Three-phase Rectifiers

Lecture 12

Electrical Engineering Department

Power Electronics and Special Machine

By

Dr. Mustafa Fadel

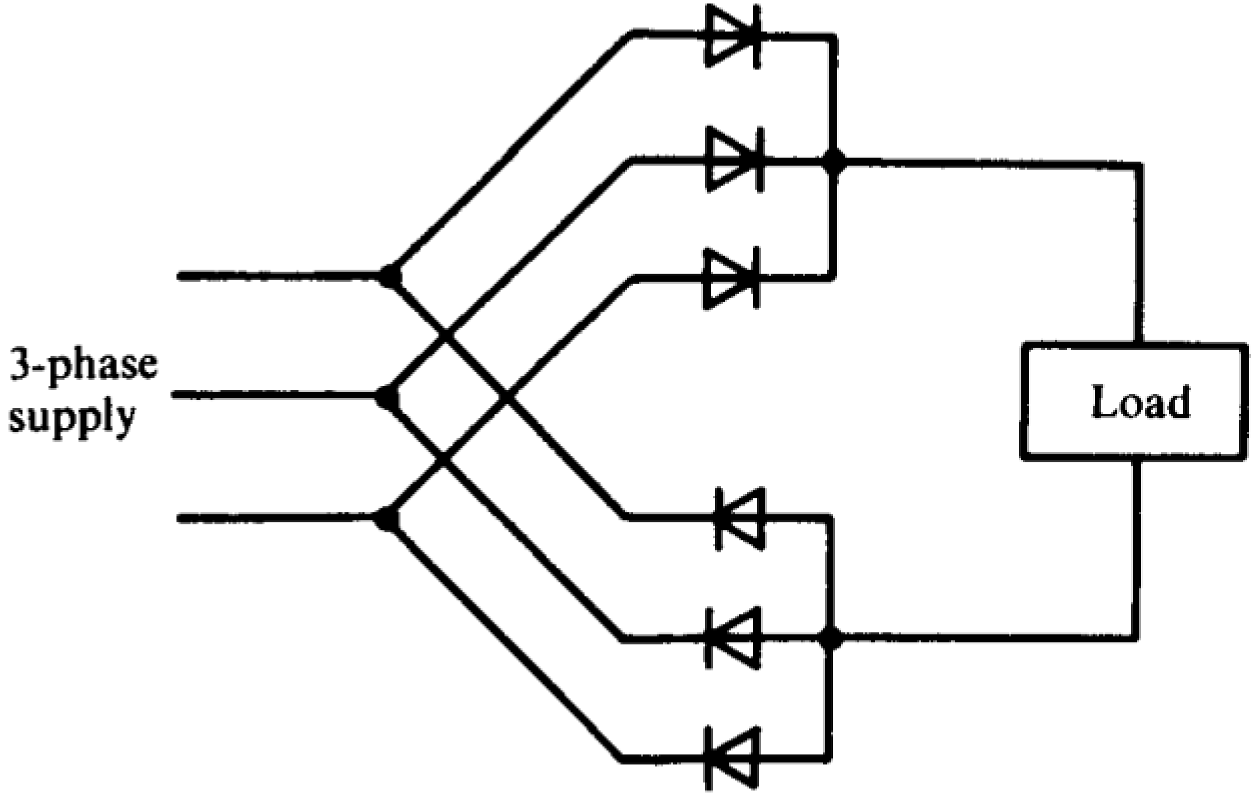
Important Notice

Note to Students:

These lecture materials are provided as supplementary support to help clarify and reinforce the concepts discussed in the main course lectures. They are not a substitute for the official course materials or the primary references assigned. Students are encouraged to refer to the original sources and attend the main lectures to ensure full understanding of the subject.

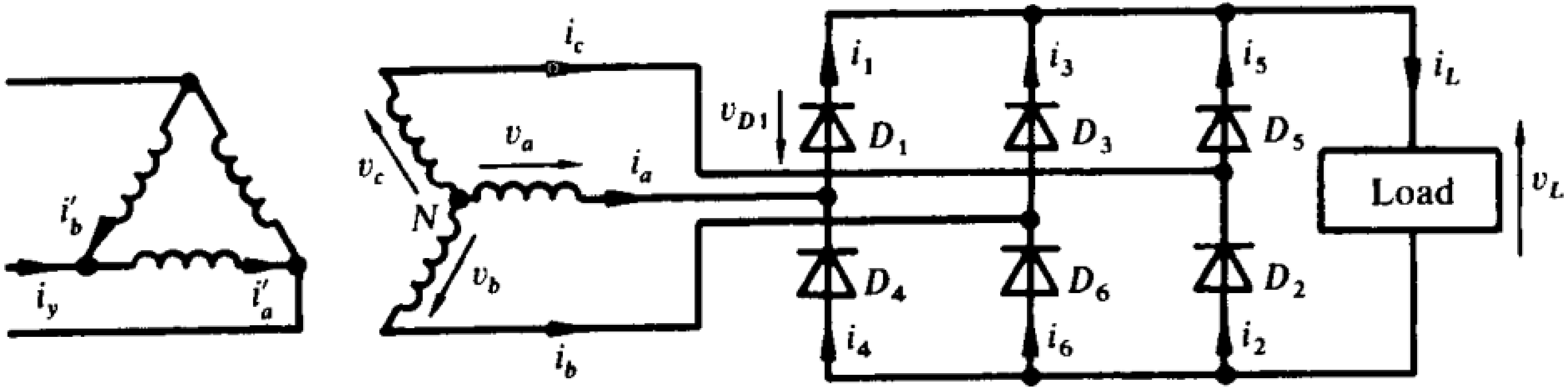
Uncontrolled Three-phase Bridge Rectifier(or Double-way)

The circuit of three-phase bridge rectifier feeding load is shown below

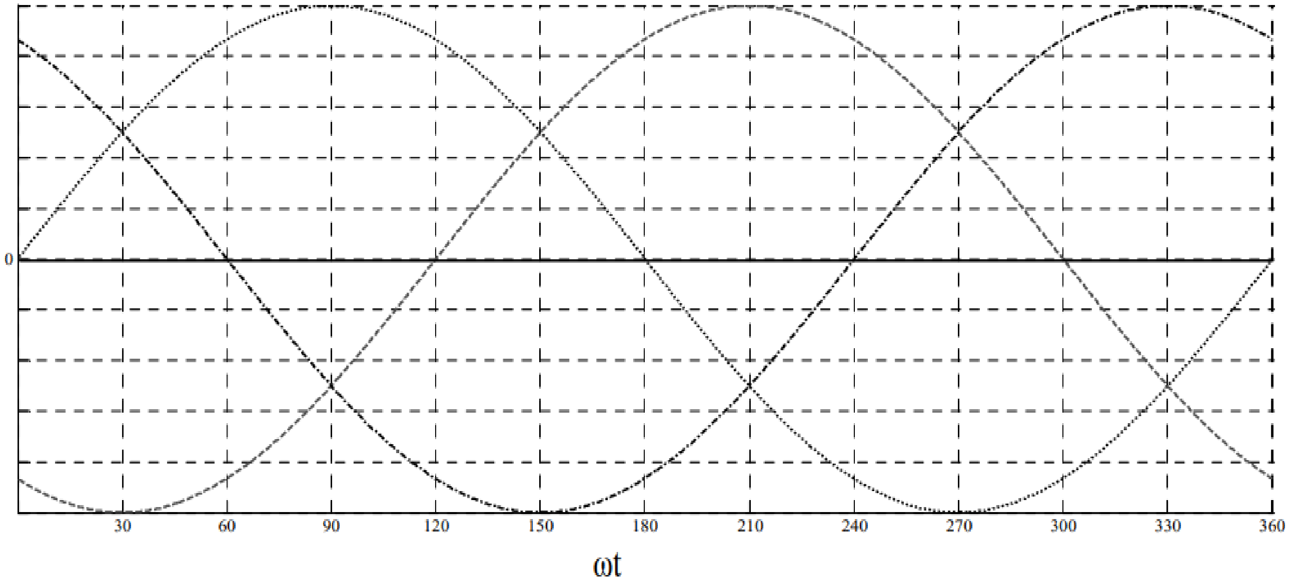


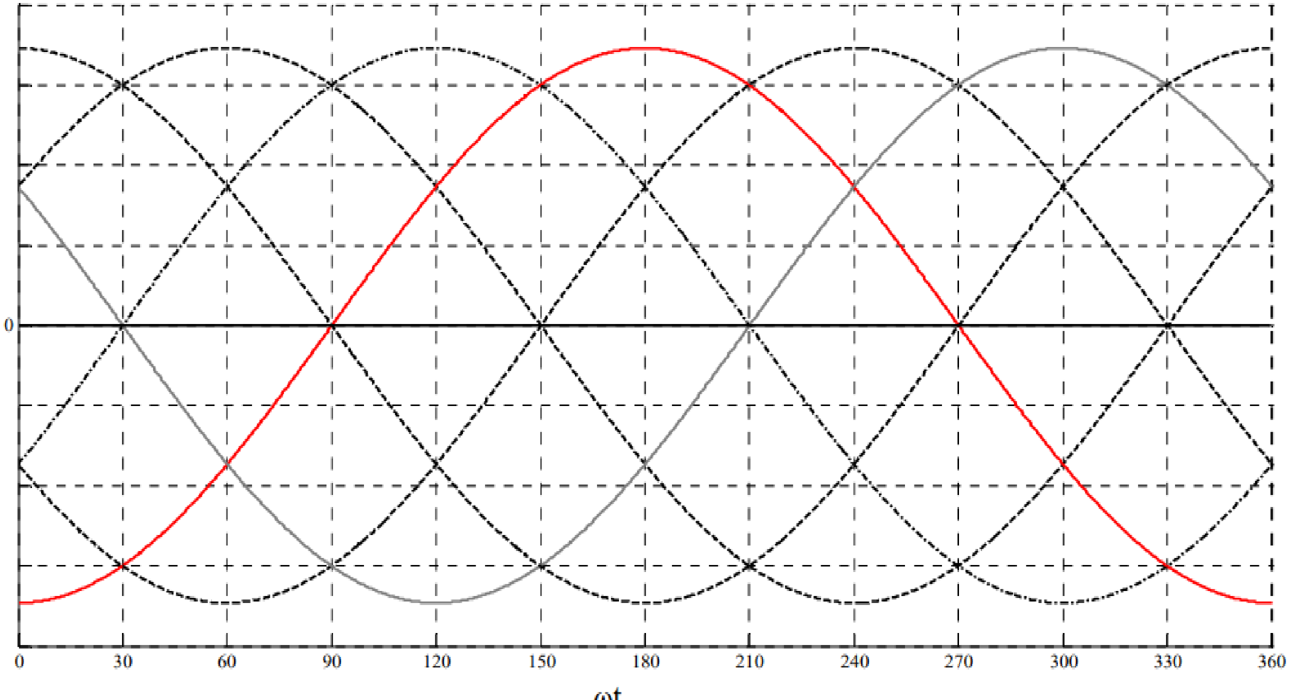
Uncontrolled Three-phase Bridge Rectifier(or Double-way)

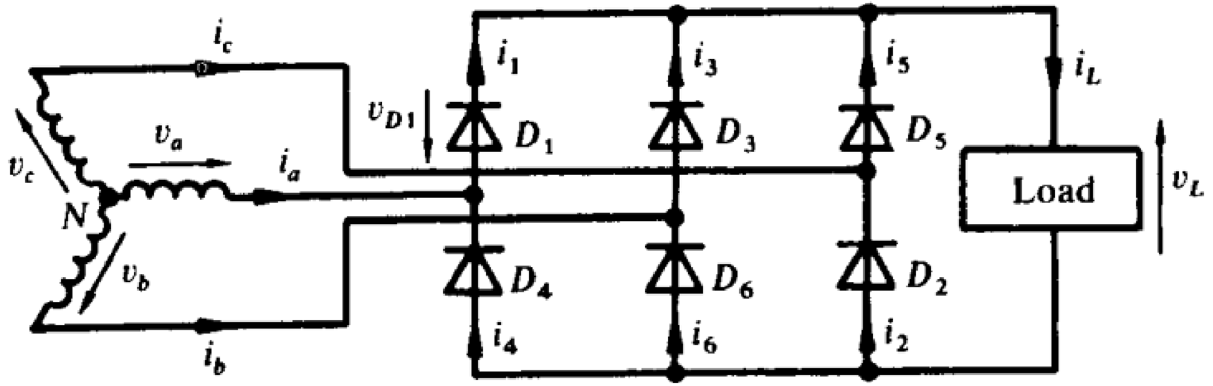
Another representation for circuit of three-phase uncontrolled bridge rectifier feeding load is shown below:



Uncontrolled Three-phase Bridge Rectifier(or Double-way)







Uncontrolled Three-phase Bridge Rectifier(or Double-way)

The six voltages of three-phase bridge rectifier can be written as:

$$V_{ab} = V_a - V_b = \sqrt{3}\, V_m \sin(\omega t + 30°)$$

$$V_{ac} = V_a - V_c = \sqrt{3}\, V_m \sin(\omega t - 30°)$$

$$V_{bc} = V_b - V_c = \sqrt{3}\, V_m \sin(\omega t - 90°)$$

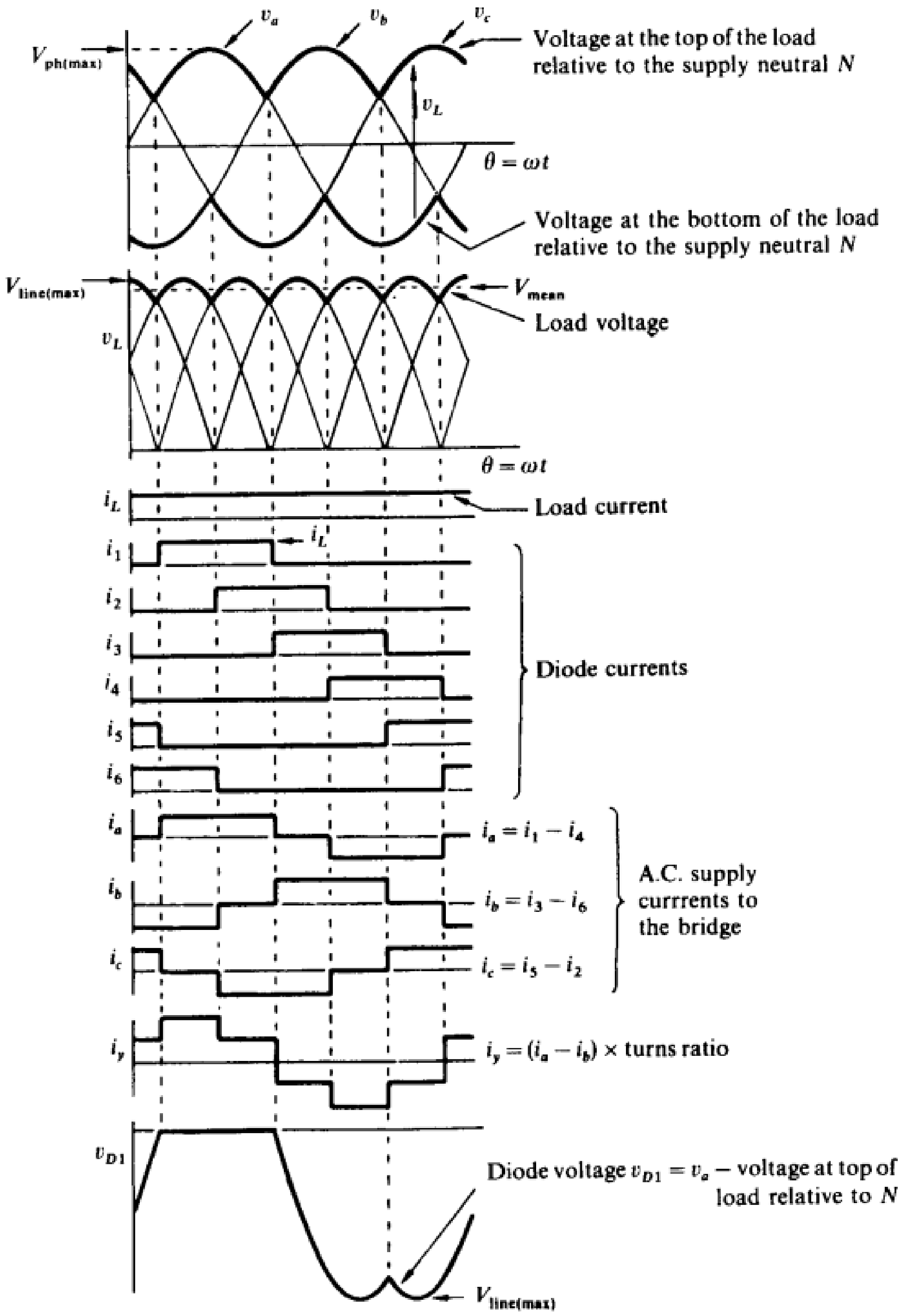
$$V_{ba} = V_b - V_a = \sqrt{3}\, V_m \sin(\omega t - 150°)$$

$$V_{ca} = V_c - V_a = \sqrt{3}\, V_m \sin(\omega t - 210°)$$

$$V_{cb} = V_c - V_b = \sqrt{3}\, V_m \sin(\omega t + 270°)$$

Uncontrolled Three-phase Bridge Rectifier(or Double-way)

The waveforms of three-phase full-wave rectifier feeding load is shown:



The mean load voltage is

$$V_{mean} = \frac{1}{2\pi/6}\int_{\frac{\pi}{3}}^{\frac{2\pi}{3}} V_{line}\sin(\omega t)\, d\omega t$$

$$V_{mean} = \frac{3V_{line}}{\pi} \text{ or } \frac{3\sqrt{3}V_{phase}}{\pi}$$

Uncontrolled Three-phase Bridge Rectifier(or Double-way)

Example: A three-phase bridge uncontrolled rectifier supplies a DC load of 300 V, 60 A from a 415 V, 3-phase AC supply via a delta-star transformer. Determine the required diode and transformer specification. Assume a diode voltage drop of 0.7 V and continuous load current.

Uncontrolled Three-phase Bridge Rectifier(or Double-way)

Solution:

$$V_{mean} = \frac{3V_{line}}{\pi} - (2 \times 0.7)$$

$$300 = \frac{3V_{line}}{\pi} - 1.4$$

$$V_{line} = 315.6\ V$$

$$V_{phase} = \frac{V_{line}}{\sqrt{3}} = 182.211\ V$$

$$V_{phase,rms} = \frac{V_{phase}}{\sqrt{2}} = 128.9\ V$$

Uncontrolled Three-phase Bridge Rectifier(or Double-way)

Solution:

Diode rating, P.R.V= V_{line}=315.6 V

$$I_{rms} = \frac{60}{\sqrt{3}} = 34.6\ A$$

Secondary phase current RMS value $\left(\frac{60^2+60^2}{3}\right)^{1/2} = 49\ A$

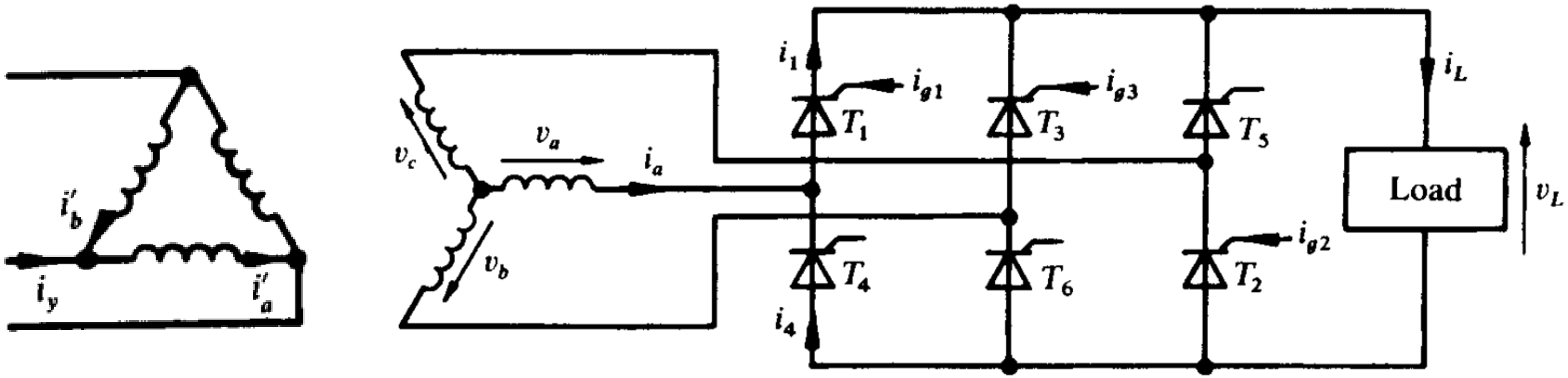
Transformer rating=3 x 315.6 x 49= 18.9 kVA

Transformer ratio = (Primary/ Secondary) = 415/128.9

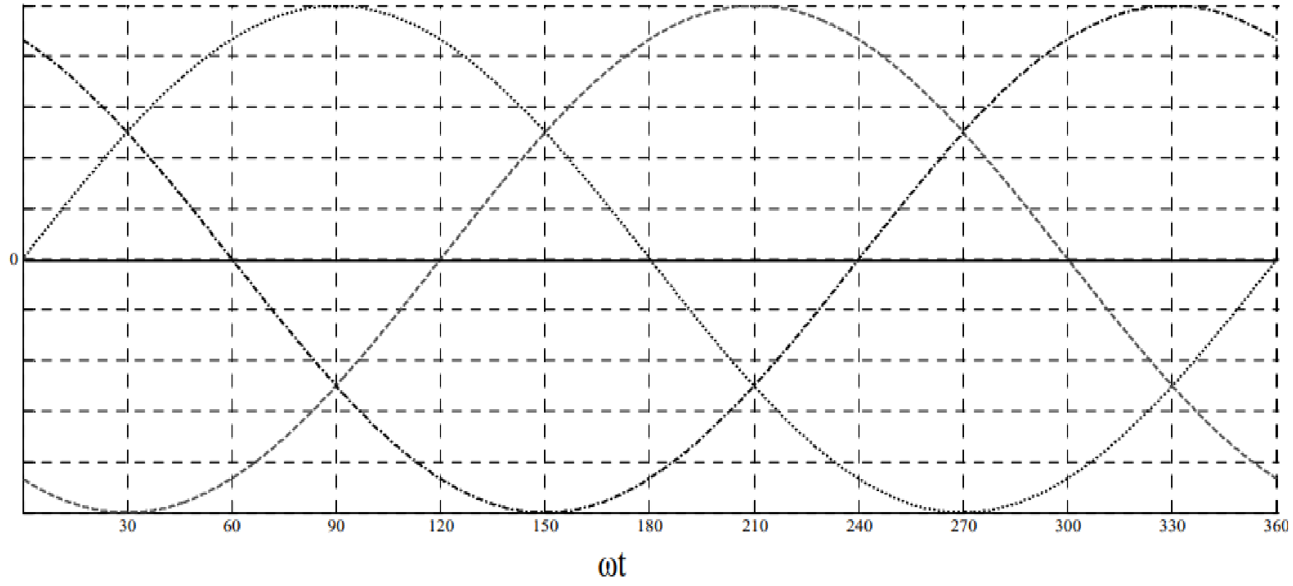
Primary phase RMS current= 49 x (128.9/415)=15.2 A

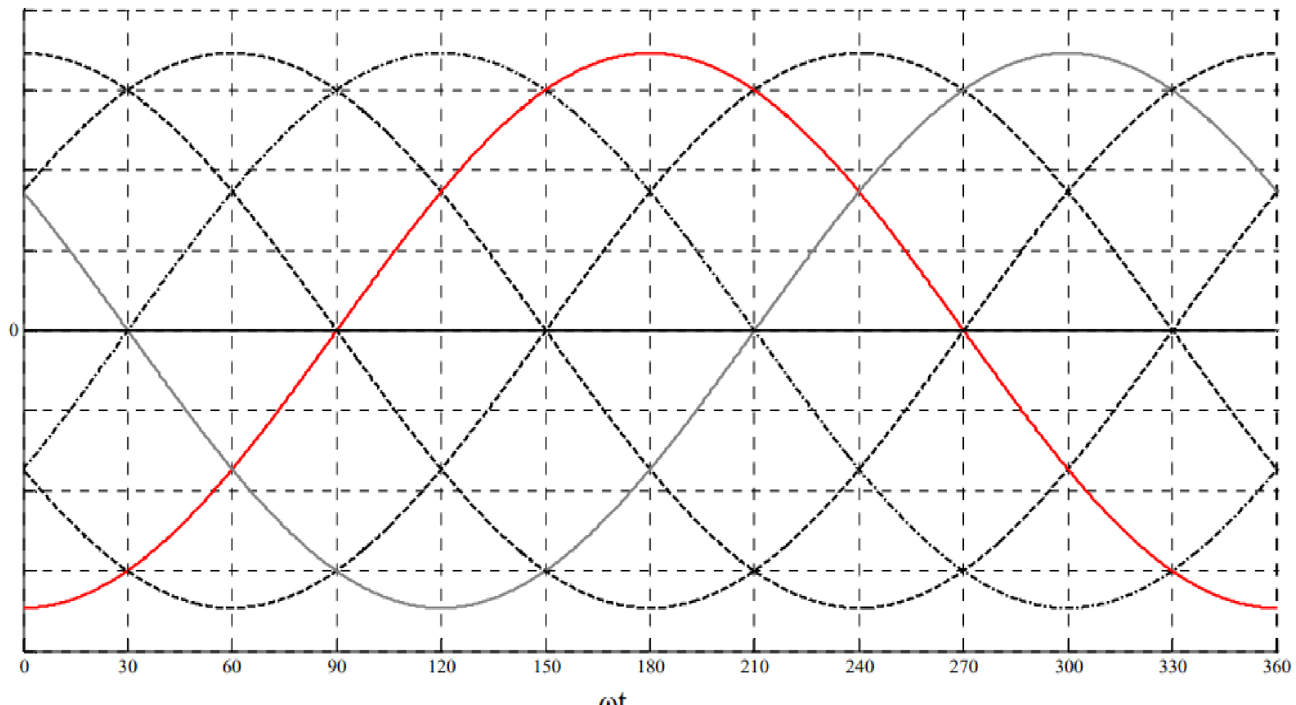
Fully Controlled Three-phase Bridge Rectifier

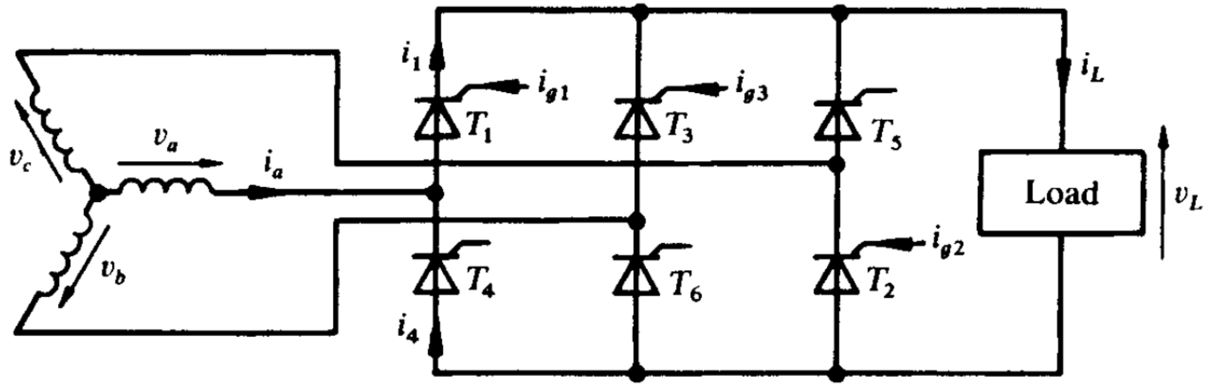
The circuit of three-phase fully controlled bridge rectifier feeding load is shown below:



Fully Controlled Three-phase Bridge Rectifier

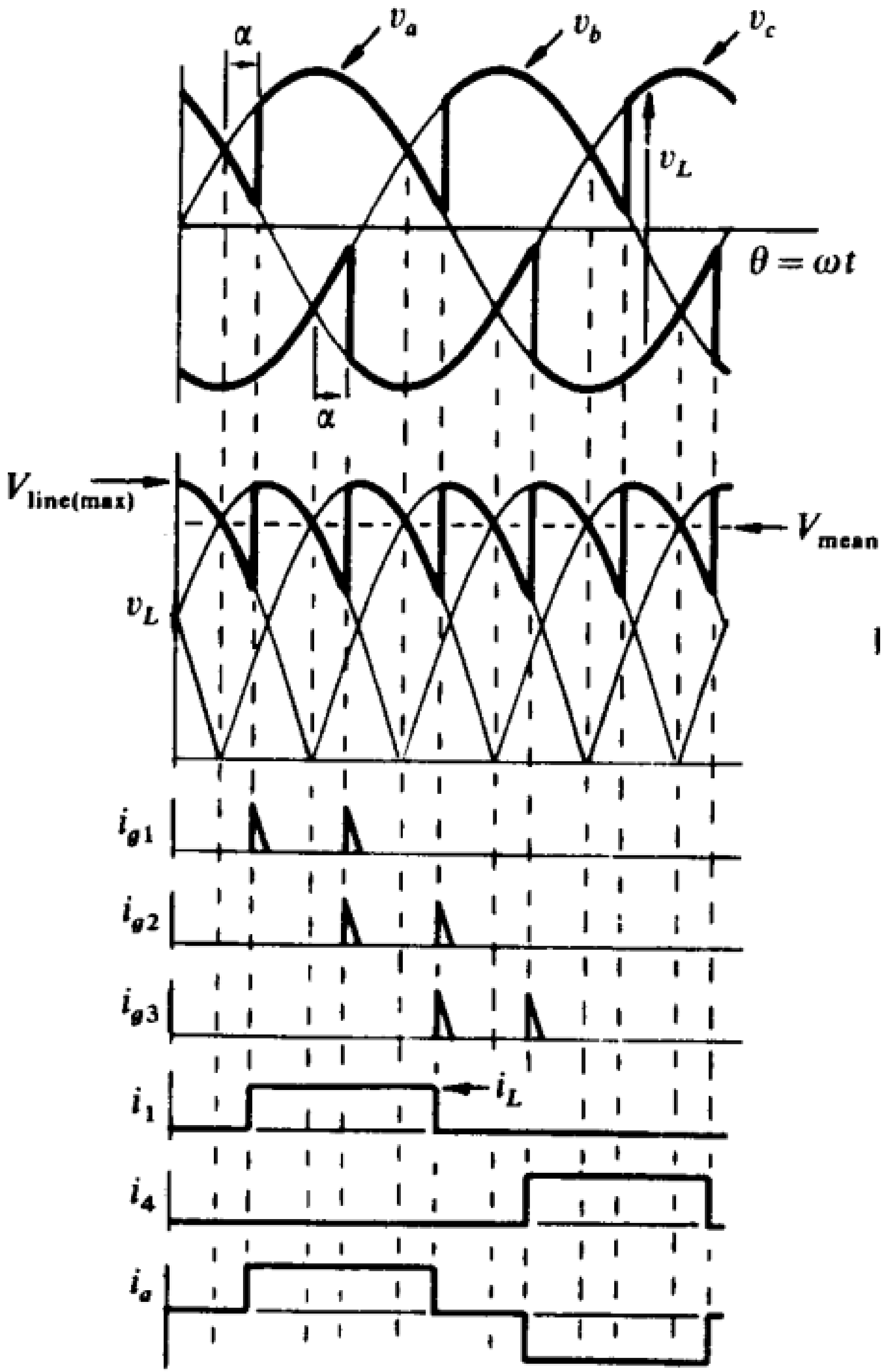






Fully Controlled Three-phase Bridge Rectifier

The waveforms of three-phase full-wave rectifier feeding load is shown:



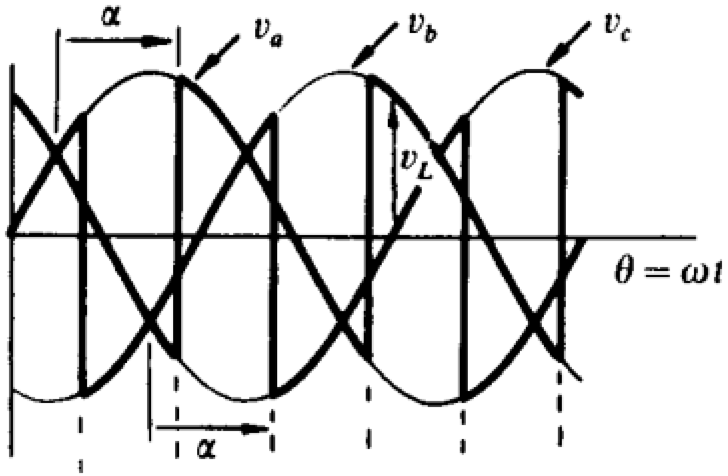
The mean load voltage is

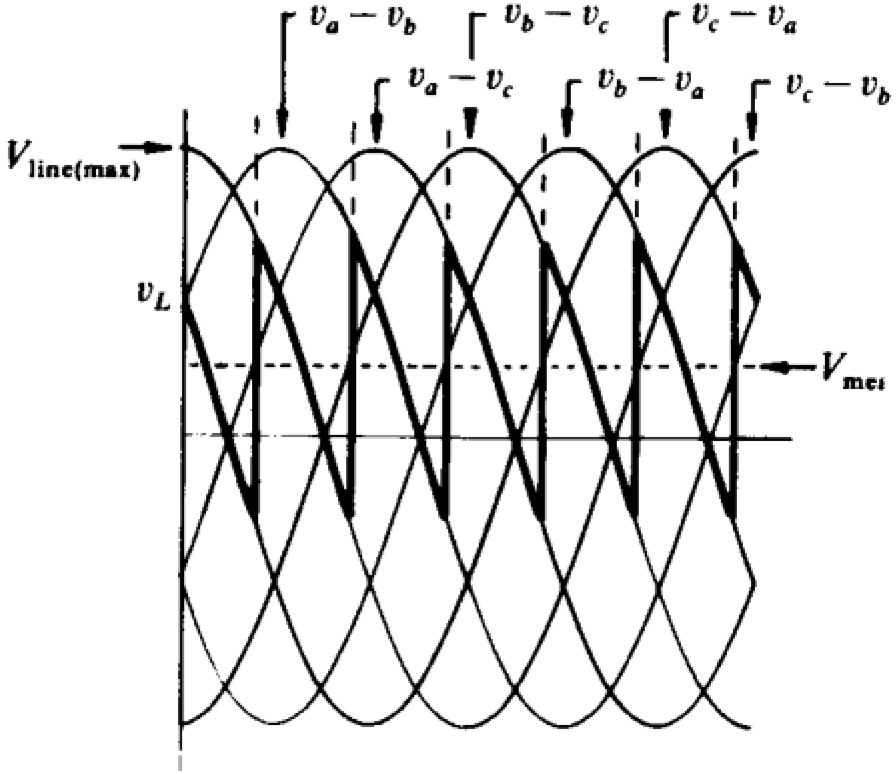
$$V_{mean} = \frac{1}{2\pi/6} \int_{\frac{\pi}{3}+\alpha}^{\frac{2\pi}{3}+\alpha} V_{line} \sin(\omega t) \, d\omega t$$

$$V_{mean} = \frac{3V_{line}}{\pi} \cos\alpha \ \text{ or } \frac{3\sqrt{3}V_{phase}}{\pi} \cos\alpha$$

Fully Controlled Three-phase Bridge Rectifier

The waveforms of three-phase full-wave rectifier feeding load is shown:





The mean load voltage is

$$V_{mean} = \frac{1}{2\pi/6}\int_{\frac{\pi}{3}+\alpha}^{\frac{2\pi}{3}+\alpha} V_{line}\sin(\omega t)\, d\omega t$$

$$V_{mean} = \frac{3V_{line}}{\pi}\cos\alpha \text{ or } \frac{3\sqrt{3}V_{phase}}{\pi}\cos\alpha$$

Fully Controlled Three-phase Bridge Rectifier

Example: A fully-controlled three-phase rectifier bridge circuit is supplied by line voltage of 220 V. Assuming continuous load current and a thyristor voltage drop of 1.5 V, determine the mean load voltage at firing delay angles of 0°, 30°, 45°, 60°, and 90°. Plot the waveform of the thyristor voltage at a firing delay angle of 75°.

Fully Controlled Three-phase Bridge Rectifier

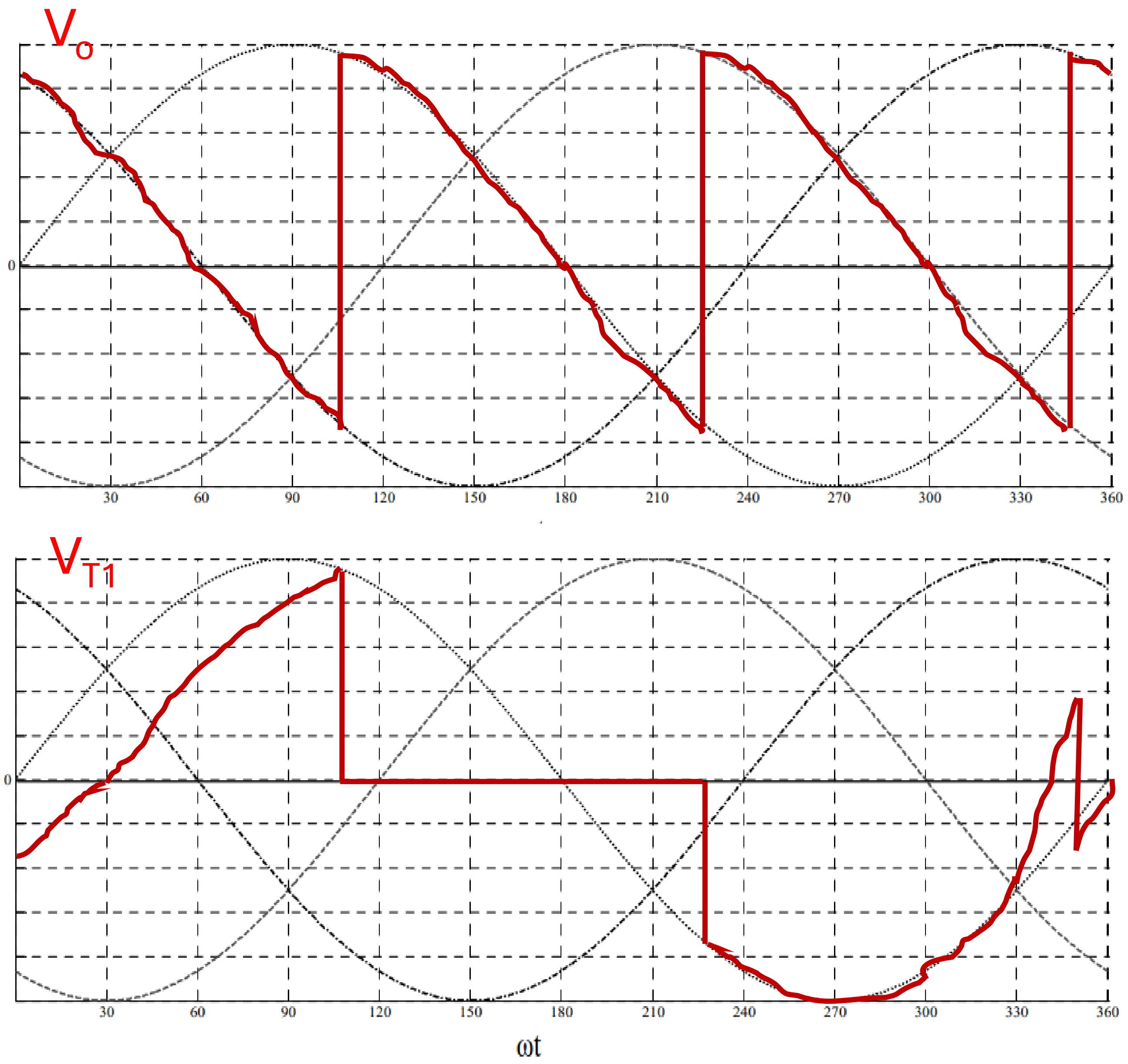
Solution:

$$V_{mean} = \frac{3V_{line}}{2\pi}\cos\alpha - (2 \times 1.5) = \frac{3 \times 220\sqrt{2}}{2\pi}\cos\alpha - (2 \times 1.5)$$

α	0°	30°	45°	60°	90°
V_{mean}	294 V	254 V	207V	146 V	0 V

Fully Controlled Three-phase Bridge Rectifier

Solution: The voltage across thyristor T_1 is given by the phase-A source voltage Va minus the load voltage Vo, i.e., $V_{T1}=Va-Vo$



Thanks for listening!