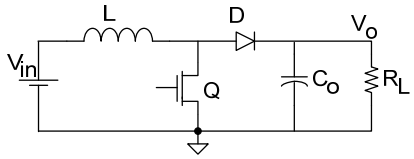
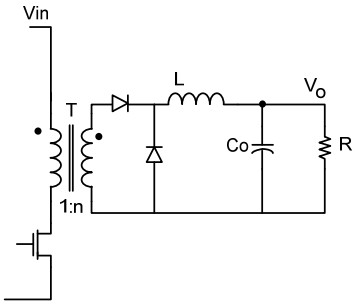
Drivers

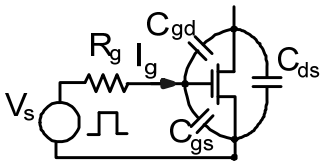
- What is a driver
- MOSFET capacitances
- Diver operation
- Gate capacitance
- Gate drive calculation
- Driver types
- High-side driver
  - Isolation
  - Optocoupler
  - Boot-strap supply

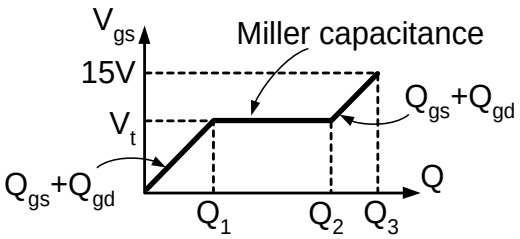
Driver



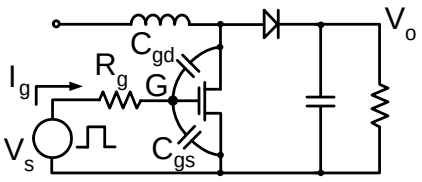


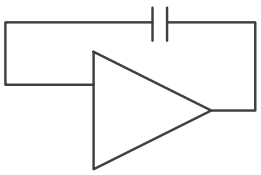
MOSFET capacitances





Miller effect





$V_{Cgs}(0) = 0 \qquad V_{Cgs}(\infty) = V_{GSmax}$

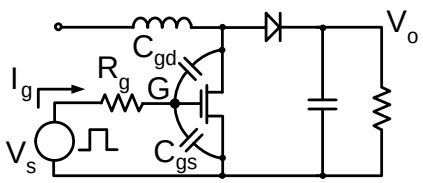
$V_{Cgd}(0) = -V_O \qquad V_{Cdg}(\infty) = V_{GSmax}$

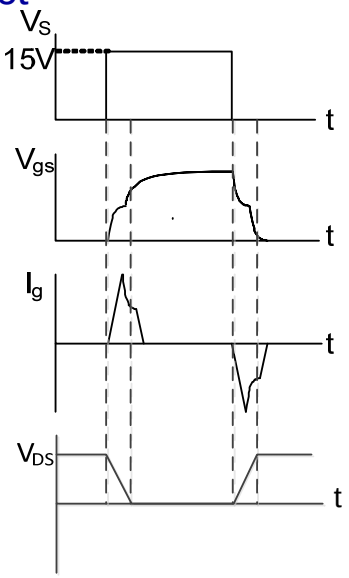
$$C_m = C\left[1-(-k)\right] = C\left[1+k\right]$$

$$Q_{total} = V_{GS}C_{gs} + (V_{GS} + V_O)C_{gd}$$

$$C_{eq} = \frac{Q_{total}}{V_{GS\max}} = C_{gs} + C_{gd}\left(1 + \frac{V_o}{V_{GS\max}}\right)$$

Miller effect

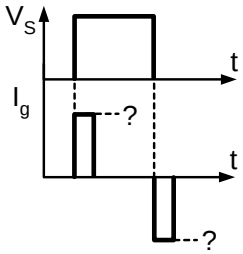




Required drive calculation

Equivalent capacitance

Assuming constant drive current



$$C_{eq} = C_{gs} + C_{gd}\left(1 + \frac{V_o}{V_{GS\max}}\right)$$

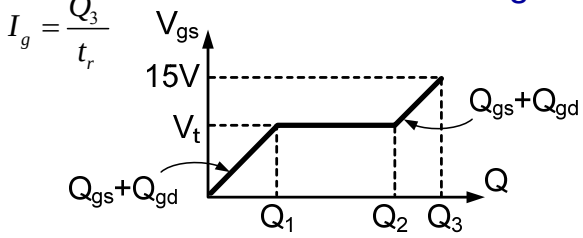
$$Q_{total} = I_g \cdot t_{on} = C_{eq} \cdot V_{gs\max}$$

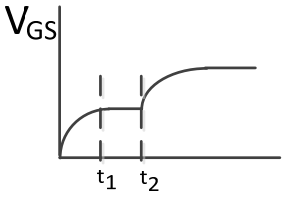
$$I_g = \frac{C_{eq} V_{gs\max}}{t_{on}}$$

Required drive calculation

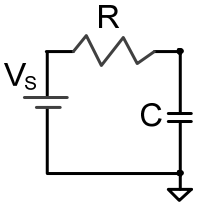
Gate charge

$$I_g = \frac{Q_3}{t_r}$$





For t1

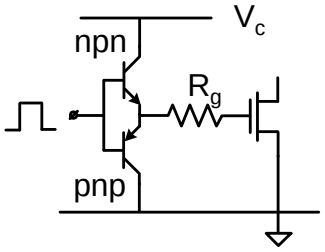


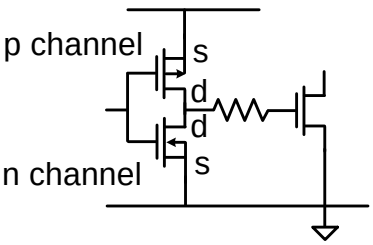
For t2

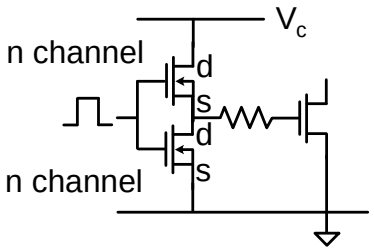
$$\Delta Q = \Delta I \cdot t_2$$

$$\Delta I = \frac{\Delta V}{R_g}$$

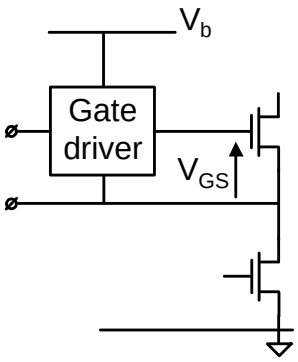
Driver types





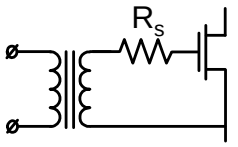


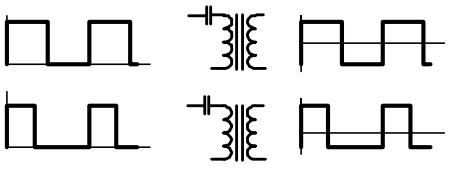
High-side driver



High-side driver

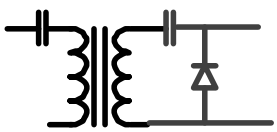
Transformer



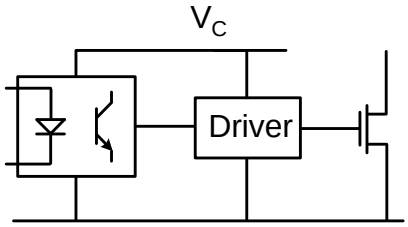


Problem of large Don

Possible solution: DC restorer



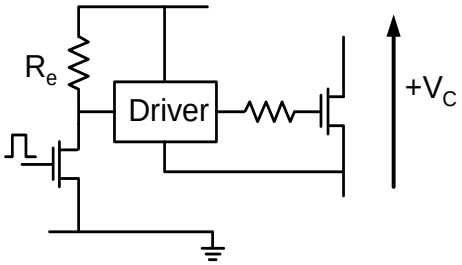
High-side driver
Optocoupler



V_C - floating supply

High-side driver
Potential offset

floating supply

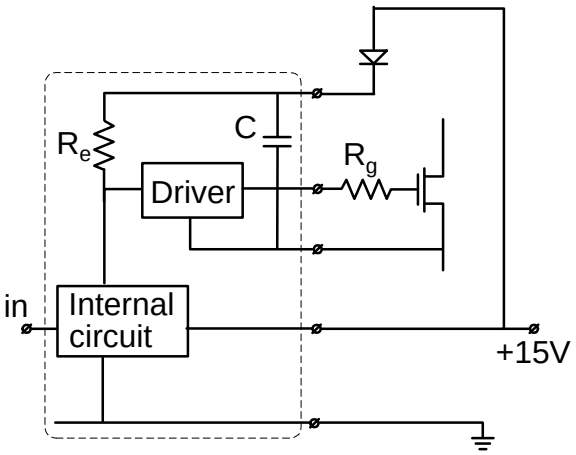


Logic signal is referred to GND

FET is used to sustain the high voltage

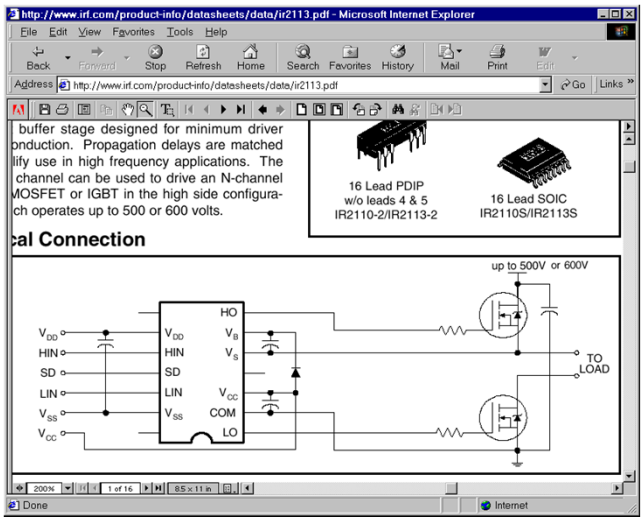
High-side driver

Boot-strap supply – floating capacitor



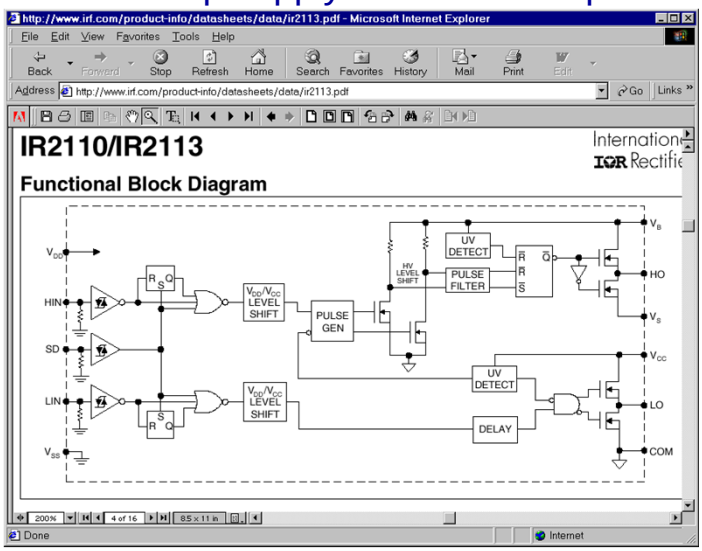
High-side driver

Boot-strap supply – commercial product



High-side driver

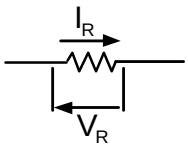
Boot-strap supply – commercial product

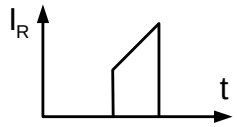


Current sensing

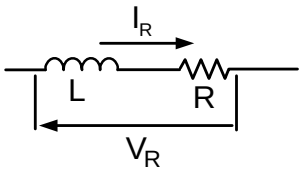
- Resistive sensing
- Current transformer
- Measuring DC
- Reset
- Design
- Hall effect

Resistive sensing

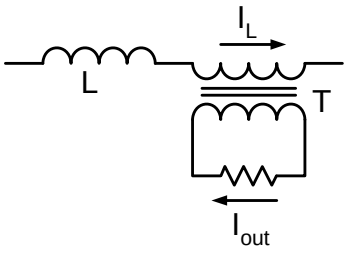


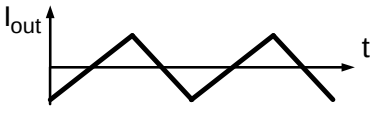


Parasitic inductance



Current transformer



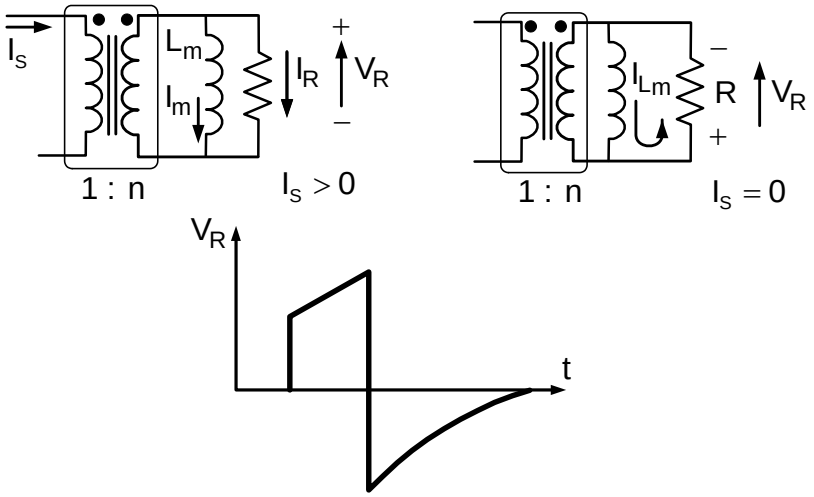


DC component via primary lost

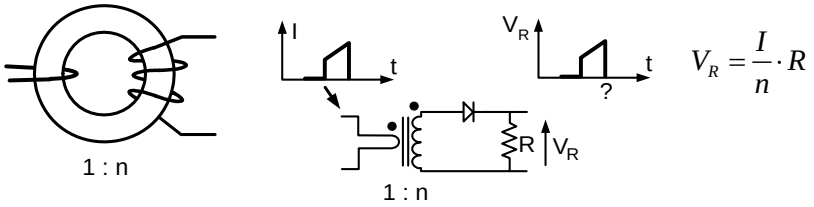
DC component may saturate transformer

Current transformer

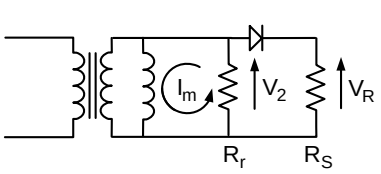
Pulse current - Problem due to reset



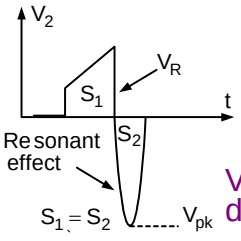
Pulse current transformer



Reset with resistor

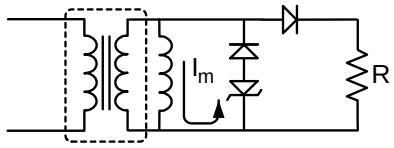


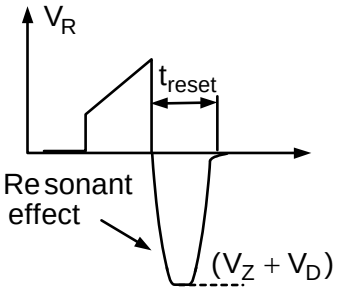
$R_r > R_s$



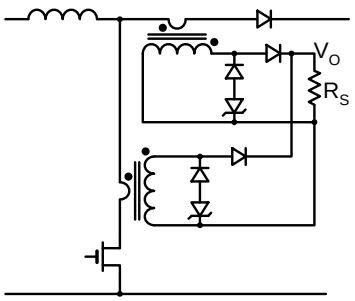
V_{pk} may damage diode

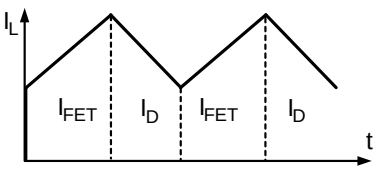
Pulse current transformer
Reset with clamp



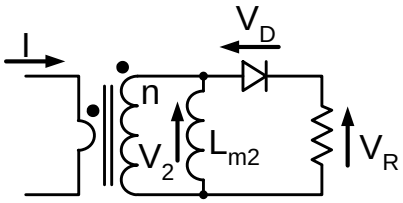


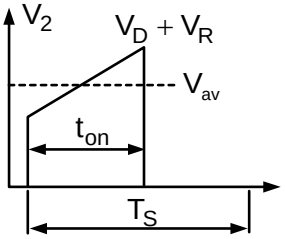
Measuring inductor current
Combining two sensors





Design of current transformer





Transformer saturation is a function of the **voltage**

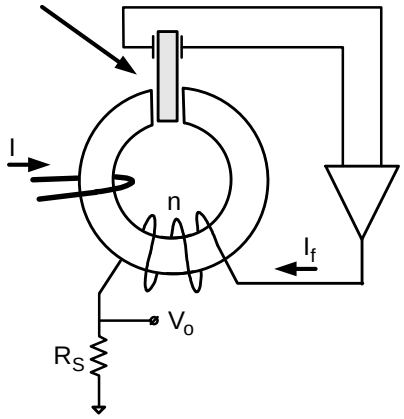
$$B_{max} = \frac{\int V dt}{nA_e} \qquad V_R \cong \frac{I}{n}R$$

$$\int V dt = V_{av} t_{on} = \frac{V_{av} D_{on}}{f_s}$$

$$B_{\max} = \frac{I_{av} R D_{\max}}{nA_e f_s}$$

Hall Effect sensor

Active Device
Hall effect sensor



Zeroing the flux by feedback

$$I_f \cdot n = I \qquad V_o = \frac{I}{n} R_S$$