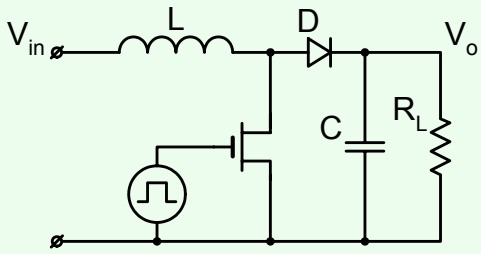
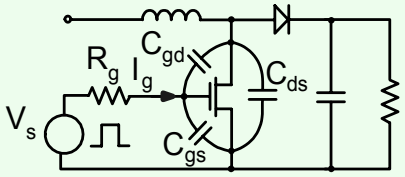
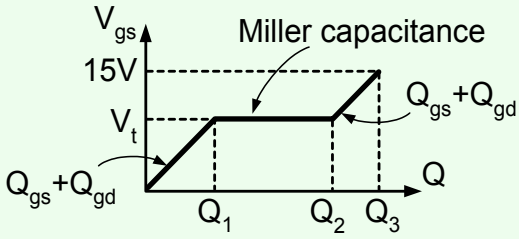
Drivers

Driving a MOSFET



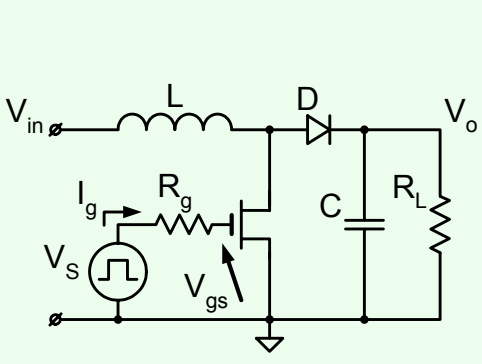
Driver Requirements

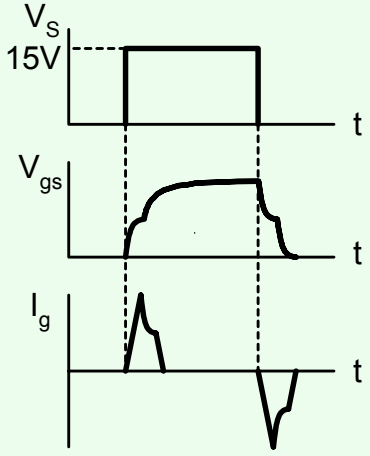




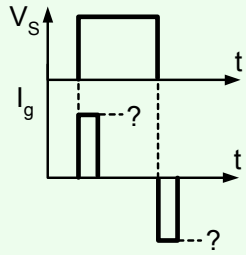
- Capacitors are non-linear

Gate Current



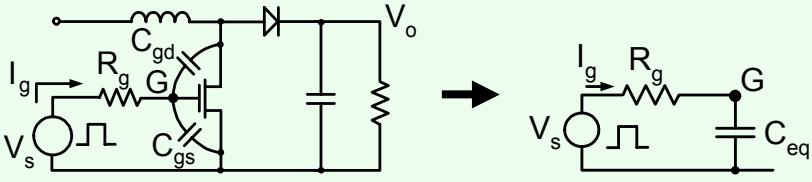


Calculating Required Drive



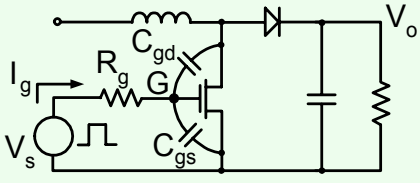
* Assumption: Constant Current

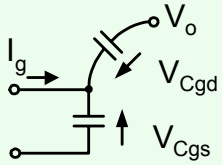
Method A: Equivalent capacitor



Gate capacitance

$$C_{eq} = \frac{Q_{total}}{V_{gs\,max}}$$





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

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

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

Miller Effect

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

Gate capacitance

Calculating required I_g (constant), t_{on}:

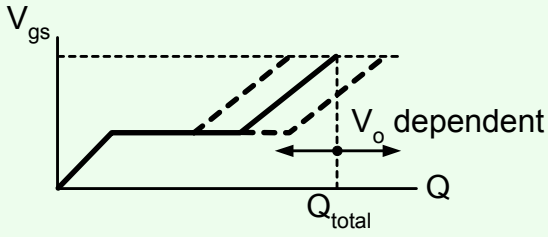
$$C_{eq} = C_{gs} + C_{gd}(1 + \frac{V_o}{V_{GSmax}})$$

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

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

Calculating Required Drive

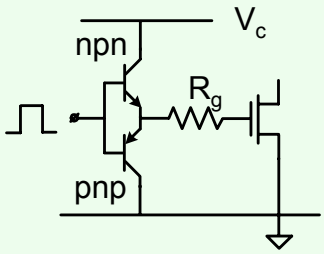
Method B: Gate Input Charge



$$Q_{total} = I_g \cdot t_{on}$$

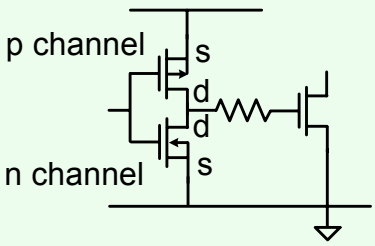
$$I_g = \frac{Q_{total}}{t_{on}}$$

Gate Drivers



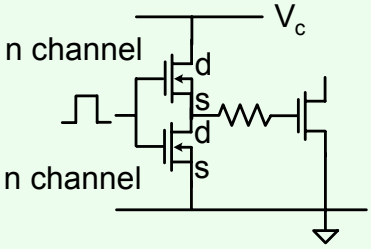
Push pull - complementary

$V_c=V_{gs\ max}$

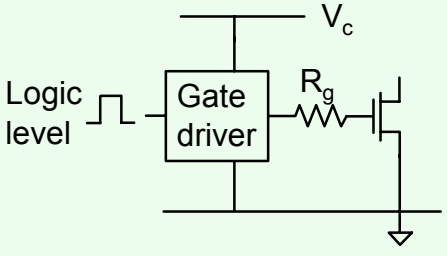


O.K. Watch for through-shoot current

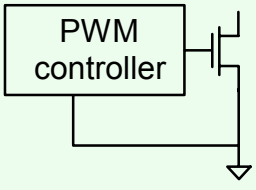
Drivers



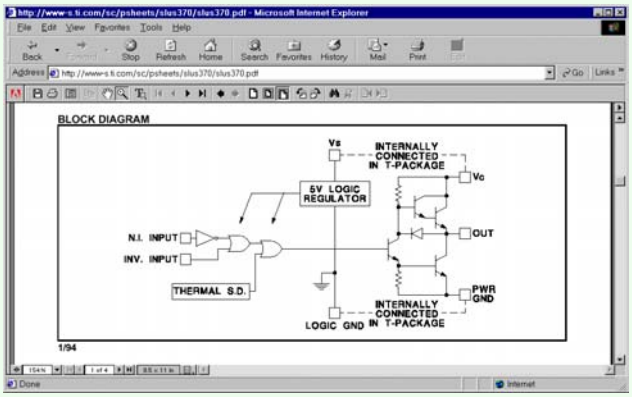
BAD



OR

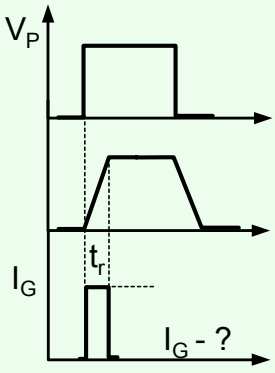


Commercial driver



- **Totem pole**

Example



Given: required t_r

Question: Why can I_G be considered constant ?

$$t_r \cdot I_G = \sum Q \qquad I_G = \frac{\sum Q}{t_r}$$

Example

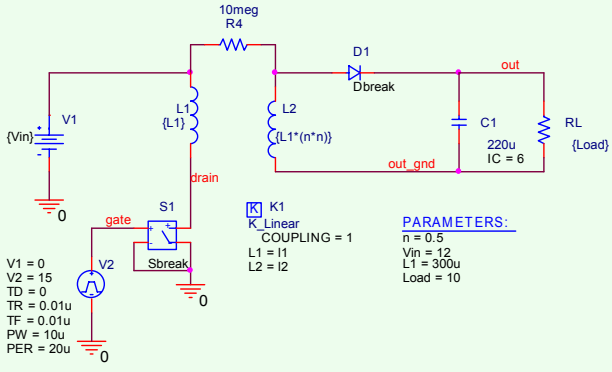
If $t_r \approx 100\,nS = 10^{-7} S$

$\Sigma Q \approx 50\,nQ$

$$I = \frac{100\ nS}{50\ nQ} = 2\ A$$

Significant current !

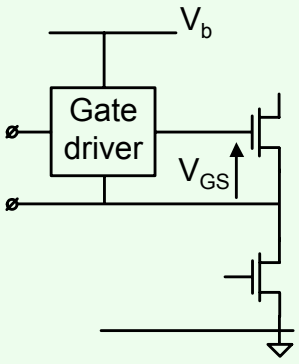
Exercise



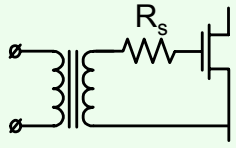
- **Replace the switch with a mosfet, put a 10 Ohm resistor is series with gate and measure the input current to gate**

High-Side Drive

The problem



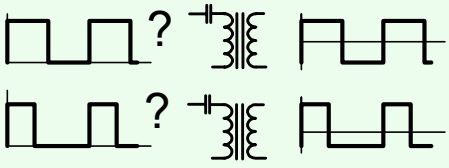
Possible solution :
Transformer coupling



Problem

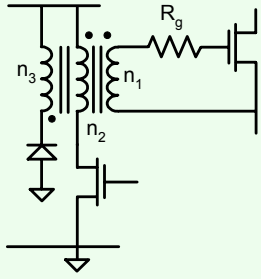
1.Wide range of D_{on}

Driver isolation

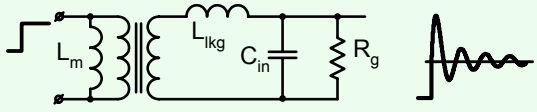


Possible solution :

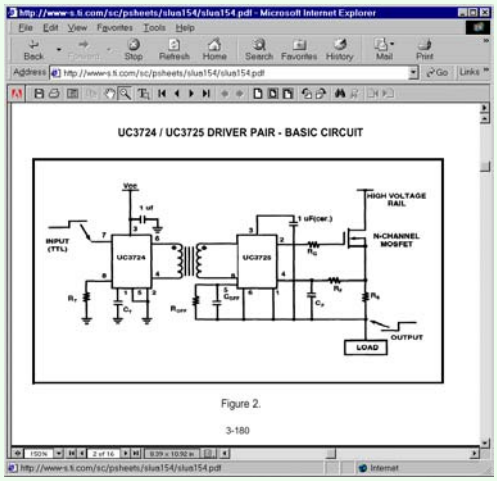
Like Forward



Problem #2 - Leakage

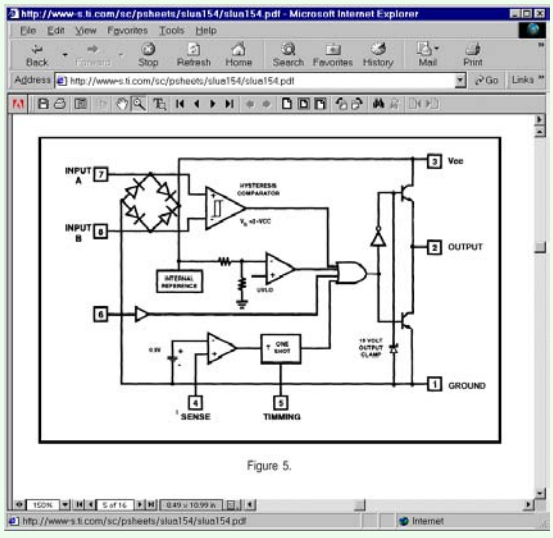


Transformer isolation

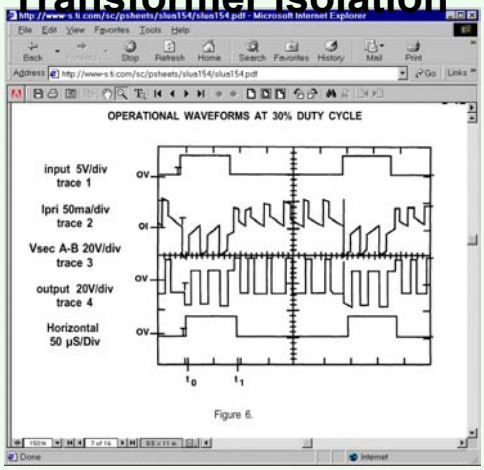


- Power and signal pass via transformer – High Frequency modulation

Transformer isolation



Transformer isolation

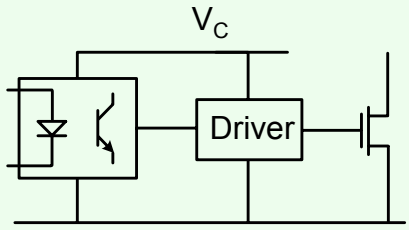


- Signal coding and reconstruction

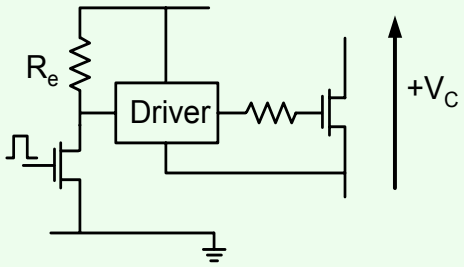
Driver isolation

Solution #2: Optical

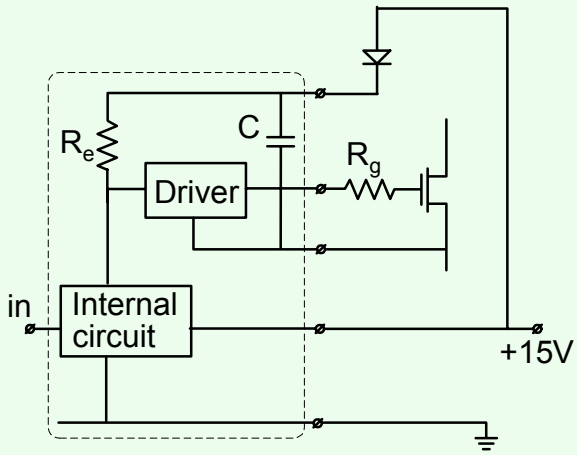
V_C - floating supply



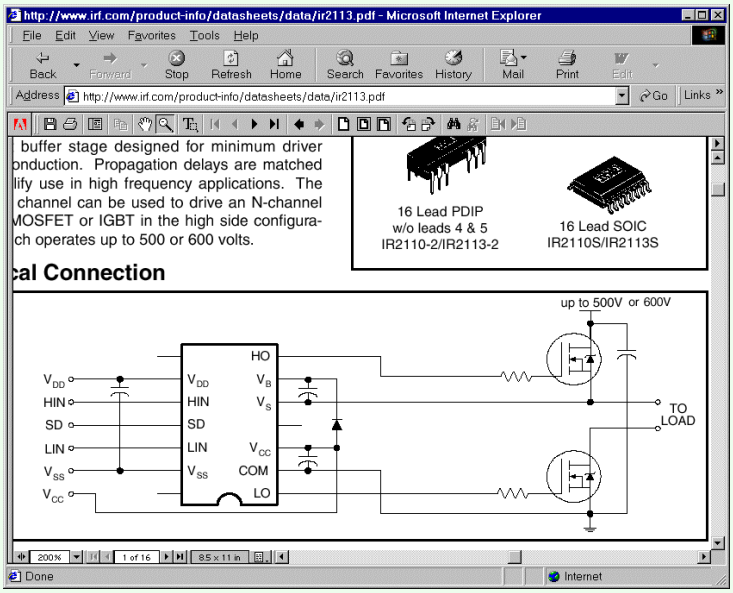
Solution #3
Potential offset

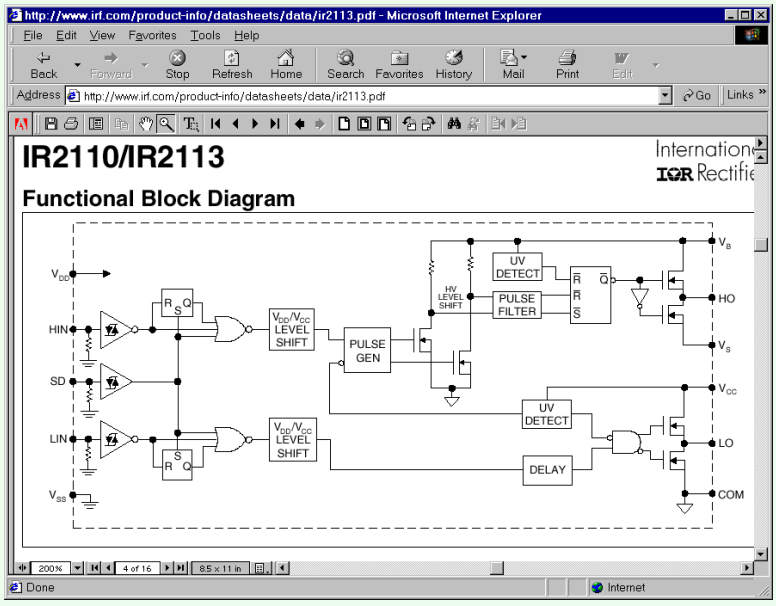


Potential offset + floating C supply

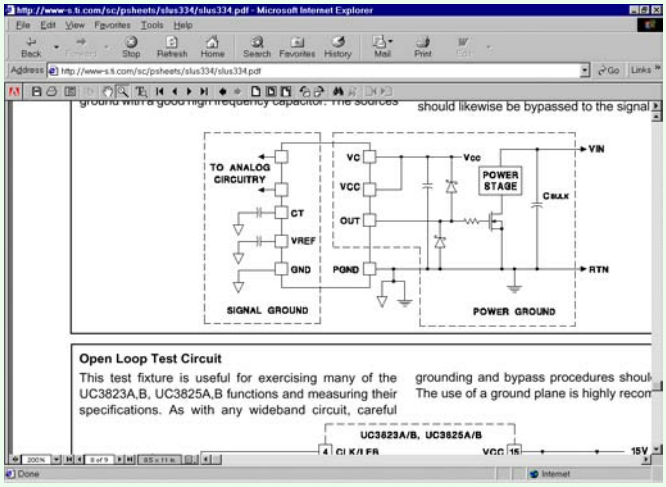


Available for HB, FB

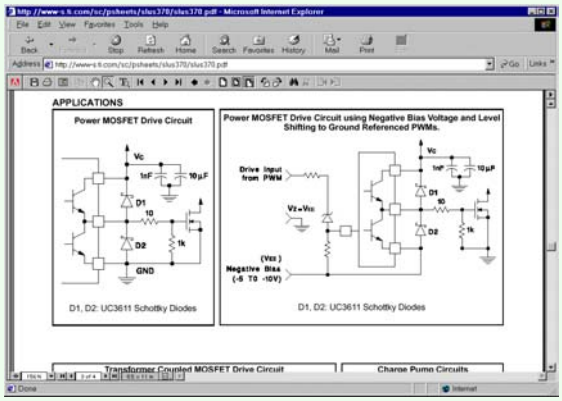




Low-side drive

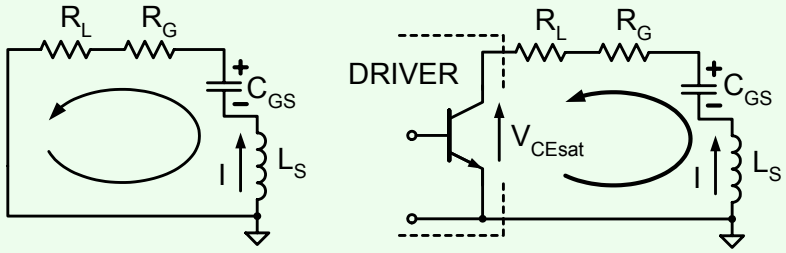


Steering diodes

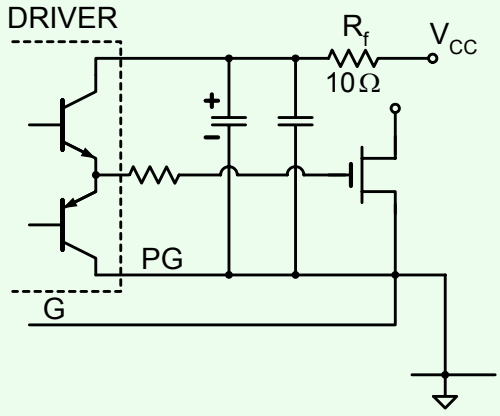


- Why the diodes ?

Turn “off”



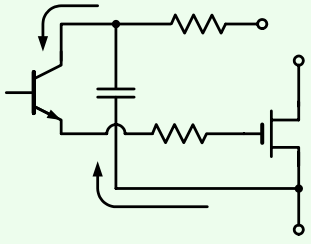
Lock current close to source



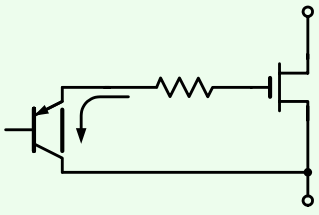
Trace current path to make sure current is locked

Current path

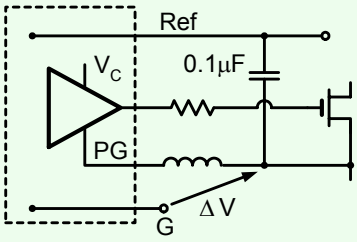
High



Low



Real life example



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