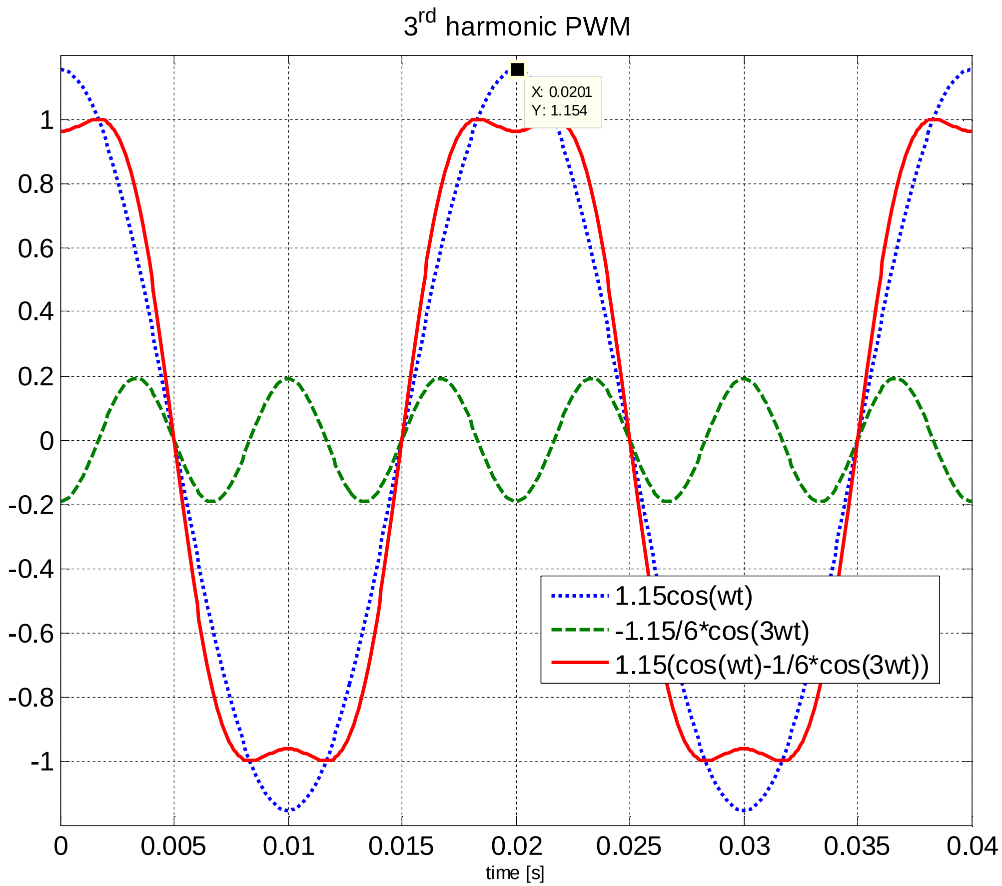
- $m_a = 1.15$
- Single phase ac-voltage:

$$\hat{V}_{AN1} = m_a \frac{V_d}{\sqrt{3}}$$

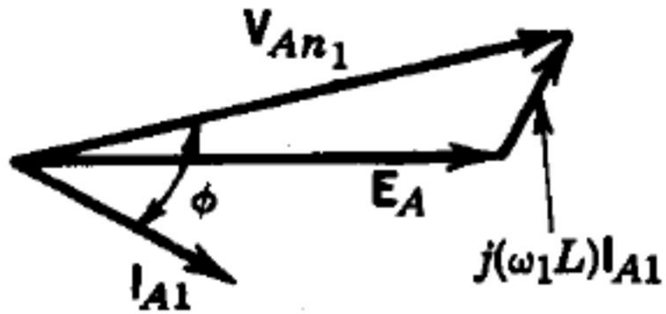
- Phase-phase (Line-Line):

$$\hat{V}_{LL1,rms} = m_a \frac{V_d}{\sqrt{2}}$$

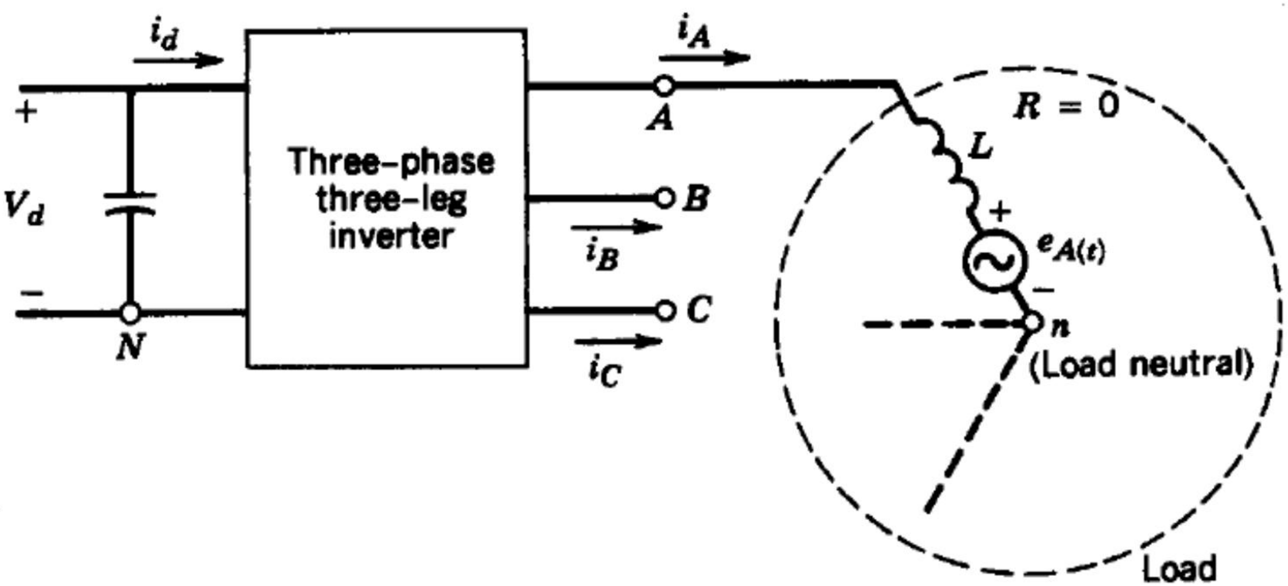
- Peak of total = 1



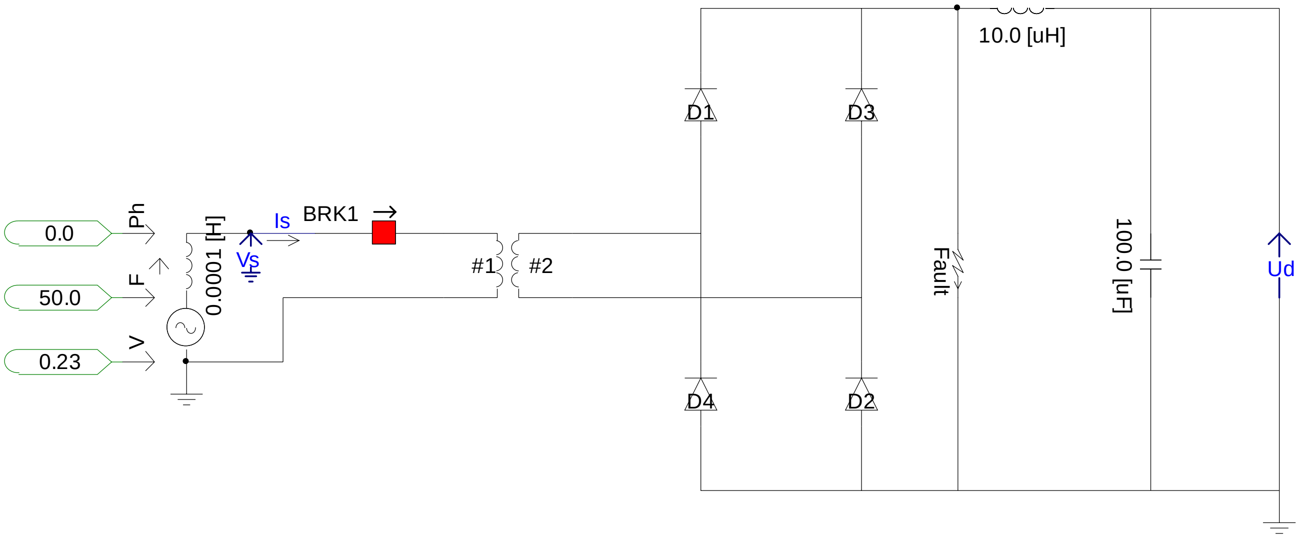
Three phase inverter ripple



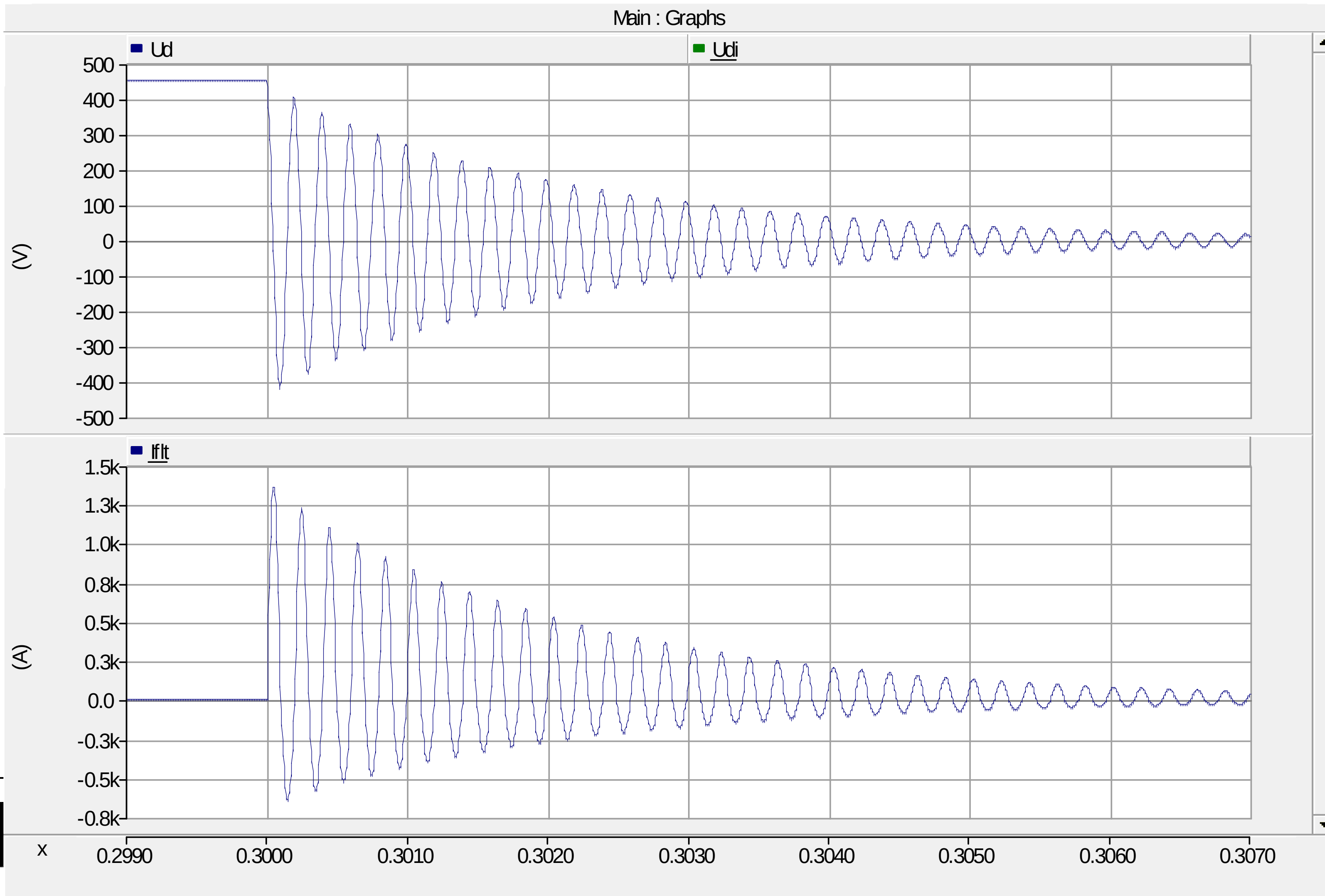
- All ripple across L
- 3rd harmonic PWM:
  3rd harmonic from the 3 phases add to zero



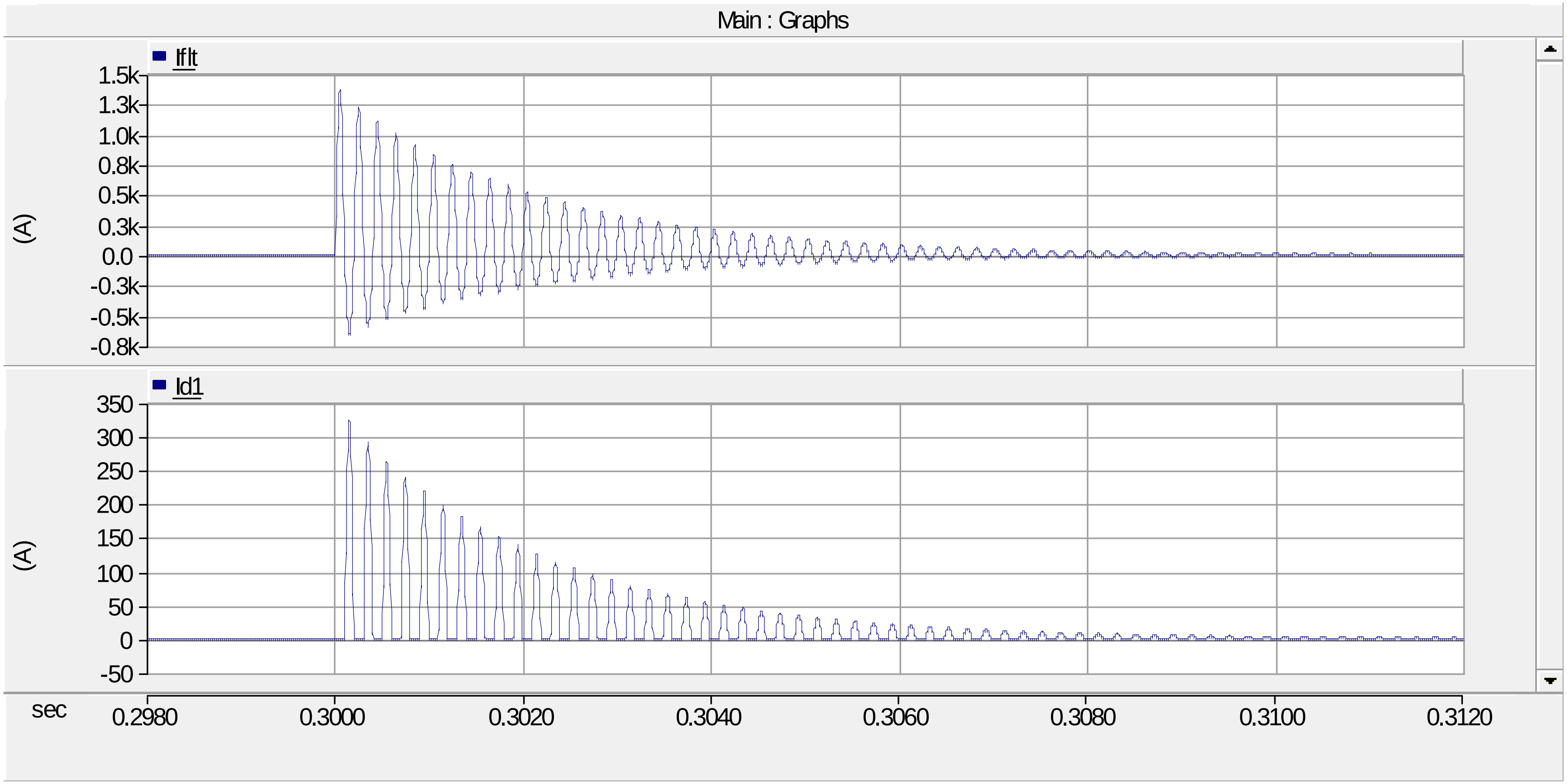
Short circuit



Short circuit current oscillation



Fault current and diode current



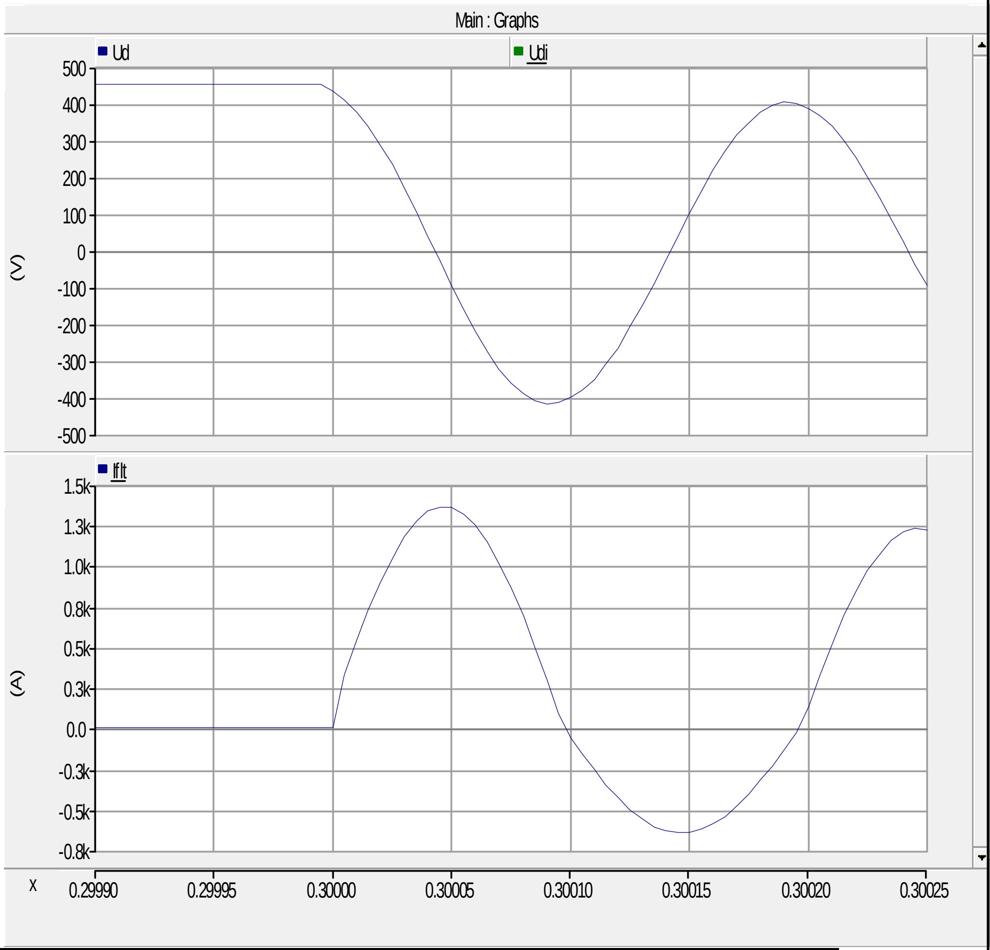
Short circuit current

- Peak current

$$\hat{I}_{sc} = \frac{U_d}{\sqrt{\frac{L}{C}}}$$

- Frequency of resonance

$$\omega_0 = \frac{1}{\sqrt{LC}}$$



Lecture 12

Exercises

12-100

a) Calculate the short circuit current in the Lab 3 circuit setup. Consider Q1 and Q2 to conduct ideally at the same time. Assume parasitic inductance to the dc-side being 50nH.

b) Is this peak current acceptable for the MOSFET without failure?

12-101

a) Calculate the MOSFET case and junction temperature at 25 C ambient for 0.95A rms load current. Neglect switching losses. Use the data sheet for thermal and electrical data of the MOSFET. Consider a MOSFET without heatsink.

b) Calculate the required thermal resistance (R_{th}) of the heatsink to keep the case temperature below 80 C when the peak current of the MOSFET is 20A. Neglect switching losses.

c) What is the junction temperature in this case?

www.liu.se