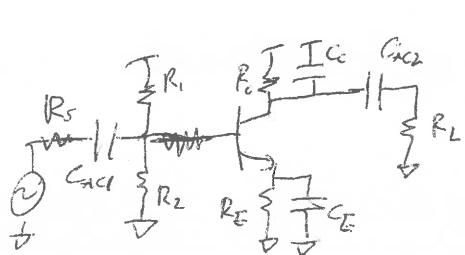


OCTC practice	SOTC	Cascode Amplifier	Xfer fns, pole-zero plots and step dynamics
- CE w/ output pole	- setup & deriv. - constraints & What to apply it to	- R_{in} , R_{out} , A_v , V_{sw} - OCTC BW analysis ↳ Note treat Miller gain! ↳ Other issues w/ $c_B w/ r_o$	~ Show 5 plots & step responses ~ FVT & IVT ~ dominant poles & non-dominant dynamics ~ AC couple

We ended last time introducing OCTC, but I think we could use some practice



You say

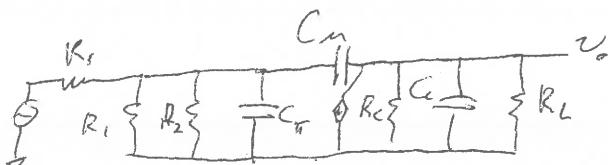
you

- ① What caps do we find OCTC for? which are shorted?
- ② Draw small signal \leftrightarrow together
- ③ Find OCTC \leftrightarrow you

Find OCTC for C_π , C_m , C_c

~ pole coupling

~ "If I shorted this does A_v go up or down" \leftarrow if down, include



$$OCTC_\pi = C_\pi (R_1 \parallel R_2 \parallel R_s)$$

$$OCTC_m = C_m (R_E \parallel R_L)$$

$$OCTC_u = C_u (R_1 \parallel R_2 \parallel R_s + R_E \parallel R_L + g_m (R_E \parallel R_L) (R_1 \parallel R_2 \parallel R_s))$$

- Got u using formula from last time



$$i_t = g_m v_{BE} + \frac{v_t - v_E}{R_{cc}}$$

$$-v_{BE} = i_t R_{BB} \quad \text{(cancel)} = v_E$$

$$i_t = -g_m R_{BB} i_t + \frac{v_t - i_t R_{BB}}{R_{cc}}$$

$$i_t (1 + R_{BB} + g_m R_{BB}) = v_t / R_{cc}$$

Right
 \int
Resist

$$\frac{v_t}{i_t} = R_{eff} = R_{cc} + R_{BB} + g_m R_{BB} R_{cc}$$

- Equation holds for this common small signal structure

Calculating flow is \leq pain, can some OCTC-like technique help?

↳ yes! SCTC!

↳ account for all the "zero-causing" caps we skipped in motivator ckt.

OCTC reminder

$$\text{Let } H(s) = \frac{Av}{(1+\zeta_1 s)(1+\zeta_2 s)\dots(1+\zeta_n s)} = \frac{1}{1 + s \sum \zeta_i + \dots + T^2 C_i s^n}$$

SCTC

$$\text{Let } H(s) = \frac{Av k s^n}{(s+p_1)(s+p_2)(s+p_3)\dots s^n + s^{n-1} \sum p_i + \dots} = \frac{A k s^n}{s + \sum p_i}$$

— Alternate form of poles, need k

— High pass-like behavior

Assert low order terms matter
b/c @ high f close to ζ_i

Assert high order terms matter b/c @
low f far from ζ_i

$$\text{so } H(s) = \frac{Ak s}{s + \sum p_i}$$

— Pole located @ sum of pole frequencies, still hard to find

$$\sum \zeta_i = \sum \text{OCTC}_i \quad | \quad \sum p_i = \sum \text{SCTC}_i^{-1}$$

$$\text{where } \text{OCTC}_i = C_x \cdot R_{TH} \Big|_{\text{caps open}} \quad | \quad \text{where } \text{SCTC}_i = C_x \cdot R_{TH} \Big|_{\text{All other caps short}}$$

Discussion:

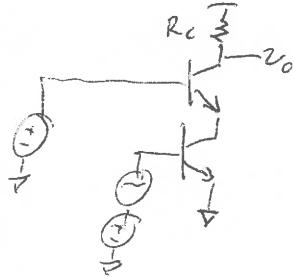
- Same caveats ~ SCTC is a weird network qty not associated w/ particular zero
- performs worst w/ colocated poles, but still conservative
- Mostly used to find flow, so throw out "pole-causing" caps in analysis
- ↳ occasionally used w/ OCTC to get 2^{nd} order poles in 2-pole system.
non-dominant
- Practice on motivator ckt if time →

• OCTC & Miller have both revealed that C_M is a problem.

↳ get around it with a classic amplifier

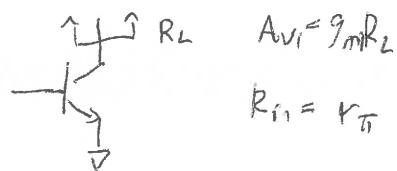
↳ one of the iconic analog tricks

↳ called a cascade amplifier. Compound amp made of CE - CB



- As usual, omitting bias details here

- DC analysis



$$R_{in1} = \frac{1}{g_{m2}} + \frac{R}{g_{m2}r_{o2}}$$

$$A_{v2} = g_{m2} R_C$$

$$A_{v,\text{tot}} = A_{v1} A_{v2}$$

$$= g_{m1} \left(\frac{1}{g_{m2}} + \frac{R}{g_{m2}r_{o2}} \right) \cdot g_{m2} R_C$$

$$\approx g_{m1} R_C$$

$R_{out} = R_C \parallel$ interesting stuff
that turns out
really big

~~Note~~ Note that Miller cap C_M only sees A_{v1} !

$$A_{v1} = g_{m1} \left(\frac{1}{g_{m2}} + \frac{R}{g_{m2}r_{o2}} \right) \approx 1 \quad \leftarrow \text{cap is not Millerized! Big BW extension! Not linked to } A_{v2} \right)$$

- Pay for it in $V_{SW} \approx$ need $2 \cdot V_{CE,\text{sat}}$ over the structure

Interesting R_{out} calc's

- same as degenerated CE

$$i_t = g_{m2} V_{GE2} + \frac{V_t - V_m}{r_{o2}}$$

$$V_m = i_t (r_{o2} \parallel r_{o1})$$

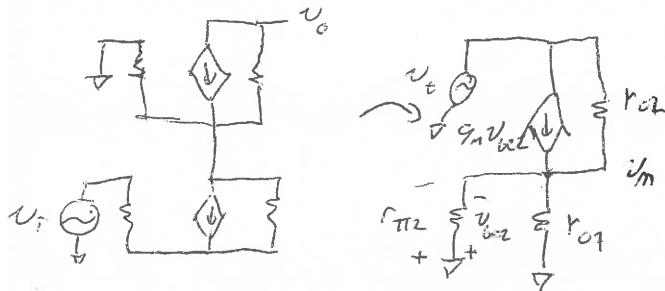
$$V_{GE2} = -V_m$$

$$i_t = i_t (r_{o2} + \frac{r_{o2} \parallel r_{o1}}{r_{o2} + r_{o1}} r_{o2})$$

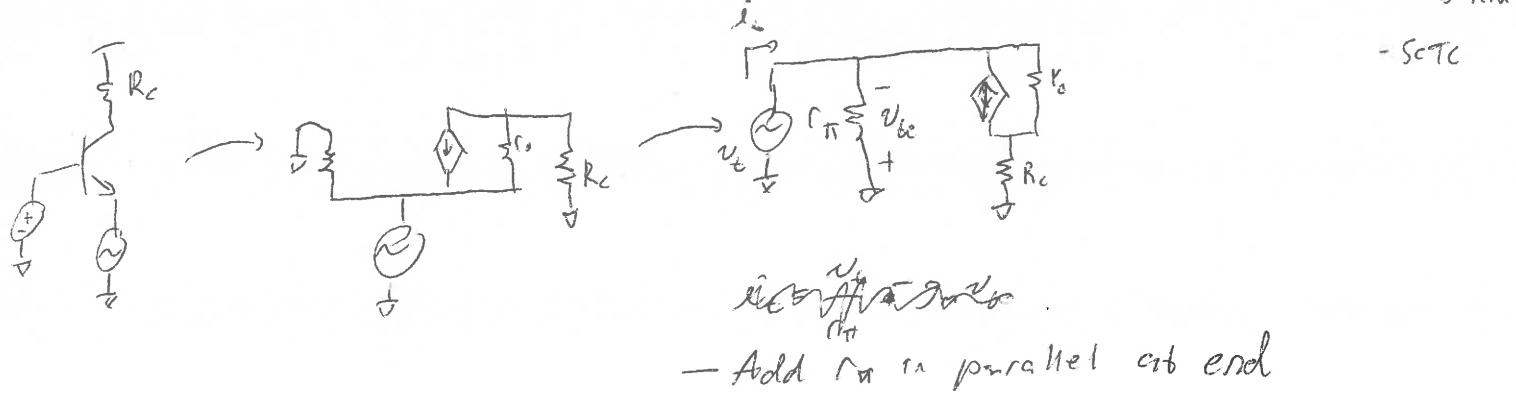
$$R_{out} = \left[\frac{r_{o2}}{r_{o2} + r_{o1}} \right] r_{o2} + 1 + g_{m2} (r_{o2} \parallel r_{o1})$$

$$R_{out} \approx r_{o2} \left(1 + \frac{r_{o2}}{r_{o2} + r_{o1}} \right)$$

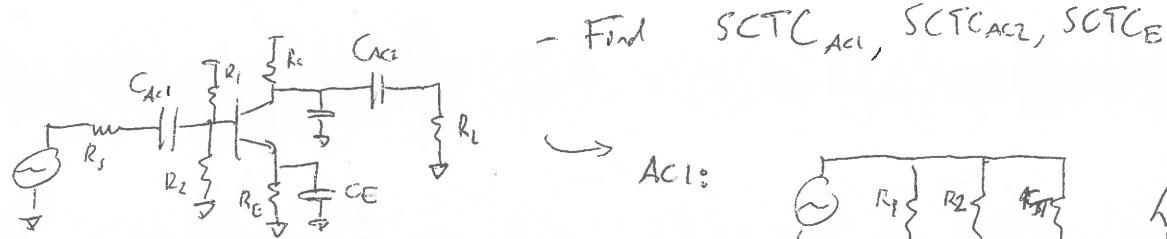
$$i_t = -g_{m2} (r_{o2} \parallel r_{o1}) i_t + \frac{V_t}{r_{o2}} = \frac{r_{o2} \parallel r_{o1}}{r_{o2}} i_t \quad \boxed{\text{big}}$$



Common base R_{in} depends on R_C



SCTC Practice



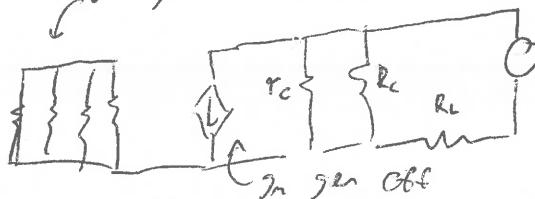
AC1:



$$SCTC_{AC1} = C_{AC1} (R_1 || R_2) (r_\pi + R_S)$$

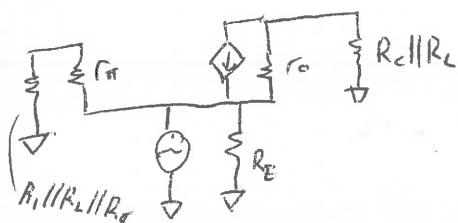
AC2:

voltage is zero



$$SCTC_{AC2} = C_{AC2} (R_o + R_L || R_C)$$

E:

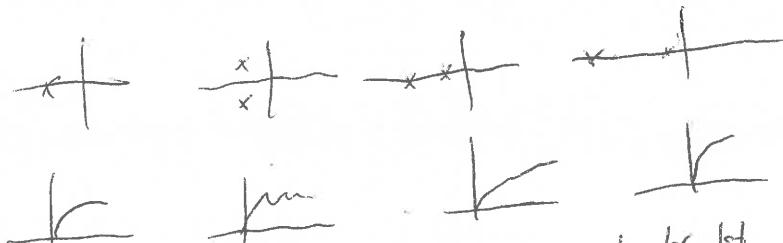


$\rightarrow A_{vss}$, but probably $\sim \frac{1}{f g_m} + \frac{R_C || R_L}{f B}$

$$\omega/f = \frac{r_\pi}{r_\pi + R_1 || R_2 || R_S}$$

Looks like common base w/ base resistance, see q above.

All pole dynamics settle after step response --



- Looks 1st order

- non-dominant pole