6 October 2016

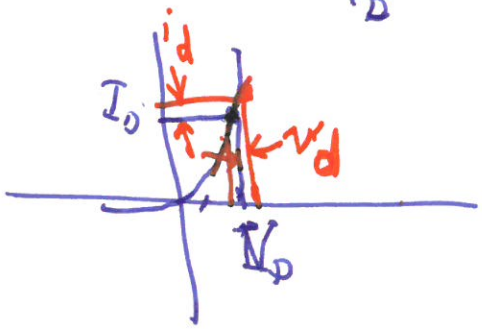
Derivative $\frac{di_D}{dV_D}$

$i_D = I_S e^{V_D/(nV_T)}$ $\quad \frac{di_D}{dV_D} = I_S \frac{1}{nV_T} e^{V_D/(nV_T)}$

$\frac{di_D}{dV_D} = \frac{i_D}{nV_T}$ $\quad r_d = \frac{nV_T}{i_D}$

AC equivalent of a diode is a resistor

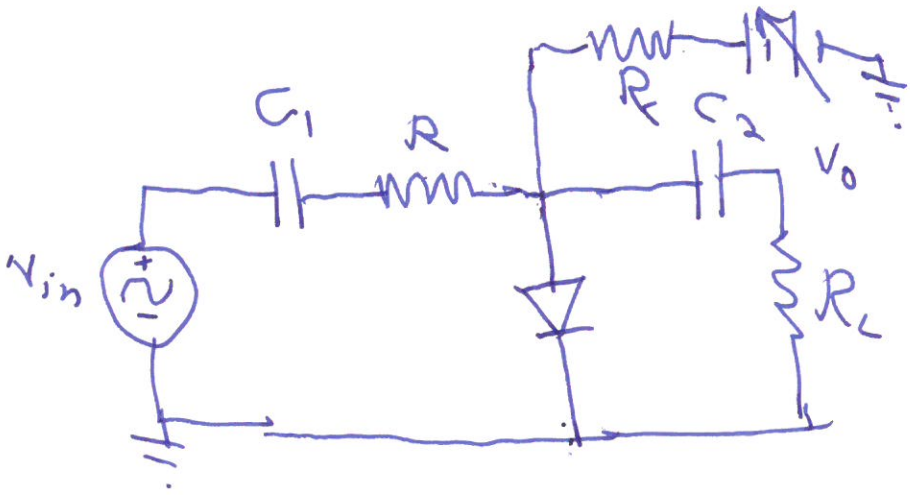
$r_d = \frac{nV_T}{i_D} = \frac{nV_T}{I_D}$

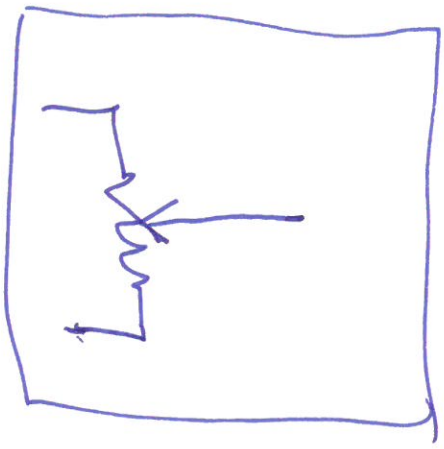


I_D is the DC current

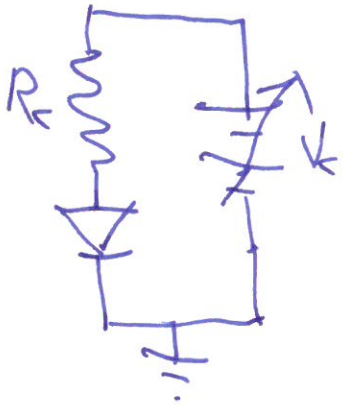
i_d is the AC current

$i_D = I_D + i_d$





① DC circuit

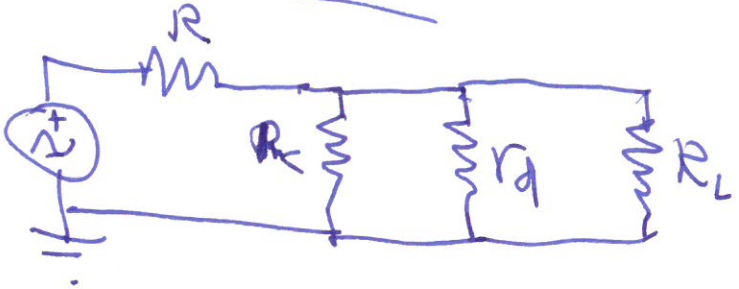


$$I_D = \frac{V_c - 0.7V}{R_c}$$

② Small signal model
Diode in AC circuit is a resistor

$$r_D = \frac{n V_T}{I_D}$$

③ AC circuit



$R_L \to \infty$
$R_c \to \infty$
$n = 1$ $R \gg r_d$

$$\frac{V_o}{V_{in}} = \frac{r_d}{R + r_d} \simeq \frac{r_D}{R} = \frac{R_c}{R} \frac{0.025V}{V_c - 0.7V}$$

All depends on $V_{in} << V_D$

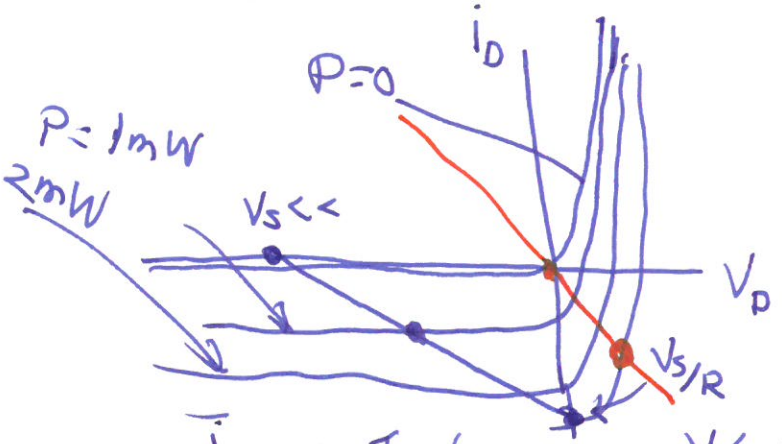
$\frac{d^2 i_D}{dV_D^2} \rightarrow \Delta i_D \propto (\Delta V_D)^2$

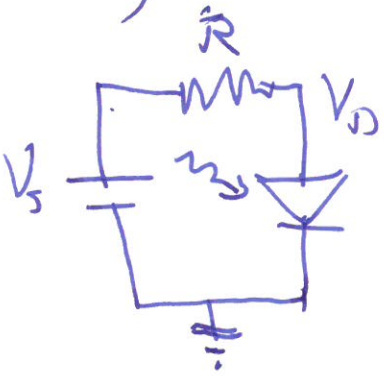
Keep ac signal small WRT DC
Else distortion.

Photodiode

Shockley Eq

$i_D = I_S\left(-1 + e^{V/V_T}\right)$





$i_D = I_S\left(-1 + e^{V/V_T}\right)$ – ? $P_{optical}$

$V_S << 0$

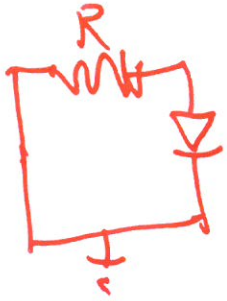
No light: $V_D = V_S$ (neg)

↑ light $V_D \rightarrow 0$

Too much light $V_D \approx 0$

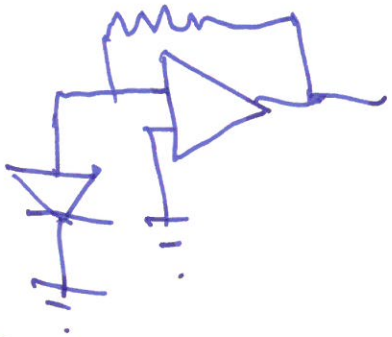
$V_S = 0$ ↑ light $V_D \rightarrow +$

$i_D \rightarrow -$



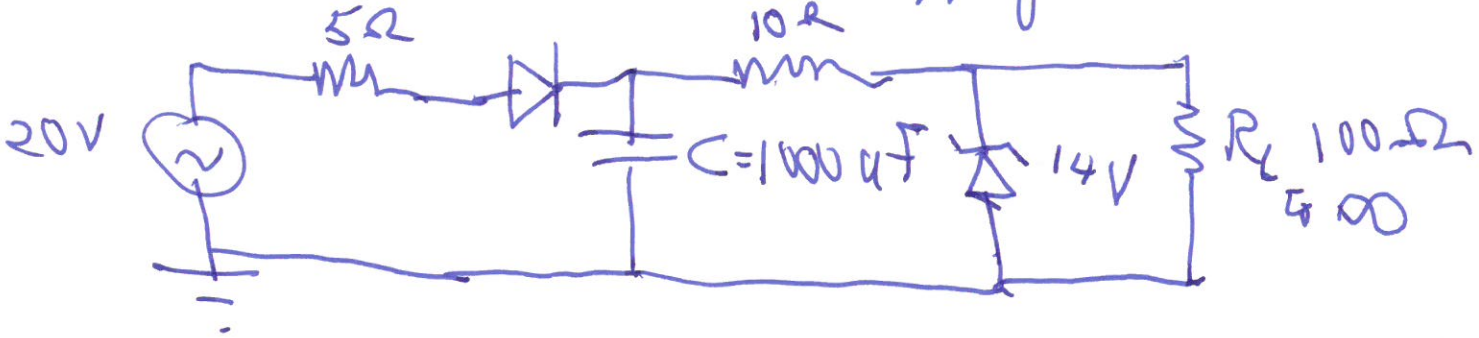
$P = i_D V_D < 0$ diode is a power source

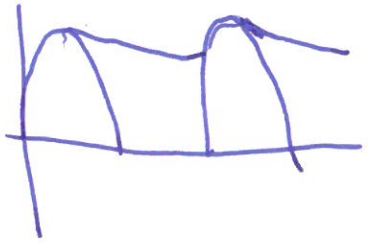
$V_S = 0$ but use transimpedance amp



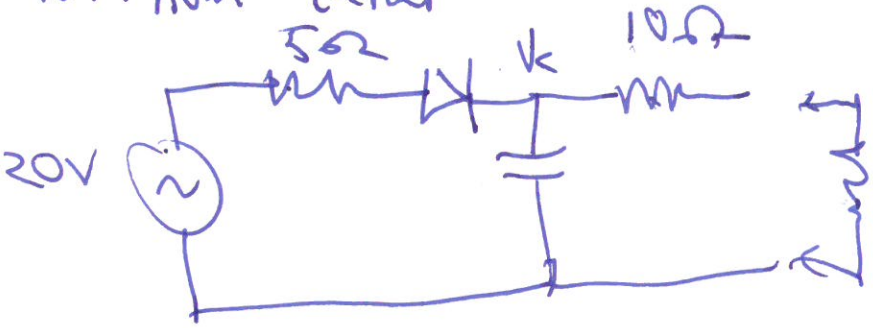
$V_{out} \propto + P_{optical}$

Final Example: power supply





Without Zener



$R_L \to \infty$

$V_c = 19.3\,V$

with $R_L = 100\,\Omega$

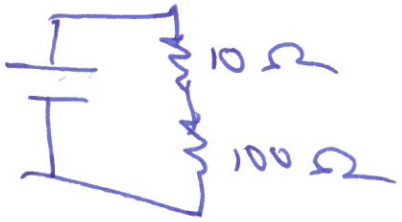
Charge: $V_c = (20V - 0.7V)\frac{110\,\Omega}{115\,\Omega}$

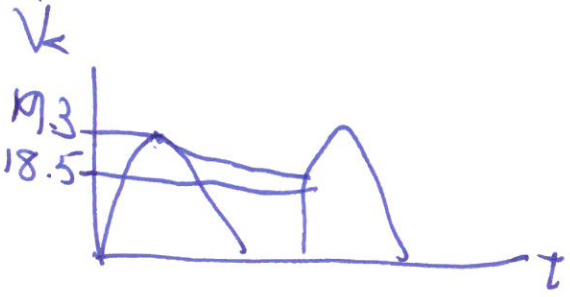
~~$V_c = 110$~~

Discharge

$V_{c_{min}} = V_{c\,max}\, e^{-T/RC}$ $R = 110\,\Omega$

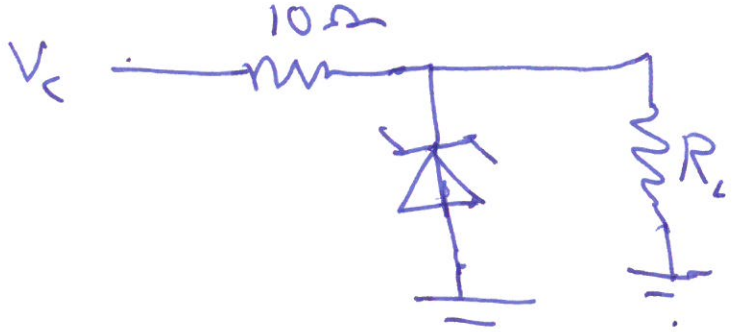
$= 18.5V$





$V_{OUT} = V_c \frac{100}{110}$ $V_{out\,min} = 15.9V$

put the zener in



$i_{Load} = \frac{14V}{100\,\Omega} = 0.14A$

$i_{zener} = \frac{(V_c - 14V)}{10\,\Omega}$ 0.31 to 0.05 A