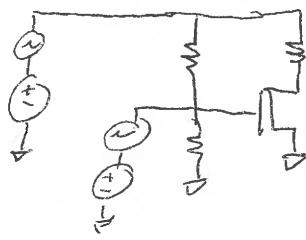


Midterm Review	Junction Capacitance	Dynamic BJT	Speed Limits
- see slides	- why? - Formula & Graph - small signal diode - photodiode ex.	- why $C_{\pi}$ & $C_m$ - Small signal model - formulas	- $f_T$ - $f_{max}$
			Goh 1.2.1 1.4.2 1.4.7 1.4.8

→ See slides for midterm review

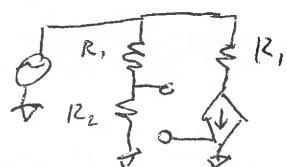
PSRR bug



me ↗

Correct ↗

Add model

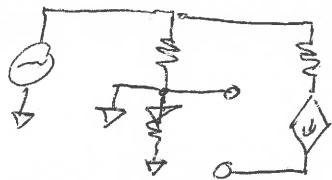


$$V_{SS} = \frac{R_2}{R_1 + R_2} V_s$$

$$V_o = V_s - g_m R_L \frac{R_2}{R_1 + R_2} V_s$$

$$\text{Add} = 1 - g_m R_L$$

PSRR reduced  
by res network  
copying  $V_s$  @  
input



$$V_{SS} = 0$$

$$\text{Add} = 1$$

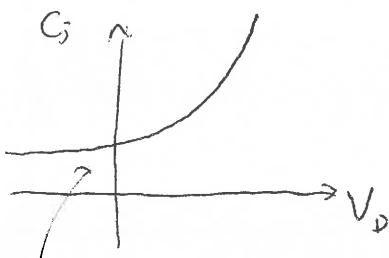
- I should have included a save resistance
- I accepted both answers, but people mostly out of time here

Recall that we introduced junction cap way back w/ diodes (bad)

$$\frac{V}{I} = C_J \quad C_J = \frac{C_{JO}}{\sqrt{1 - \frac{V}{V_{bi}}}}$$

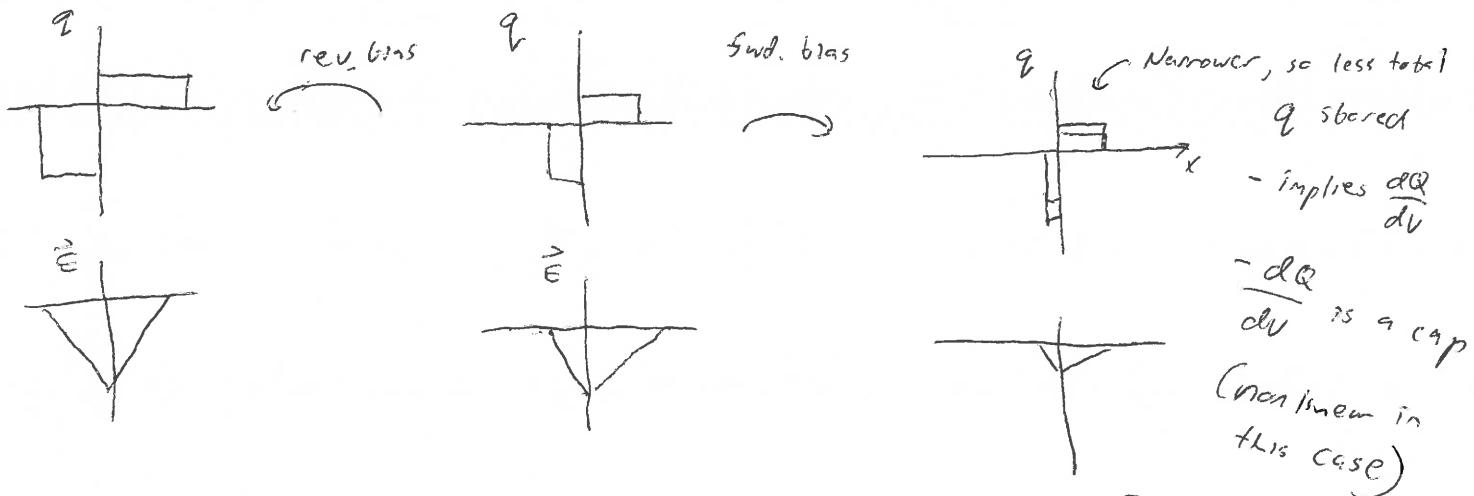
Sometimes use cube root

looks like



depends on process  
but if  $\text{SF} = \text{PF}$

- physically came from growing & shrinking PN junction depletion region



- This can be included in small signal model

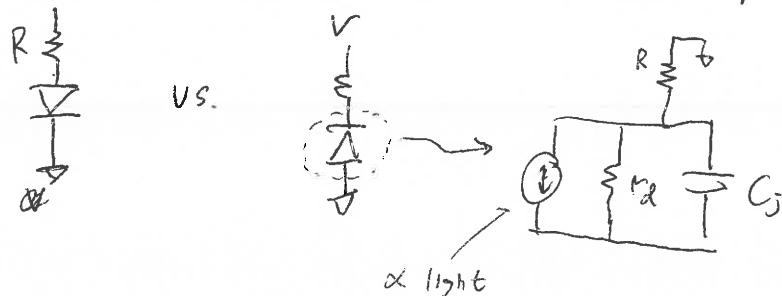


- Charge voltage, charge total  $Q$  is bucketed!

Not wiggling around much, so  $C_j$  is about the same  $\rightarrow$  linear in small sig.

- Photodiode design application

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



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

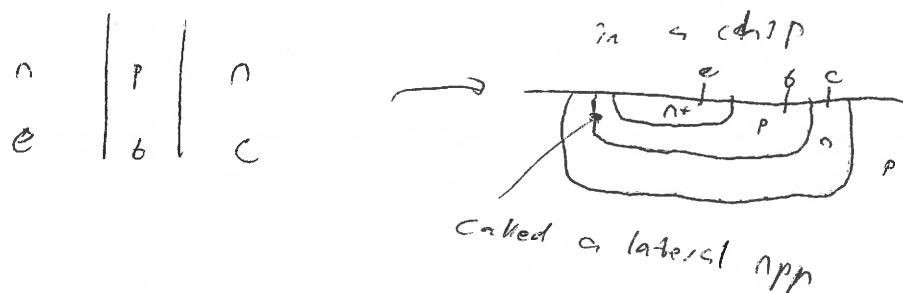
$$\chi = C_j (r_d \parallel R)$$

$$v_o = \chi \frac{r_d \parallel R}{1 + (r_d \parallel R) C_j s}$$

Want rev. bias  $\rightarrow C_j$  smaller  
 $\rightarrow r_d$  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 junctions too



- has junctions between base-carrier &  $C_{je}, C_{ce}$
- base-collector, 2 caps!
- Almost const.  $\beta/\alpha$  if  $V_b$  fixed

- In addition to junction, 1 other type of charge storage

↳ higher  $C_b$  means more total q passing through base

↳ has to be supplied externally  $\sim C_{be}$

↳ metaphor  $\sim$  changing thickness of water stream

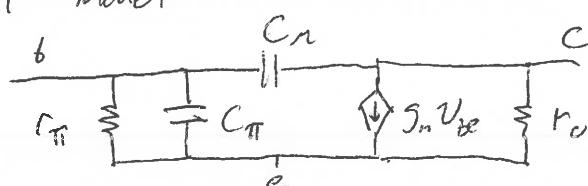
↳ base charging cap  $C_b = \sum g_m$

↑  
- Forward transit time  $\sim 10 \text{ ps}$

- ratio of  $Q_b/I_c$

- basically constant, datasheet

Small signal model

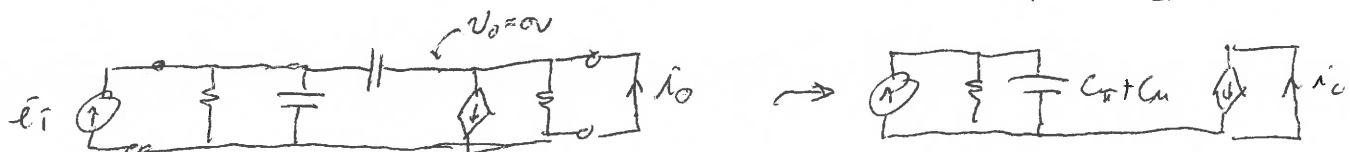


- Full Hybrid- $\pi$  model

$$- C_{bb} = C_b + C_{je}$$

How fast can we go?

- often measured w/  $f_T$ , frequency where  $A_f$  drops to 1



$$V_o = g_m V_{be}$$

$$V_{be} = i_b \cdot \frac{R/(C_{bb} + C_{ce})}{R + 1/(C_{bb} + C_{ce})s} = \frac{R}{1 + R_s(C_{bb} + C_{ce})s}$$

$$\text{so } A_f = \frac{\beta}{1 + \beta \left( \frac{C_{bb} + C_{ce}}{g_m} \right) s}$$

$$\Rightarrow f_T \approx \frac{1}{2\pi} \frac{g_m}{C_{bb} + C_{ce}}$$

Graph