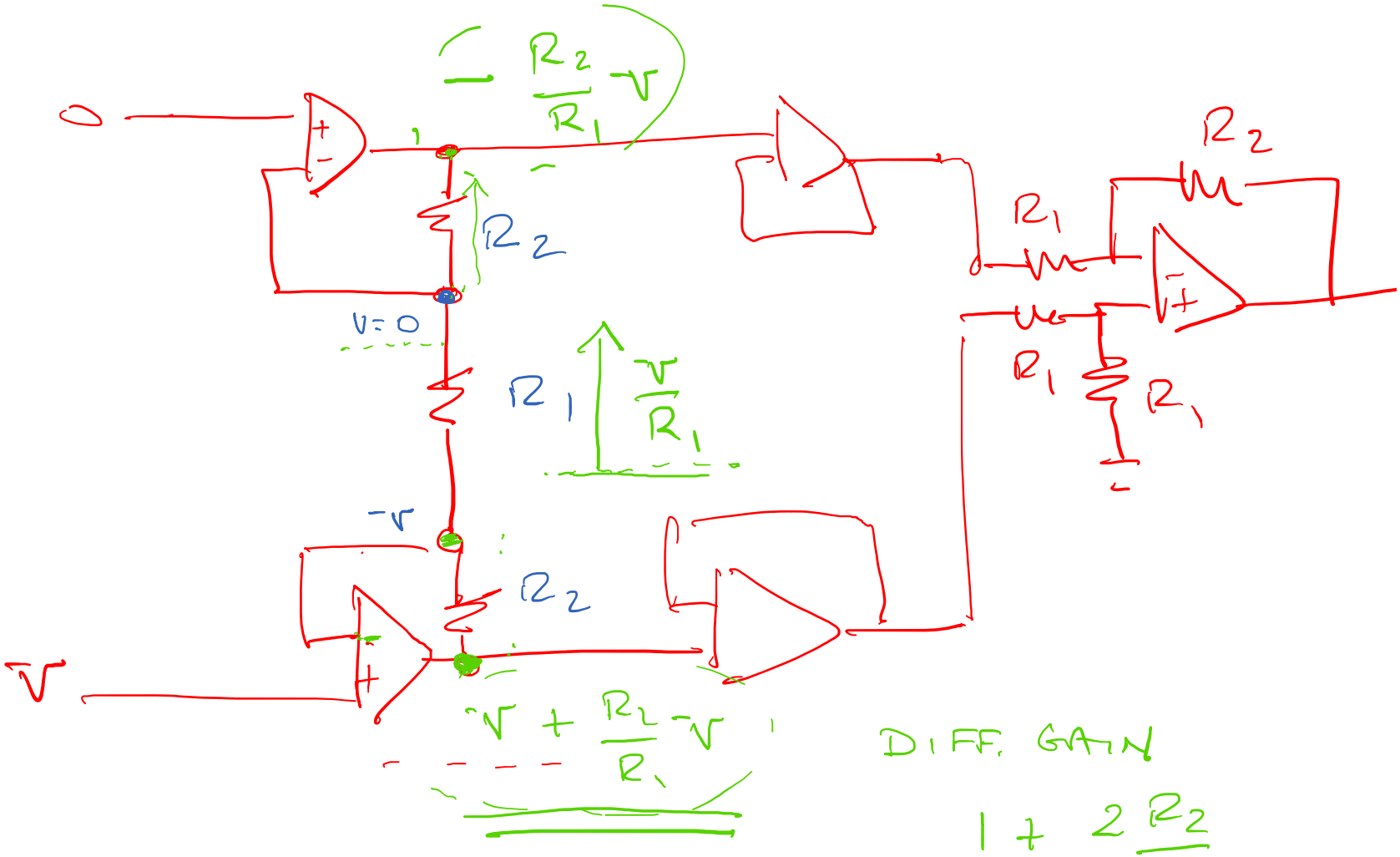
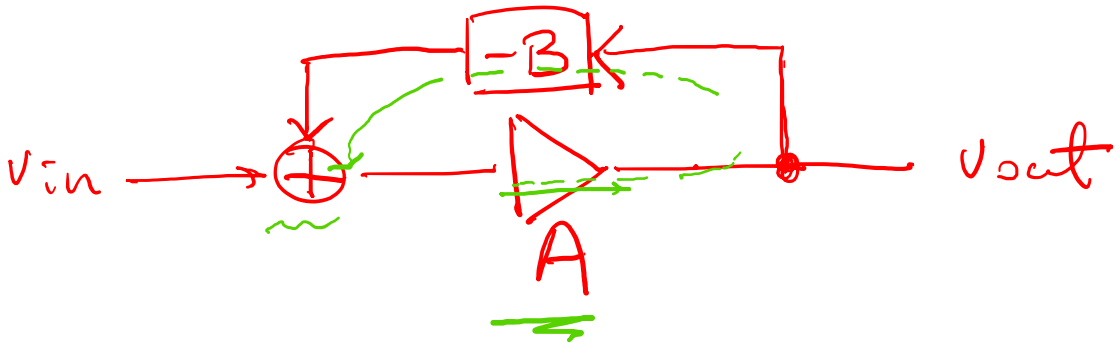

0
V
$-\frac{R_2}{R_1}V$
R_2
V=0
R_1
$\frac{V}{R_1}$
-V
R_2
$-V+\frac{R_2}{R_1}V$
R_2
R_1
R_1
R_1
DIFF. GAIN
$1+2\frac{R_2}{R_1}$

NEGATIVE FEEDBACK



$$V_{out} = \frac{A}{1 + AB} V_{in} \approx \frac{1}{B}$$

A: OPEN LOOP GAIN $\quad V_{out} = A[V_+ - V_-]$

B: FEEDBACK FRACTION PROGRAMMED BY EXTERNAL R's

→ $G \approx 1/B$: CLOSED LOOP GAIN

AB: LOOP GAIN

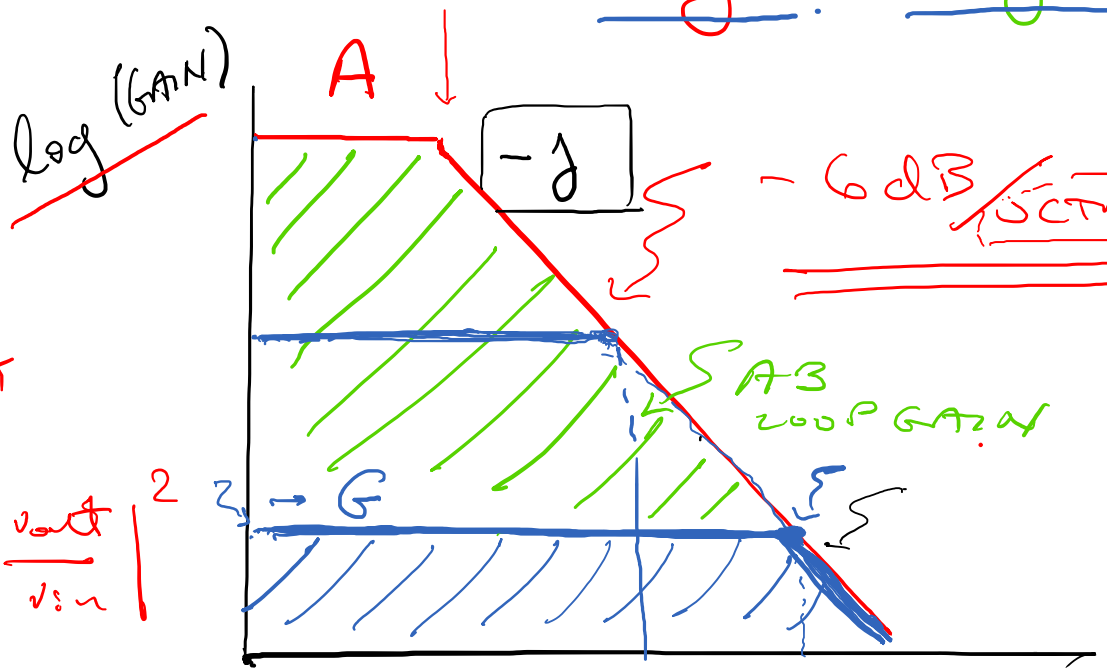
OPEN LOOP

LOOP GAIN

CLOSED LOOP GAIN

$$* \quad A = (AB)\frac{1}{B} = (AB)G$$

$$\log A = \log (AB) + \log G$$



BODE PLOT

3 dB → FACTOR 2

6 dB FACTOR 4

$\left|\frac{\text{Vout}}{\text{Vin}}\right|^2$

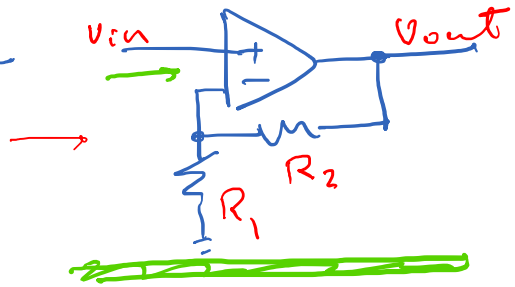
(VOLTAGE)

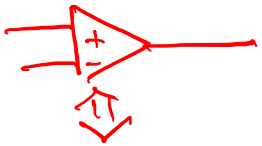
GAIN * BANDWIDTH → FIXED

$$\frac{V_o}{V_i} \sim \frac{\frac{1}{j\omega C}}{R} \sim \frac{1}{\omega}$$

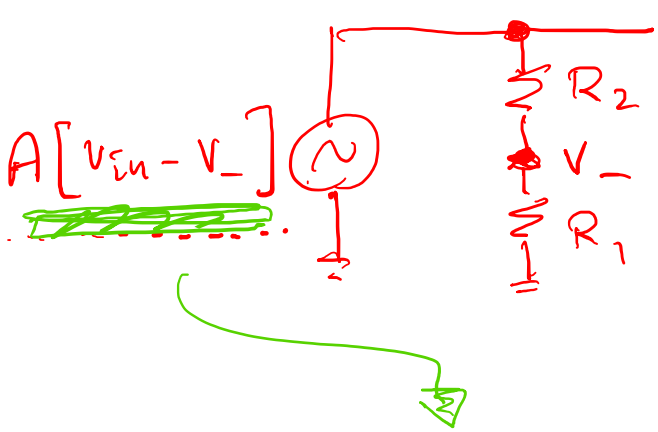
MORE DETAILED LOOK

NONINVERTING STAGE





EQUIVALENT:



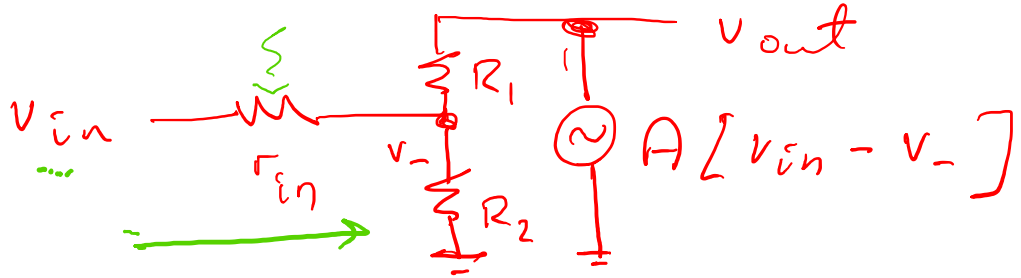
$$\rightarrow \quad v_- = \frac{R_1}{R_1+R_2} A\left[v_{in} - v_-\right]$$

$$= \frac{AR_1}{(A+1)R_1 + R_2} v_{in}$$

$$G = \frac{v_{out}}{v_{in}} = A \frac{R_1+R_2}{(A+1)R_1+R_2} \; ; \quad \text{AS} \quad A \rightarrow \infty ,$$

$$G \rightarrow 1 + \frac{R_2}{R_1}$$

NONINVERTING STAGE: INPUT IMPEDANCE



$$v_{out} = G\, v_{in}$$

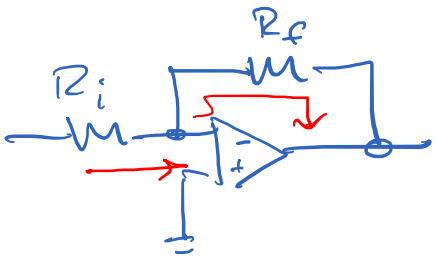
$$I_{in} = \frac{v_{in} - v_-}{r_{in}} = \boxed{\frac{v_{out}}{A}} \frac{1}{r_{in}} = \frac{G}{A} \frac{1}{r_{in}} v_{in}$$

$$\boxed{R_{in} = \frac{A}{G} r_{in}}$$

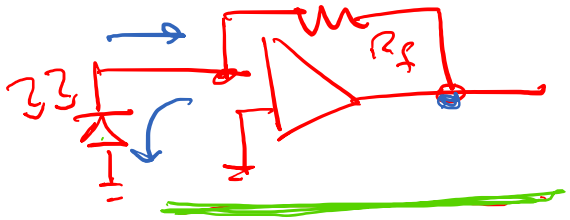
ENHANCED BY FACTOR $\frac{A}{G}$ (LOOP GAIN)

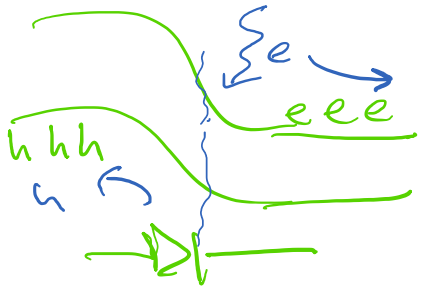
RELATIVE TO NO FEEDBACK!

TRANSRESISTANCE AMPLIFIER

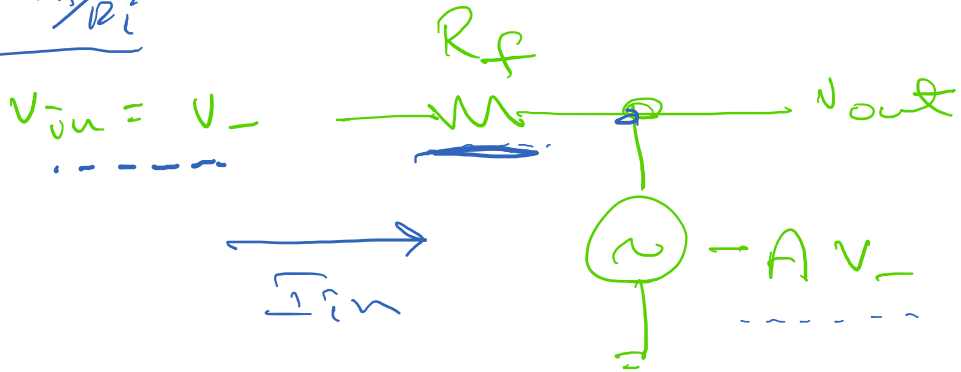


e g





$G = -R_f/R_i$

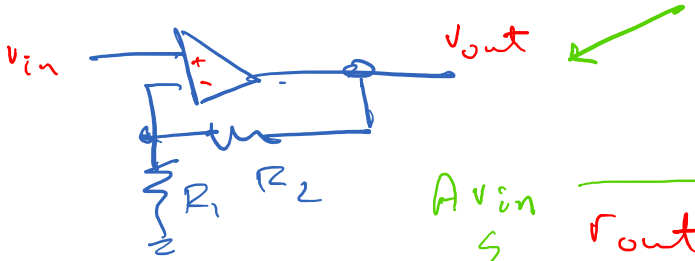


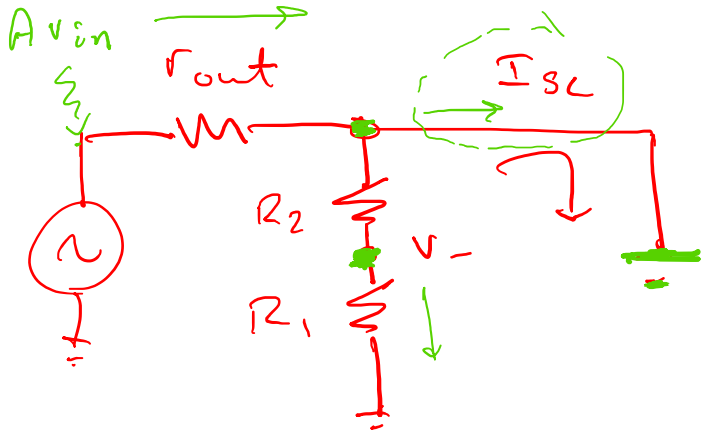
$$I_{in} = \frac{[1+A]}{R_f} V_-$$

$$\Rightarrow \boxed{R_{in} = \frac{R_f}{1+f}}$$

SUPPRESSION OF INPUT RESISTANCE

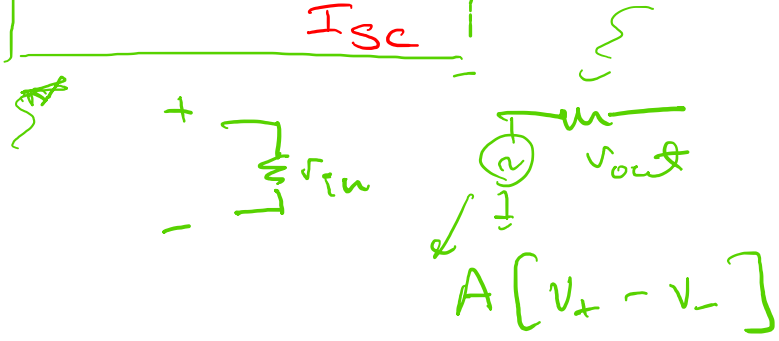
NONINVERTING AMP : OUTPUT IMPEDANCE





$$A\left[V_{in} - V_-\right]$$

$$R_{out} = \frac{V_{oc}}{I_{SC}}$$

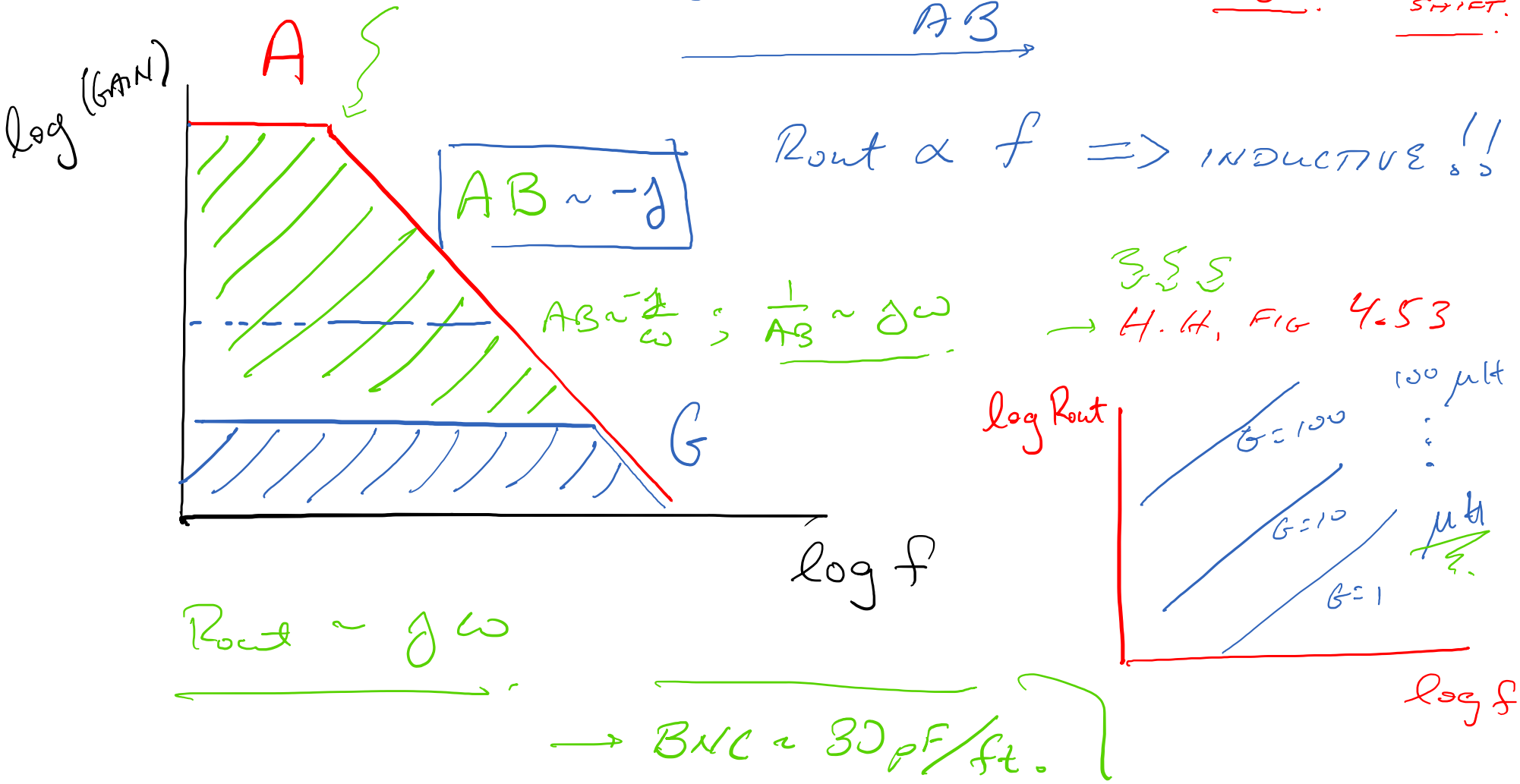


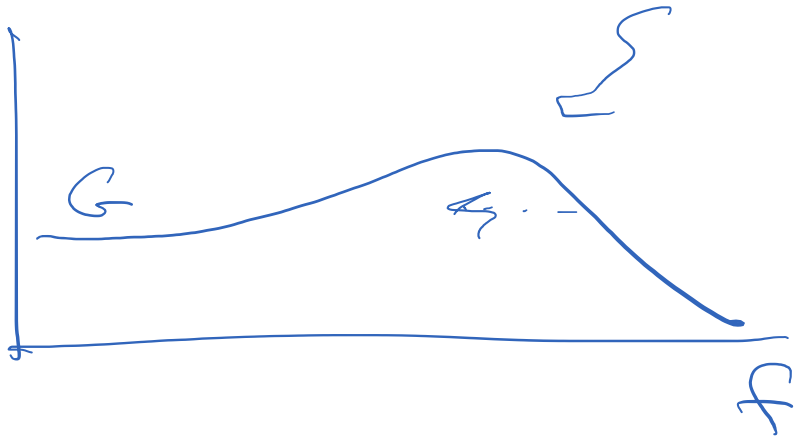
$V_- = 0$

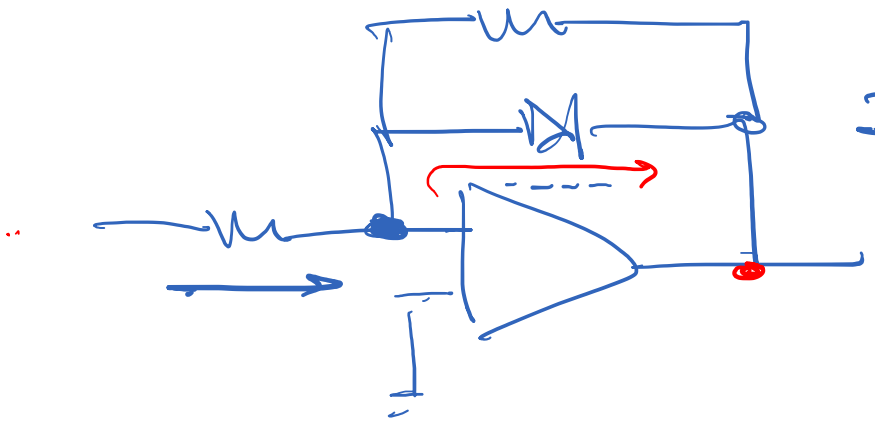
$$I_{SC} = \frac{A v_{in}}{r_{out}} \; ; \quad \boxed{V_{oc} = G v_{in}}$$

$$\boxed{R_{out} = \frac{G}{A} r_{out} = \frac{r_{out}}{1 + AB}}$$

R_{out} IS SUPPRESSED BY FACTOR AB [LOOP GAIN] RELATIVE TO NO F. BACK.


$R_{out} \approx \frac{v_{out}}{AB}$
$\rightarrow \times j$. 90° PHASE SHIFT.
$R_{out} \propto f \Rightarrow$ INDUCTIVE!!
log (GAIN)
A
$AB \sim -j$
$AB \sim \frac{1}{\omega}$; $\frac{1}{AB} \sim j\omega$
$\rightarrow$ H. H, FIG 4.53
G
log f
log Rout
100 μH
G=100
G=10
G=1
μH
log f
$R_{out} \sim j\omega$
$\rightarrow$ BNC ≈ 30 pF/ft.





$$I = I_0 e^{eV/kT}$$

$$V \sim \ln I$$