EE140 Spring 2014
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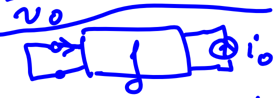
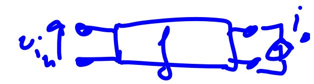
Summary 2-port

Feedback type	2-port params	Output value	Input value	T.F	Z_i	Z_o	To calc. loading: At input	To calc. loading: At output	f
shunt-shunt	y	v_o	i_s	$\frac{v_o}{i_s}$ trans-resist.	Low	Low	s.c. output feedback node	s.c. input feedback node	Apply voltage at output, and s.c. input f.b. ports & measure current ← $f = \frac{i_{in}}{v_o}$
shunt-series	g	i_o	i_s	$\frac{i_o}{i_s}$ current gain	Low	High	o.c. output feedback node	s.c. input feedback node	 Apply current at output and s.c. input fb port & measure current $f = \frac{i_{in}}{i_o}$
series-shunt	h	v_o	v_s	$\frac{v_o}{v_s}$ volt. gain	High	Low	s.c. output feedback node	o.c. input feedback node	$f = \frac{v_{in}}{v_o}$  Apply voltage at output and o.c. input fb. port & measure voltage.
series-series	z	i_o	v_s	$\frac{i_o}{v_s}$ trans cond.	High	High	o.c. output feedback node	o.c input feedback node	$f = \frac{v_{in}}{i_o}$  Apply current at output and o.c. input fb. port & measure voltage.

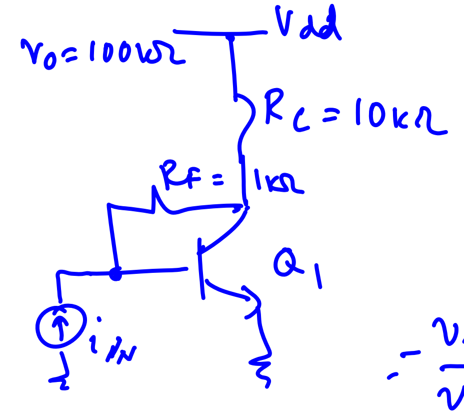
a, Z_{in}, Z_o

Comparing $\underline{\underline{RR}}$ with $\underline{a\cdot f}$

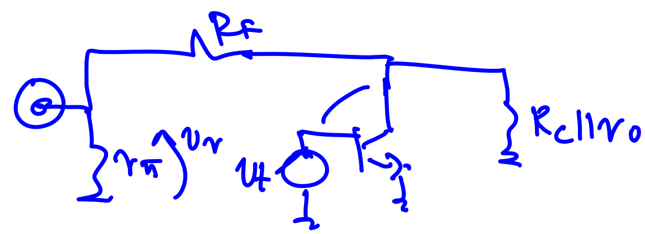
return ratio — loop gain (T)

$g_m = 38.4\,mS$

$r_\pi = 5.2\,k\Omega$



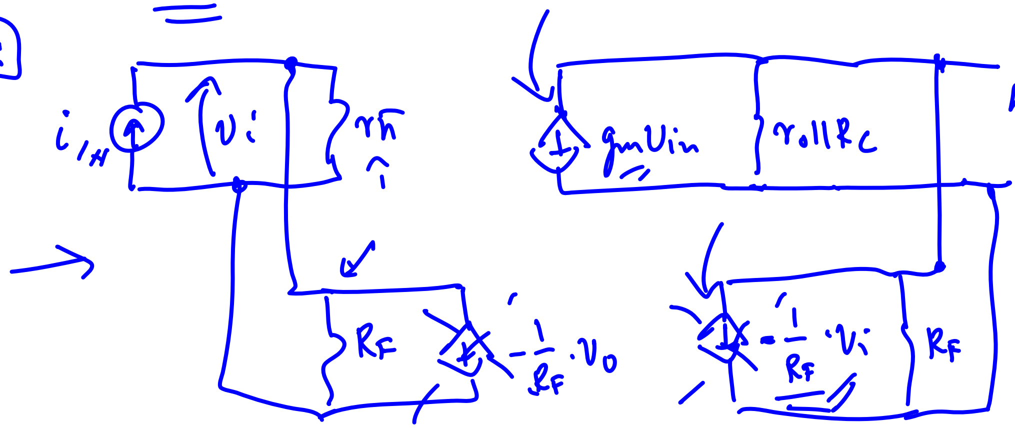
$\underline{\underline{RR:}}$

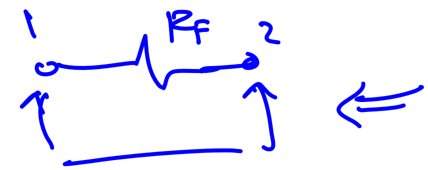


$$-\frac{v_r}{v_t} = RR = g_m \cdot r_\pi \frac{R_c\|r_o}{r_\pi + R_F + R_c\|r_o} = \frac{g_m}{R_F}(r_\pi\|R_F)\left(r_o\|R_c\|(r_\pi+R_F)\right)$$

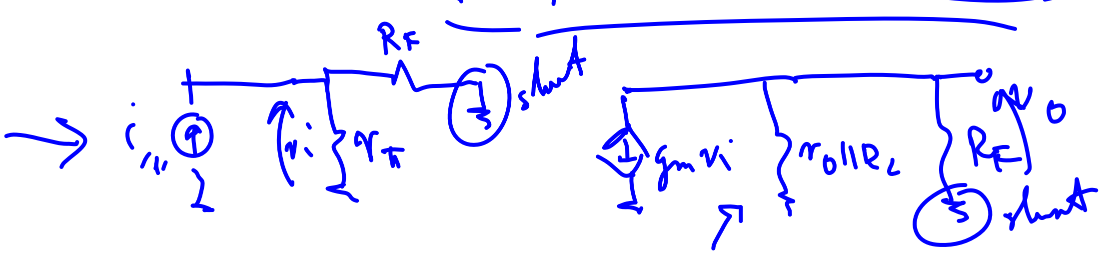
$RR = \underline{\underline{119}}$

$\boxed{\text{2-port:}}$





$$a\cdot f = -\underbrace{\left(\overset{y_{21a}}{g_m} - \overset{y_{21f}}{\frac{1}{R_F}}\right)(r_\pi\|R_F)\cdot(R_F\|r_o\|R_c)}_{a}$$



$\underline{\text{unilat. assumption:}}$ $\left(-\frac{1}{R_F}\right)$

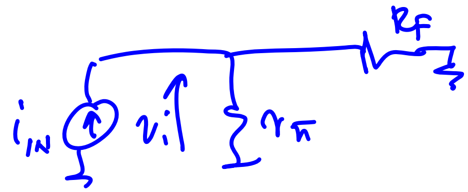
$$|y_{21f}| = \frac{1}{R_F} = 1\,mS << |y_{21a}| = g_m = 38.4\,mS$$

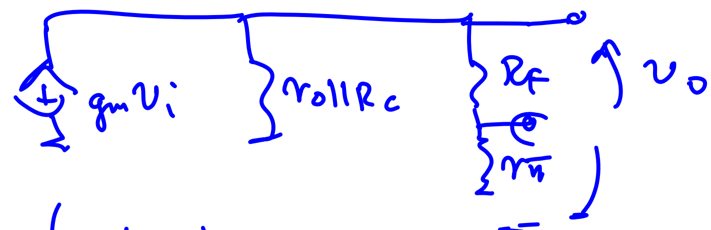
$a \cdot f = \underline{\underline{28}}$ or 29

with unilat assumption (i.e. neglect $\left(-\frac{1}{R_F}\right) = y_{21,f}$)

$$A_{CL} = \frac{1}{f} \cdot \frac{af}{1+af} = -966\,\Omega \quad \text{or} \quad -967\,\Omega$$

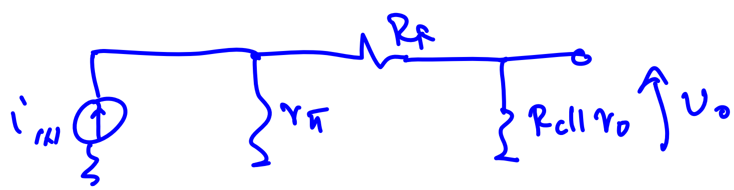
A_{eq}:





$$A_{eq} = -g_m \cdot \left(r_o \| R_C \| (r_\pi + R_F)\right) \cdot \left(r_\pi \| R_F\right) = (-R_F) \cdot RR$$

A_o:



$$A_o = \frac{r_\pi}{R_F + r_\pi + R_C \| r_o} \cdot R_C \| r_o$$

$$A_{CL} = \frac{A_{eq} + A_o}{1 + RR} = \left(-R_F + \frac{1}{g_m}\right) \frac{RR}{1+RR}$$

$$= \frac{1}{R_F} \cdot (r_\pi \| R_F)\left(R_C \| r_o \| (r_\pi + R_F)\right) \approx \frac{RR}{g_m}$$

$$= (-974\,\Omega) \cdot \frac{119}{120} \approx \boxed{-966\,\Omega}$$

When is $RR = a \cdot f$?

$RR = af$

when:

1. $|y_{21a}| >> |y_{21f}|$

2. $|(y_{11a} + y_{11f})(y_{22a} + y_{22f})| >> |(y_{12a} + y_{12f}) \cdot y_{21f}|$

$\underline{RR(y_{21a})} = a \cdot f$

replace y with g, h, z

y_s, y_L lumped into y_{11a}, y_{22a}