Prof. Juan Rivas

Name:

Consider the design of a power MOSFET gate drive circuit switching at $f_s = 10$ MHz. The MOSFET has a gate capacitance $C_g = 1$ nF, gate resistance $R_g = 100$ mΩ, and lead/package gate inductance $L_g = 250$ pH. The device has negligible gate-drain capacitance C_{gd} and neglect the effects the drain voltage/current may have on the gate-drive circuit. To prevent damage in the device, the gate-source voltage must remain between ± 15 V. The threshold voltage for this part is $V_{th} = 2$ V and the channel can be considered fully enhanced when the gate voltage is greater than 8 V.
Consider the following gate driving circuit schemes:

1 Simple gate drive

In the gate drive circuit of figure 1, the amplitude of the driving square voltage is $V_{sq,max} = 10$ V. Sketch the effective internal gate voltage $v_g(t)$, and label the salient features. Comment on any issues that can arise by driving the circuit in this way. How much power is lost in this gate drive circuit? Propose a way to use a single passive component (what value?) to improve the performance of the driving circuit. How much power is lost in the gate drive circuit after the improvement?

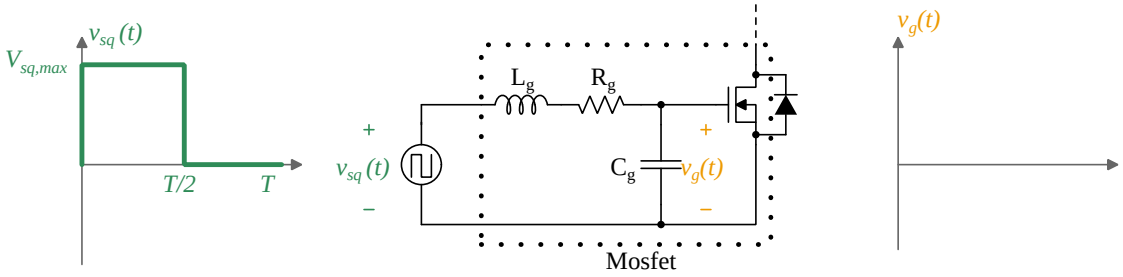

Figure 1: Simple Gate drive

2 Sinusoidal Gate drive circuit

In the gate drive circuit of figure 2, the circuit is driven by a voltage source $v_{ac}(t)$ that results in a Sinusoidal internal gate voltage $v_g(t)$ of amplitude $V_{g,ac-max} = 12.5$ V. Sketch the driving voltage $v_{ac}(t)$ and label the salient features. What are the maximum and minimum voltages of $v_{ac}(t)$. How much power is lost in this gate drive circuit?

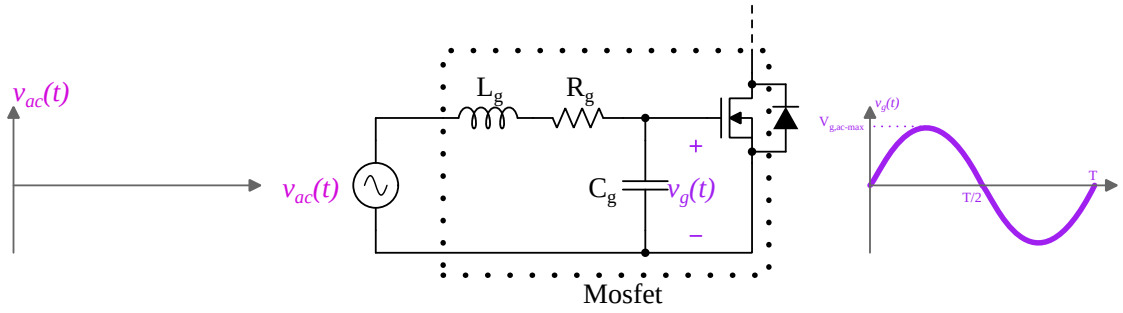

Figure 2: Sinusoidal Gate drive circuit

3 Trapezoidal Gate drive circuit

In the gate drive circuit of figure 3, the circuit is driven by a current source $i_t(t)$ that results in a trapezoidal gate voltage $v_g(t)$ with $V_{g,t-max} = 10$ V and rise time and fall times $t_r = t_f = \frac{1}{10 f_s} = 10$ ns . Sketch the driving current $i_t(t)$ and label the salient features. What are the maximum and minimum current of $i_t(t)$. How much power is lost in this gate drive circuit?

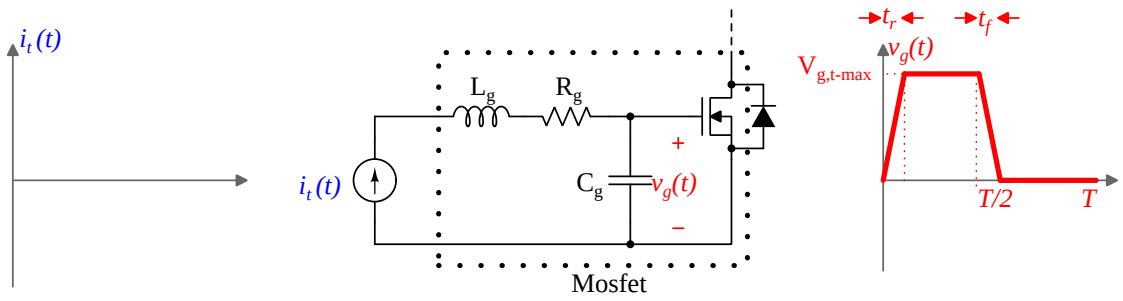

Figure 3: Trapezoidal Gate drive circuit