

E151 Lecture 16

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ENGR151

Disclaimer

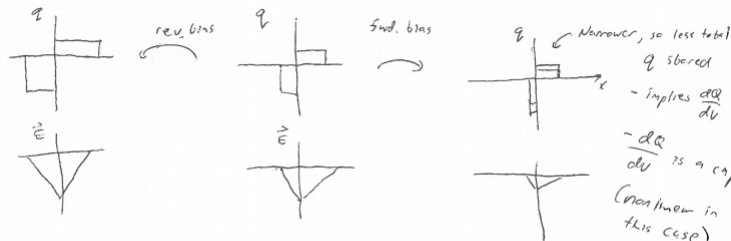
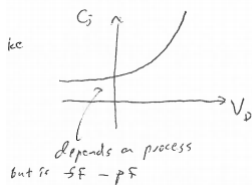
These are notes for Prof. Spencer to give the lecture, they were not intended as a reference for students. Students asked for them anyway, so I'm putting them up as a courtesy. Remember that they are not intended as a substitute for attending lecture.

PN Junctions Have Capacitance

- physically came from growing & shrinking PN junction depl. region

$$C_j = \frac{C_{j0}}{\sqrt{1 - V/V_{bi}}}$$

Sometimes use cube root



- This can be included in small signal model



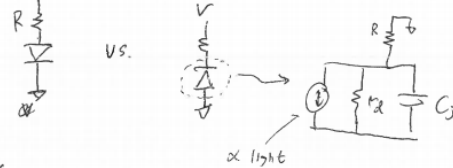
- Change voltage, change total q in bucket!

- Change in width results in more "space charge"

Optional: Should I fwd/rev Bias Photodiodes?

- Photodiode design application

↳ Trying to receive fast light pulses, e.g.: fiber optics



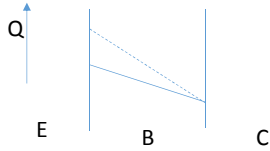
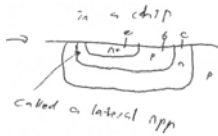
- You supply find max light frequency & decide which config to use

$$\tau = C_j (rd || R) \quad \omega_0 = \frac{1}{\tau} = \frac{1}{(rd || R) C_j}$$

- Want rev. bias $\rightarrow C_j$ smaller
- $\rightarrow rd$ bigger b/c less current
- \rightarrow No offset voltage b/c no current

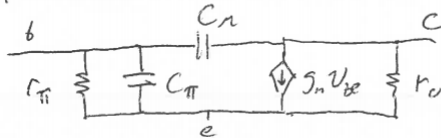
doesn't matter if large signal & slow \rightarrow see E80

BJTs Have Two PN Junctions + Base Current



cap $C_b = \tau_f g_m$
 - Forward transit time ~ 10 ps
 - ratio of Q_b/I_C
 - basically constant, clamped

Small signal model



- Full hybrid- π model

- $C_{\pi} = C_b + C_{je}$

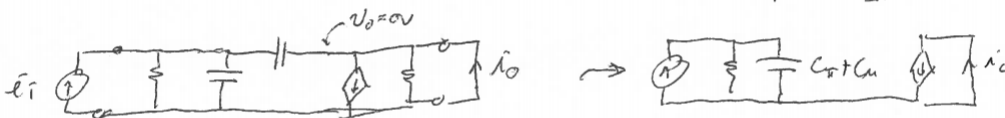
- BE junction usually forward biased, BC usually reverse biased (small)
- Charge is in transit through the base all the time, need to supply more
 - Emitter charge goes to collector, so comes from base. Changing river level ...

Describe BJT Small Signal Speed Limit with fT

How fast can we go?

- often measured w/ f_x , frequency where A_i drops to 1

S_{max} where power gain = 1



$i_o = \beta i_b$

$$V_{be} = i_i \cdot \frac{R / (C_{\pi} + C_n)s}{R + 1/(C_{\pi} + C_n)s} = \frac{r_{\pi}}{1 + r_{\pi}(C_{\pi} + C_n)s}$$

$$S_o A_{\pi} = \frac{\beta}{1 + \beta \frac{(C_{\pi} + C_n)s}{g_m}}$$

$$\rightarrow f_T \approx \frac{1}{2\pi} \frac{g_m}{r_{\pi} + r_m}$$