Electronics and
Computer Science

ELEC2208 Power Electronics and Drives

Tutorial 1 - Thyristors

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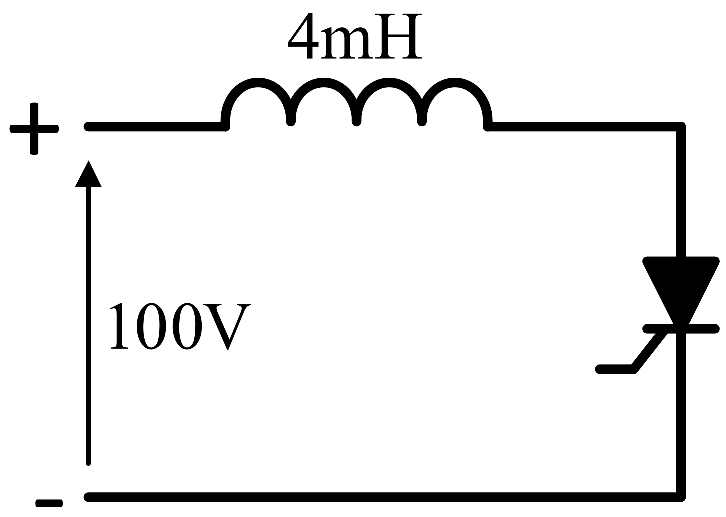
Question 1

If the latching current of the thyristor in the circuit shown is 4 mA, determine the minimum width of the gating pulse required to turn on the thyristor.



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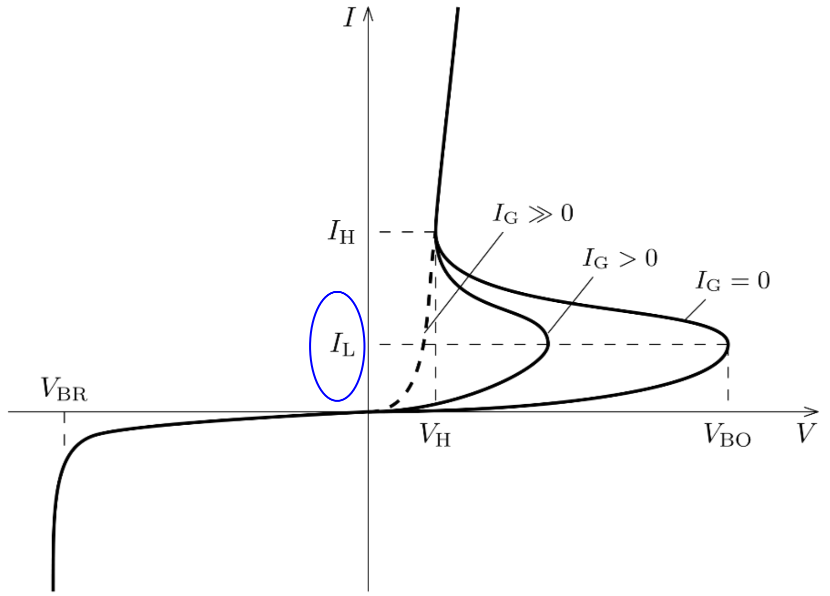
Revision

Latching Current (I_L)

Minimum principal current required to maintain the thyristor in the on state immediately after the switching from the off state, and the triggering gate signal has been removed.



→ Related to Switch ON

⇒ The duration of the gate pulse should be longer than the period for the thyristor current to get to the latching current.

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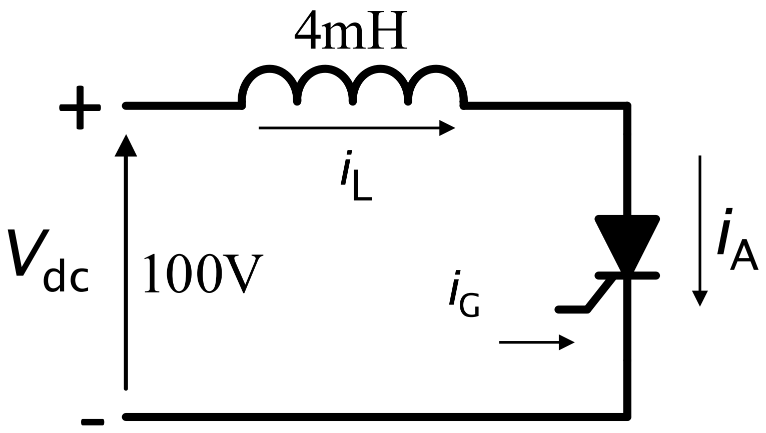
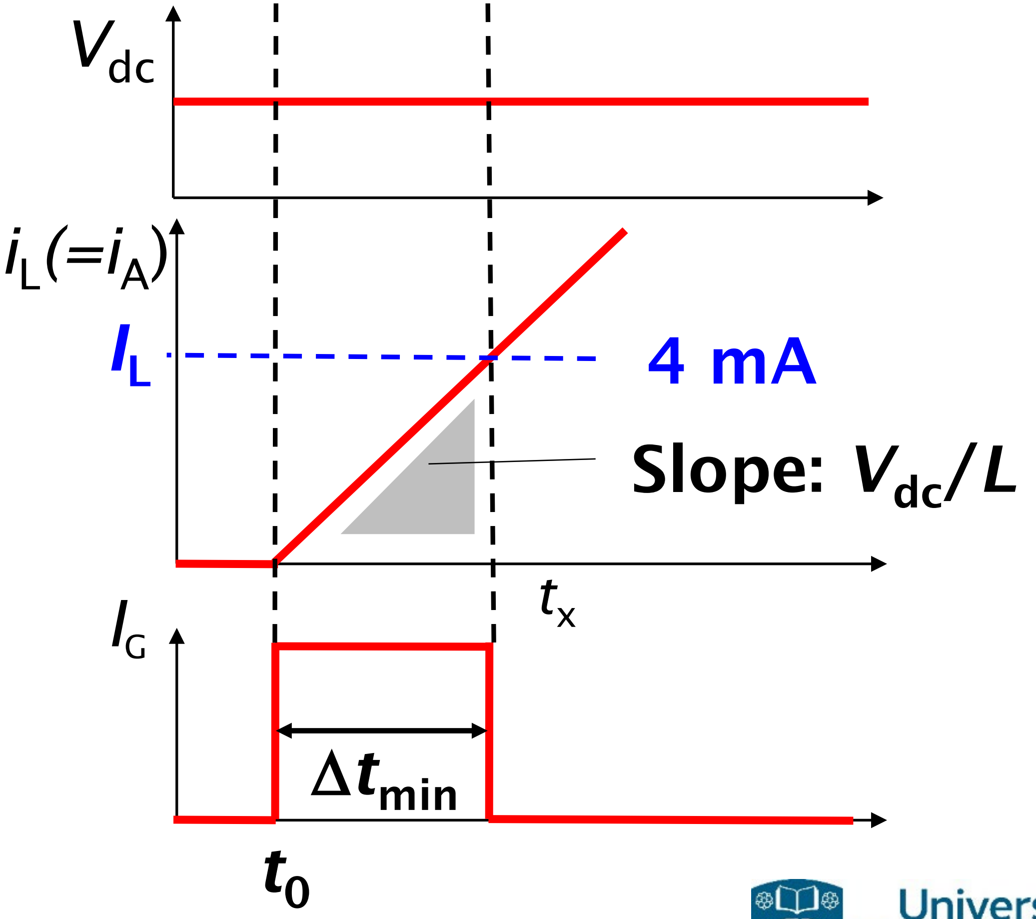
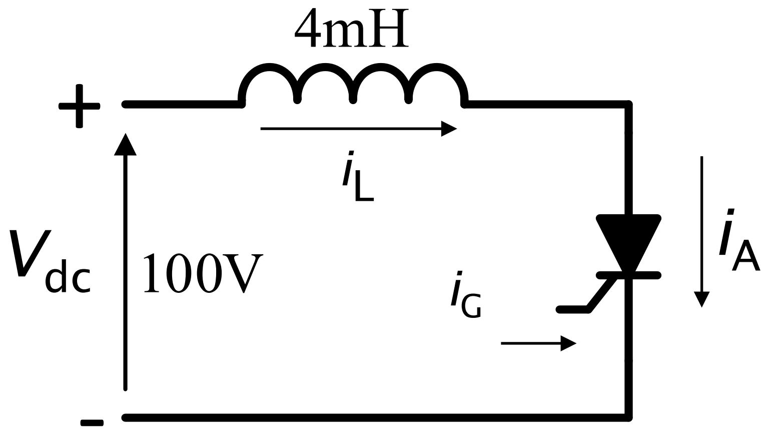
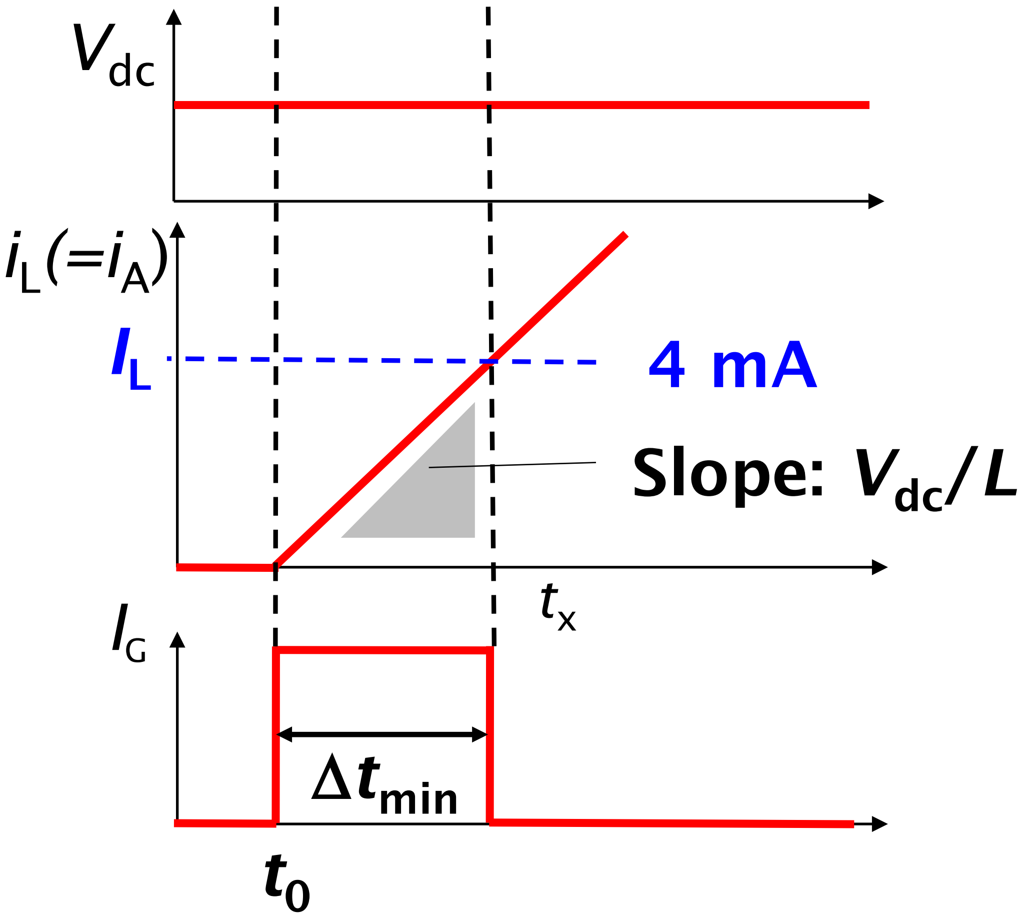


$$v_L = L\frac{di_L}{dt}$$



Answer 1





$$I_L/\Delta t_{min} = V_{dc}/L$$

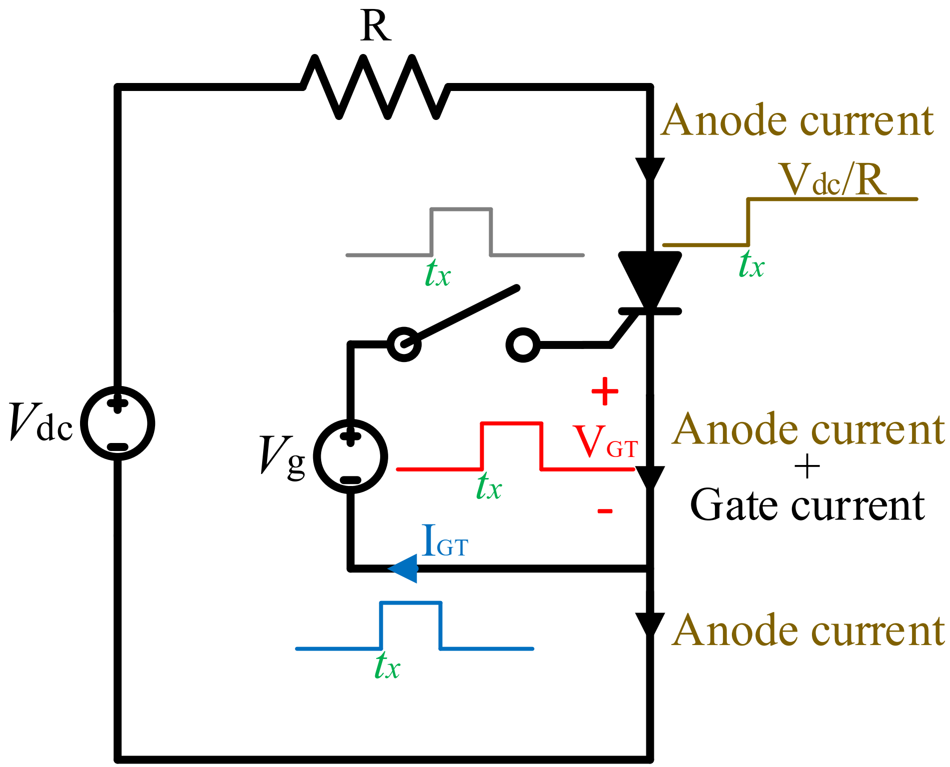
$$\Delta t_{min} = LI_L/V_{dc} = (4\ (\text{mH}) \times 4\ (\text{mA}))/100\ (\text{V})$$
$$= 16.000 \times 10^{-8}\ (\text{s}) = \mathbf{160\ (ns)}$$

Question 2

The gate-cathode characteristic for a thyristor is given by a straight line with a gradient of 16 volts per ampere passing through the origin; the gate pulse is limited to 0.5 A. If the gate source voltage is 15 V, calculate the external resistance to be connected in series with the thyristor gate.

Revision

Thyristor triggering



- Only a simple voltage pulse is needed to turn on a thyristor.
- Often the triggering circuit with low power/voltage level should be isolated from thyristor gate (power circuit) for protection.

Consider triggering circuit only.

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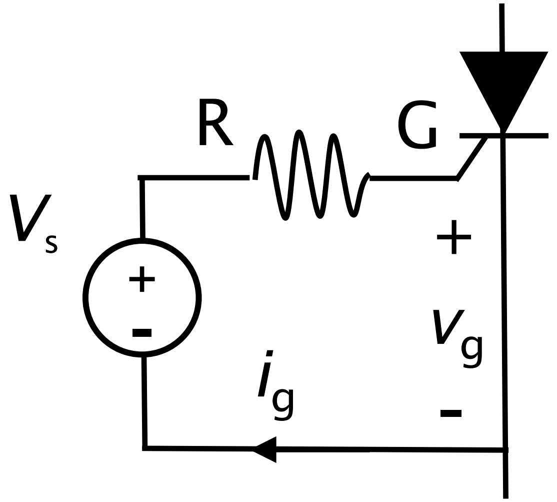
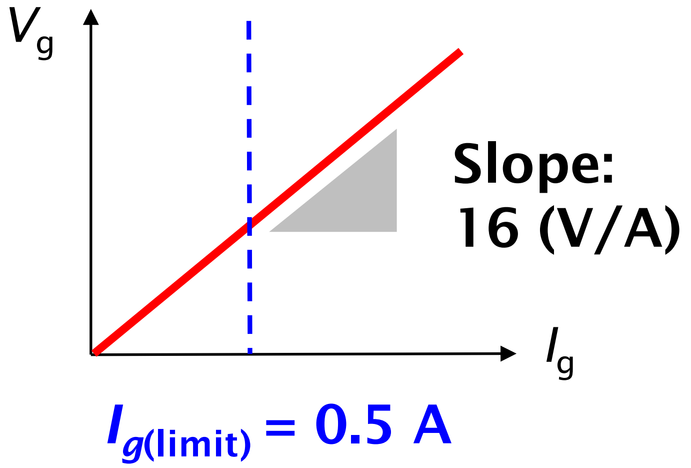
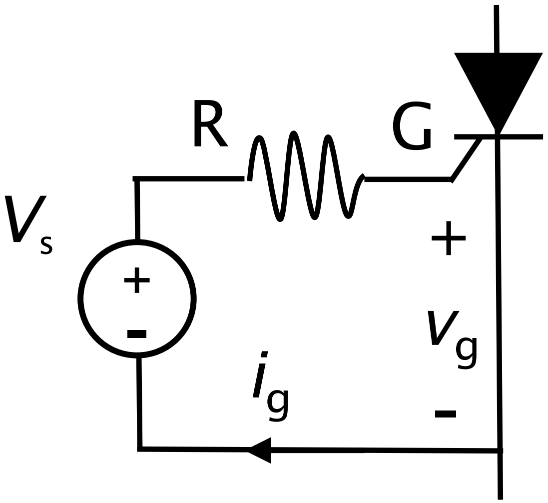
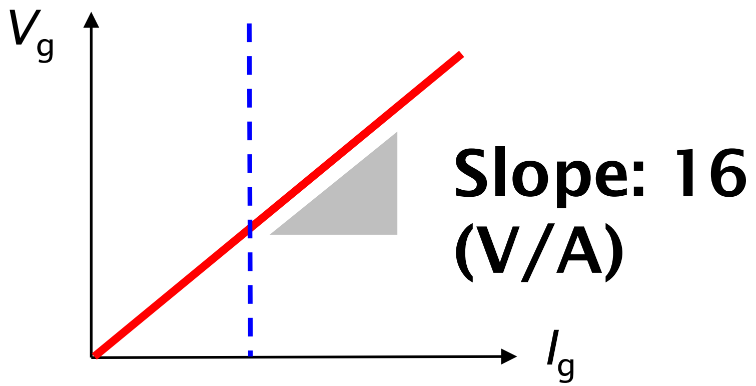




R can drop the voltage to limit the gate current.

Answer 2





$$V_g = 16 I_g$$

$$V_s = R I_g + V_g = (R + 16) I_g$$

$$I_g = V_s / (R + 16) = 15/(R + 16) = 0.5$$

$$R = 14\ (\Omega)$$

$$R + 16 = 15/0.5 = 30$$

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Question 3

The thyristor in question 2 is supplied with gate pulse of 4 μs in length. If the gate power dissipation is limited to 0.3 W, determine the maximum gate pulse repetition rate.

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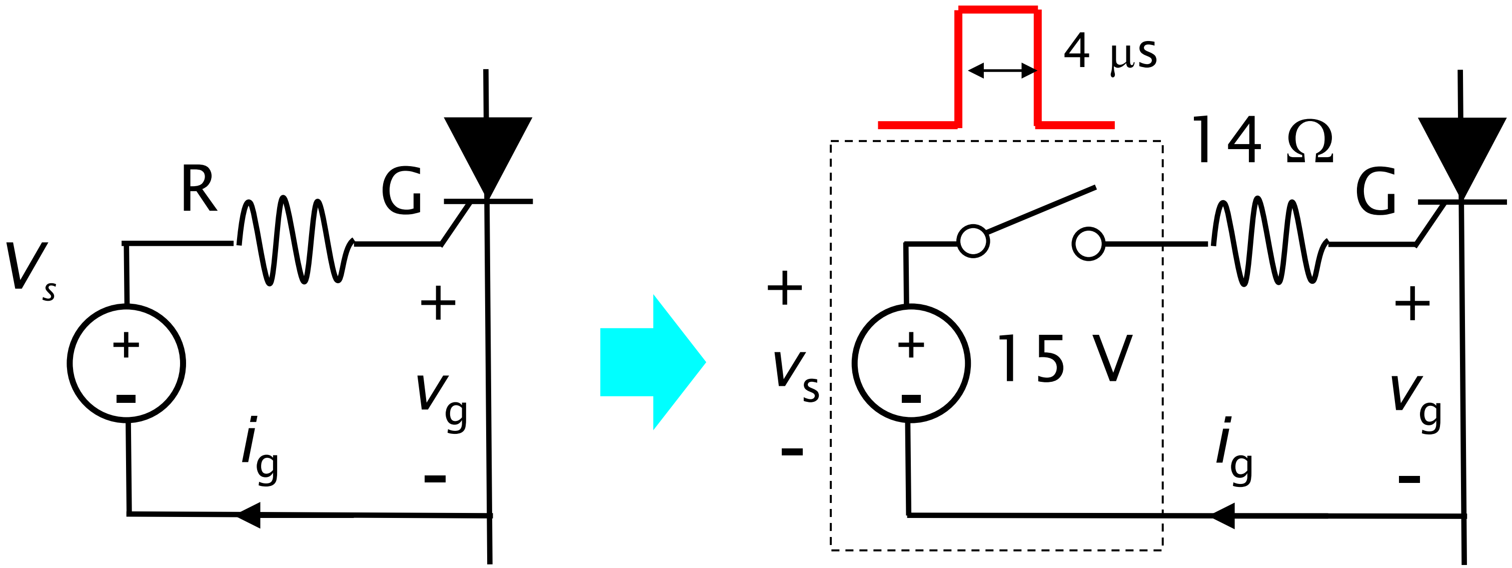


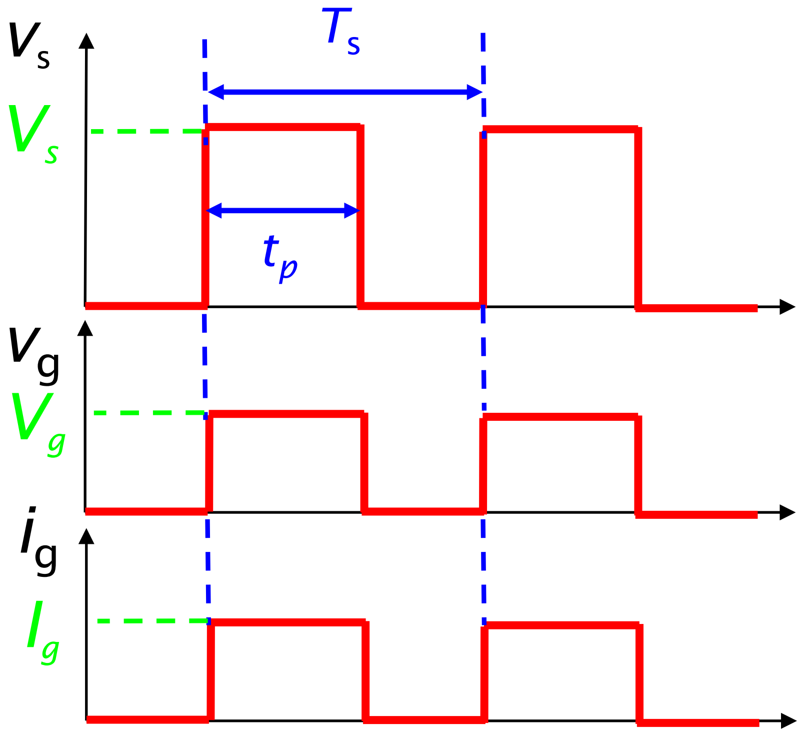
Revision

Maximum pulse repetition rate

⟶ Maximum switching frequency f_s

Gate power dissipation P_g

⟶ Average power dissipated in a period



$$f_s = \frac{1}{T_s}$$

$$P_g = \frac{1}{T_s}\int_0^{T_s} v_g(t) i_g(t) dt$$

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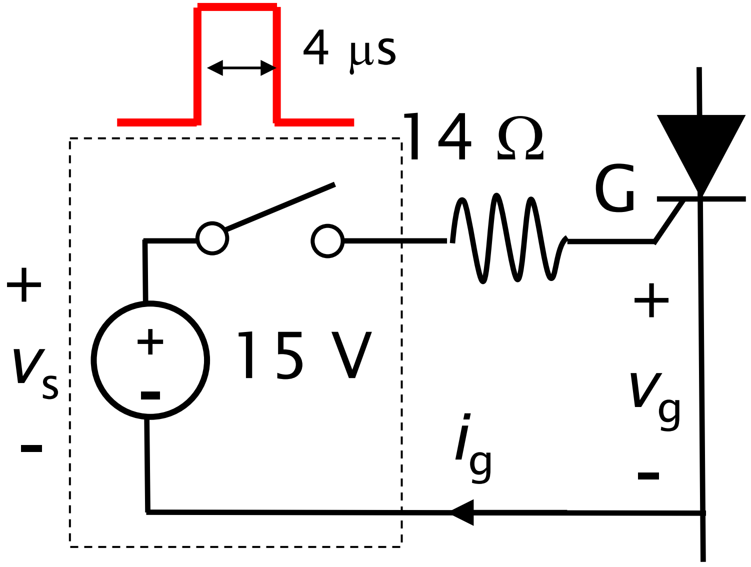
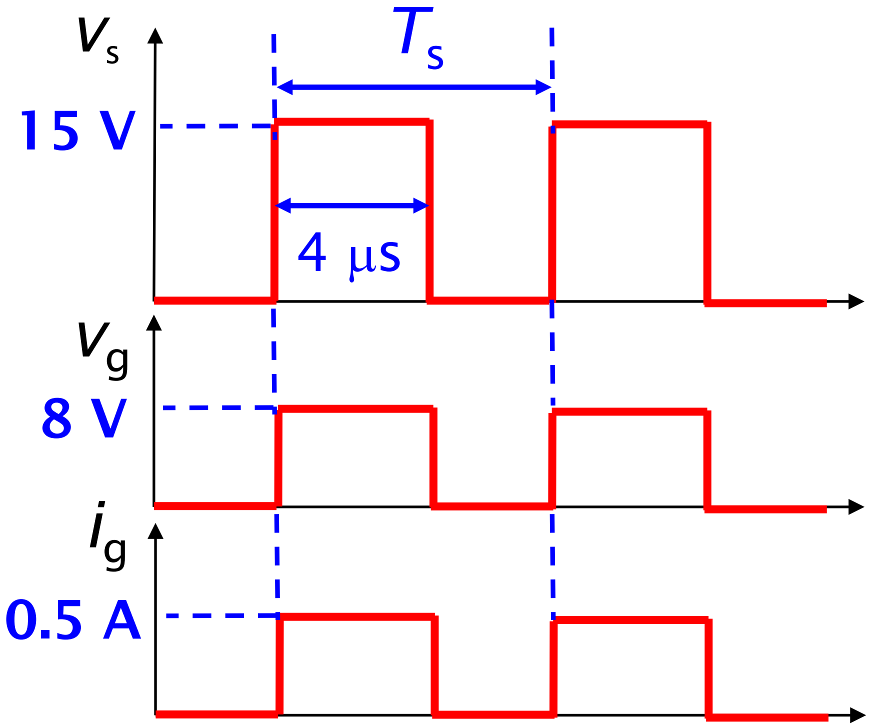


I_g = 0.5 A V_g = 8 V



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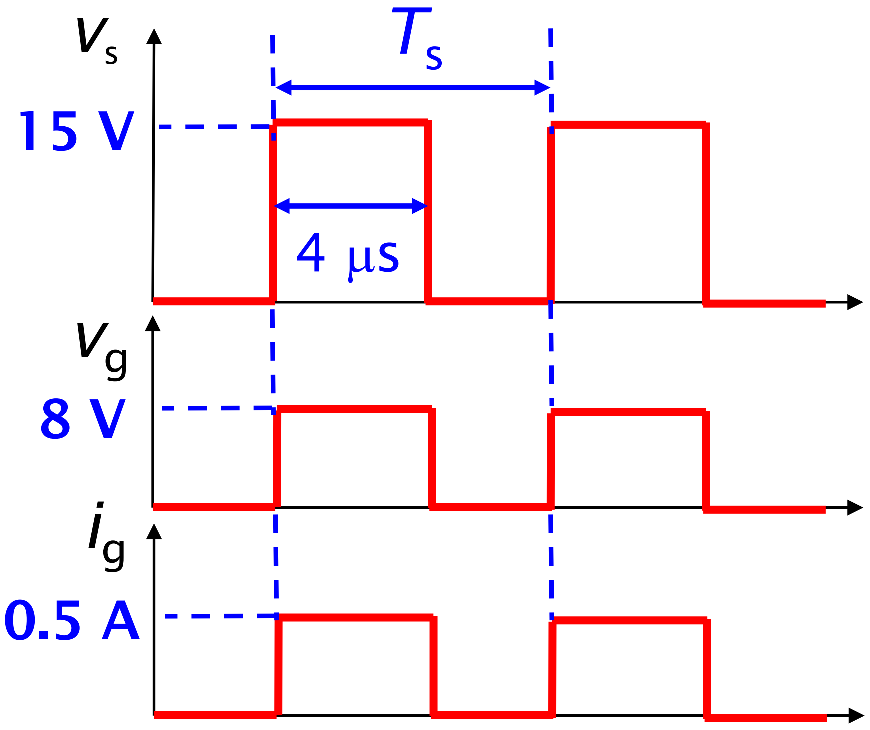

$$P_g = \frac{1}{T_s}\int_0^{T_s} v_g(t) i_g(t) dt$$

$$= \frac{1}{T_s}\left(\int_0^{4\ \mu s} v_g(t) i_g(t) dt\right) + \underbrace{\frac{1}{T_s}\left(\int_{4\ \mu s}^{T_s} v_g(t) i_g(t) dt\right)}_{0}$$

$$= \frac{1}{T_s}\left(\int_0^{4\ \mu s} (8 \times 0.5) dt\right)$$

$$= \frac{1}{T_s}[4t]_0^{4\mu} = \frac{16\mu}{T_s} \leq 0.3$$

$$f_s = \frac{1}{T_s} \leq \frac{0.3}{16 \times 10^{-6}} = 18750 = \mathbf{18.750\ kHz}$$