

ELECTROTECHNICS

POWER ELECTRONICS

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POWER ELECTRONICS

Example 1

Assignment

To the mains 3x400/230V these rectifiers are connected:

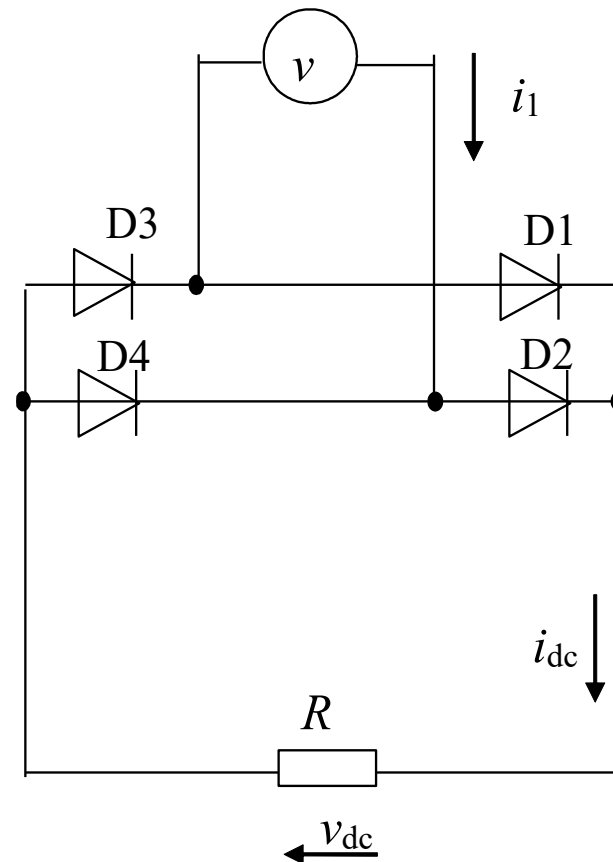
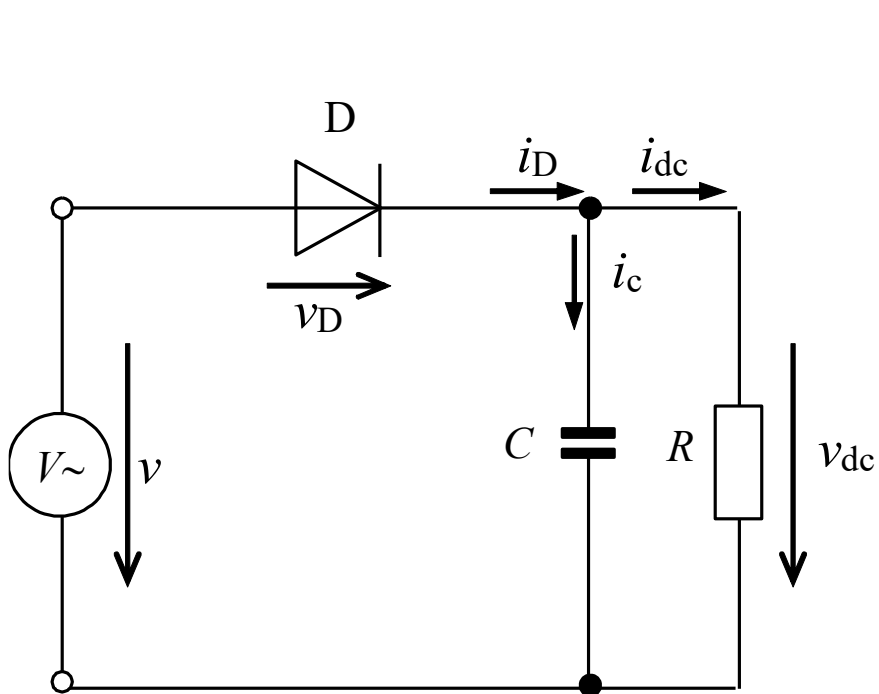
- 1) Half-wave single-phase rectifier**
- 2) Full-wave single-phase rectifier**
- 3) Half-wave three-phase rectifier**
- 4) Full-wave three-phase rectifier**

A 100 Ω resistor is connected to the each rectifier. Calculate mean value of voltage, current and power on the resistor.

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Example 1

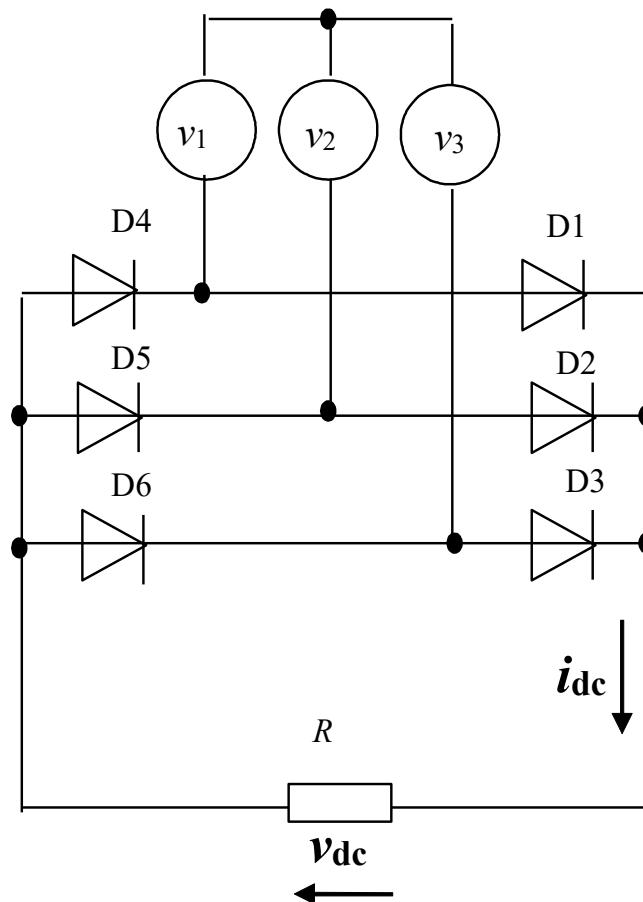
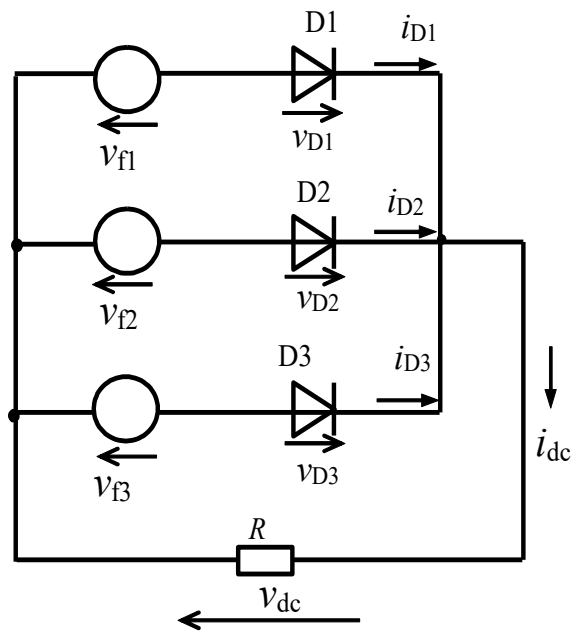
Rectifier wiring diagrams: single-phases



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Example 1

Rectifier wiring diagrams: three-phases



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Example 1

Solution

1) Half-wave single-phase rectifier:

phase voltage: $V_f = 230\text{V}$

resistor mean value voltage:

$$V_{\text{av}} = 0,45 \cdot V_f = 0,45 \cdot 230 = 103,5 \text{ V}$$

resistor mean value current:

$$I_{\text{av}} = \frac{V_{\text{av}}}{R} = \frac{103,5}{100} = 1,035 \text{ A}$$

resistor power:

$$P_{\text{av}} = V_{\text{av}} \cdot I_{\text{av}} = 103,5 \cdot 1,035 = 107 \text{ W}$$

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Example 1

Solution

2) Full-wave single-phase rectifier:

phase voltage: $V_f = 230\text{V}$

resistor mean value voltage:

$$V_{\text{av}} = 0,9 \cdot V_f = 0,9 \cdot 230 = 207 \text{ V}$$

resistor mean value current:

$$I_{\text{av}} = \frac{V_{\text{av}}}{R} = \frac{207}{100} = 2,07 \text{ A}$$

resistor power:

$$P_{\text{av}} = V_{\text{av}} \cdot I_{\text{av}} = 207 \cdot 2,07 = 429 \text{ W}$$

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Example 1

Solution

3) Half-wave three-phase rectifier:

phase voltage: $V_f = 230\text{V}$

resistor mean value voltage:

$$V_{\text{av}} = 1,17 \cdot V_f = 1,17 \cdot 230 = 269,1 \text{ V}$$

resistor mean value current:

$$I_{\text{av}} = \frac{V_{\text{av}}}{R} = \frac{269,1}{100} = 2,69 \text{ A}$$

resistor power:

$$P_{\text{av}} = V_{\text{av}} \cdot I_{\text{av}} = 269,1 \cdot 2,69 = 724 \text{ W}$$

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Example 1

Solution

4) Full-wave three-phase rectifier:

phase voltage: $V_f = 230\text{V}$

resistor mean value voltage:

$$V_{\text{av}} = 2,34 \cdot V_f = 2,34 \cdot 230 = 538,2 \text{ V}$$

resistor mean value current:

$$I_{\text{av}} = \frac{V_{\text{av}}}{R} = \frac{538,2}{100} = 5,38 \text{ A}$$

resistor power:

$$P_{\text{av}} = V_{\text{av}} \cdot I_{\text{av}} = 538,2 \cdot 5,38 = 2896 \text{ W}$$

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Example 2

Assignment

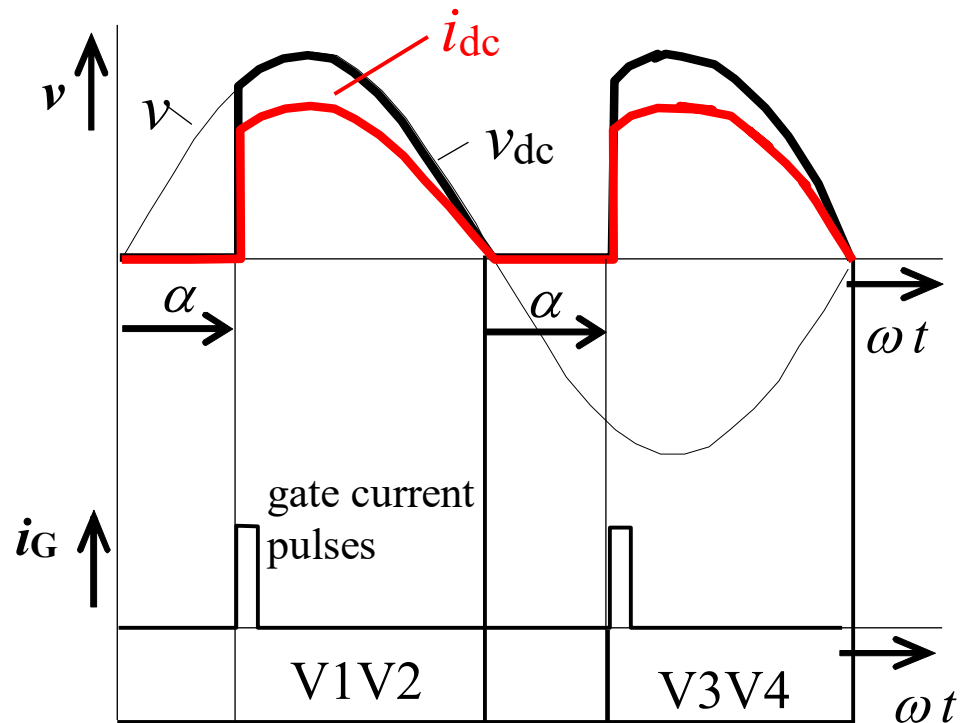
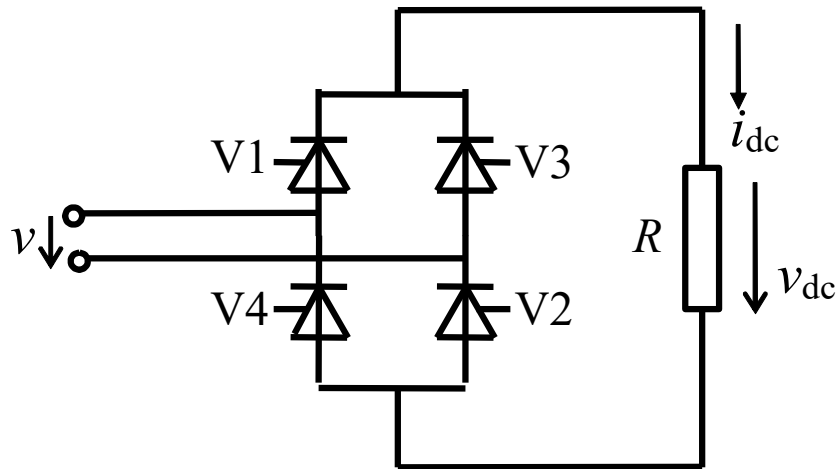
The controlled single-phase rectifier is connected to the phase voltage of the mains 3x400/230V. Calculate mean value of the voltage on a resistance load for firing angles listed below:

- 1) $\alpha=0^\circ$**
- 2) $\alpha=30^\circ$**
- 3) $\alpha=60^\circ$**
- 4) $\alpha=90^\circ$**
- 5) $\alpha=120^\circ$**
- 6) $\alpha=150^\circ$**
- 7) $\alpha=180^\circ$**

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Example 2

Rectifier connection



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Example 2

Solution

phase voltage: $V_f = 230\text{V}$

resistor mean value voltage:

$$1) V_{av(\alpha)} = V_{av} \cdot \frac{1+\cos\alpha}{2} = 0,9 \cdot 230 \cdot \frac{1+\cos 0^\circ}{2} = 207 \text{ V}$$

$$2) V_{av(\alpha)} = V_{av} \cdot \frac{1+\cos\alpha}{2} = 0,9 \cdot 230 \cdot \frac{1+\cos 30^\circ}{2} = 193,1 \text{ V}$$

$$3) V_{av(\alpha)} = V_{av} \cdot \frac{1+\cos\alpha}{2} = 0,9 \cdot 230 \cdot \frac{1+\cos 60^\circ}{2} = 155,3 \text{ V}$$

$$4) V_{av(\alpha)} = V_{av} \cdot \frac{1+\cos\alpha}{2} = 0,9 \cdot 230 \cdot \frac{1+\cos 90^\circ}{2} = 103,5 \text{ V}$$

$$5) V_{av(\alpha)} = V_{av} \cdot \frac{1+\cos\alpha}{2} = 0,9 \cdot 230 \cdot \frac{1+\cos 120^\circ}{2} = 51,8 \text{ V}$$

$$6) V_{av(\alpha)} = V_{av} \cdot \frac{1+\cos\alpha}{2} = 0,9 \cdot 230 \cdot \frac{1+\cos 150^\circ}{2} = 13,9 \text{ V}$$

$$7) V_{av(\alpha)} = V_{av} \cdot \frac{1+\cos\alpha}{2} = 0,9 \cdot 230 \cdot \frac{1+\cos 180^\circ}{2} = 0 \text{ V}$$

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Example 3

Assignment

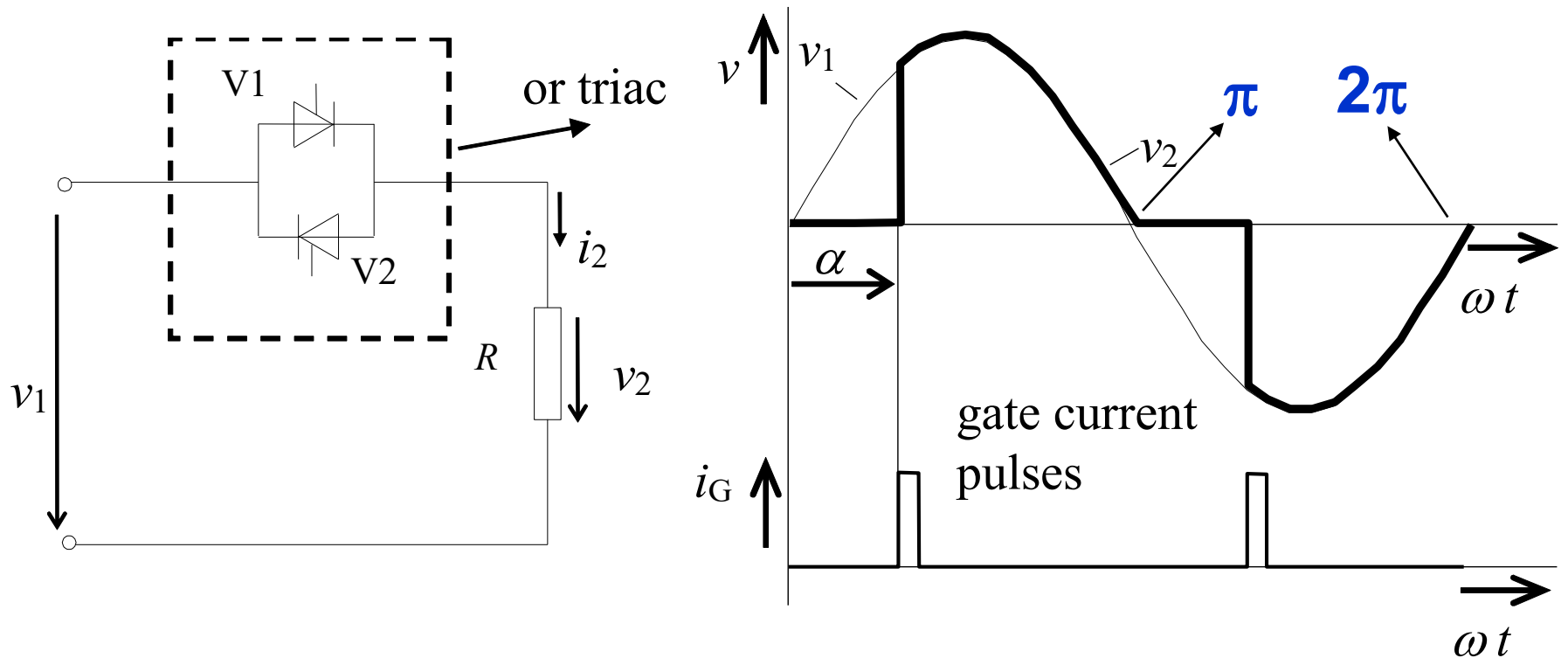
A bulb is connected to AC voltage converter (triac dimmer) supplied from single-phase network. Calculate rms value of voltage on the bulb for these firing angles:

- 1) $\alpha=0^\circ$**
- 2) $\alpha=50^\circ$**
- 3) $\alpha=100^\circ$**

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Example 3

Connection of AC voltage converter



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Example 3

Solution

On the bulb (resistance load) alternating voltage is. To calculate its rms value only one half-period is taken into account .

$$V_2 = \sqrt{\frac{1}{\pi} \cdot \int_{\alpha}^{\pi} (\sqrt{2} \cdot V_1 \cdot \sin \omega t)^2 \cdot d\omega t} \rightarrow$$
$$\rightarrow \frac{V_1}{\sqrt{\pi}} \cdot \sqrt{\pi - \alpha + \sin \alpha \cdot \cos \alpha}$$

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Example 3

Solution

1) $\alpha=0^\circ$ ($=0$ rad)

$$V_2 = \frac{V_1}{\sqrt{\pi}} \cdot \sqrt{\pi - \alpha + \sin\alpha \cdot \cos\alpha} = \frac{230}{\sqrt{\pi}} \cdot \sqrt{\pi - 0 + \sin 0 \cdot \cos 0} = 230 \text{ V}$$

2) $\alpha=50^\circ$ ($=0,8727$ rad)

$$V_2 = \frac{V_1}{\sqrt{\pi}} \cdot \sqrt{\pi - \alpha + \sin\alpha \cdot \cos\alpha} = \frac{230}{\sqrt{\pi}} \cdot \sqrt{\pi - 0,8727 + \sin 0,8727 \cdot \cos 0,8727} = 173 \text{ V}$$

3) $\alpha=100^\circ$ ($=1,7453$ rad)

$$V_2 = \frac{V_1}{\sqrt{\pi}} \cdot \sqrt{\pi - \alpha + \sin\alpha \cdot \cos\alpha} = \frac{230}{\sqrt{\pi}} \cdot \sqrt{\pi - 1,7453 + \sin 1,7453 \cdot \cos 1,7453} = 162,5 \text{ V}$$