Frequency Response

(Part 4)

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A figure of this presentation was taken from the web site of the author of the book:

R.C. Jaeger, *Microelectronic Circuit Design*. New York, NY: McGraw-Hill, 1996.

Comparison of Low-Frequency FET Responses

	R_{C_G}	R_{C_S}	R_{C_D}
CS	$R_{SS} + R_{G1} \parallel R_{G2}$	$R_S \parallel \dfrac{1}{g_m}$	$R_L + R_D$
CG	$R_{G1} \parallel R_{G2}$	$R_{SS} + (R_S \parallel \dfrac{1}{g_m})$	$R_D + R_L$
CD	$R_{SS} + R_{G1} \parallel R_{G2}$	$(R_S \parallel \dfrac{1}{g_m}) + R_L$	R_D

$$\omega_L \approx \frac{1}{R_{C_G} C_G} + \frac{1}{R_{C_S} C_S} + \frac{1}{R_{C_D} C_D}$$

Comparison of Low-Frequency BJT Responses

	R_{C_B}	R_{C_E}	R_{C_C}
CE	$R_S + (R_{B1} \parallel R_{B2} \parallel r_\pi)$	$R_E \parallel \dfrac{r_\pi + (R_S \parallel R_{B1} \parallel R_{B2})}{\beta + 1}$	$R_L + (R_C \parallel r_o)$
CB	$R_{B1} \parallel R_{B2} \parallel [r_\pi + (1+\beta)(R_E \parallel R_S)]$	$R_S + R_E \parallel r_\pi \parallel 1/g_m$	$R_L + (R_C \parallel r_o)$
CC	$R_S + R_{B1} \parallel R_{B2} \parallel [r_\pi + (1+\beta)(R_E \parallel R_L)]$	$R_L + R_E \parallel \dfrac{r_\pi + (R_S \parallel R_{B1} \parallel R_{B2})}{\beta + 1}$	$R_C \parallel [r_o + (R_E \parallel R_L)]$

$$\omega_L \approx \frac{1}{R_{C_B} C_B} + \frac{1}{R_{C_E} C_E} + \frac{1}{R_{C_C} C_C}$$

Comparison of High-Frequency FET Responses

	R_{gs}	R_{gd}
CS	r_S	$r_S[1+(r_o \parallel r_L)(g_m + 1/r_S)]$
CG	$r_S \parallel \dfrac{1}{g_m}$	$r_o \parallel r_L$
CD	$\dfrac{r_L + r_S}{1+g_m(r_L + r_S)}$	r_S

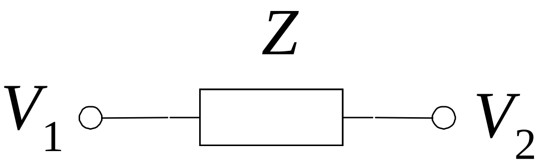
$$\omega_H \approx 1/(R_{gs}C_{gs} + R_{gd}C_{gd})$$

Comparison of High-Frequency BJT Responses

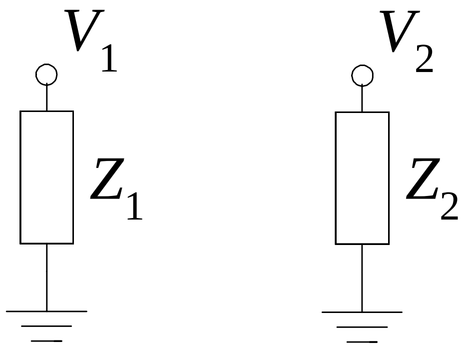
	R_π	R_μ
CE	$(r_S + r_x) \parallel r_\pi$	$R_\pi[1 + (r_o \parallel r_L)(g_m + 1/R_\pi)]$
CB	$r_\pi \parallel \dfrac{r_x + r_S}{1 + g_m r_S}$	$r_L \parallel (r_o + r_x \parallel r_S)$
CC	$r_\pi \parallel \dfrac{r_x + r_S + (r_L \parallel r_o)}{1 + g_m (r_L \parallel r_o)}$	$r_\pi \parallel \dfrac{r_L + r_S + r_x}{1 + g_m (r_L + r_S + r_x)}$

$$\omega_H \approx 1/(R_\pi C_\pi + R_\mu C_\mu)$$

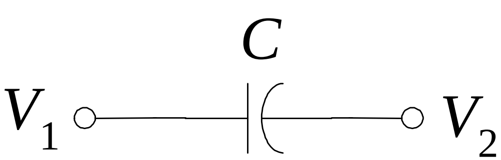
Miller´s Theorem

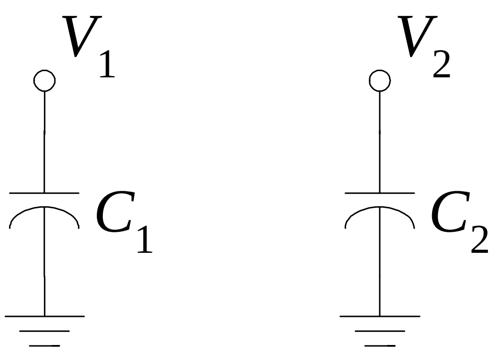


$$A_V = \frac{V_2}{V_1}$$



$$Z_1 = \frac{Z}{1 - A_V} \qquad Z_2 = \frac{Z A_V}{A_V - 1}$$



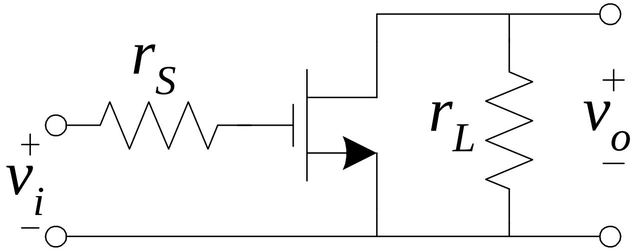


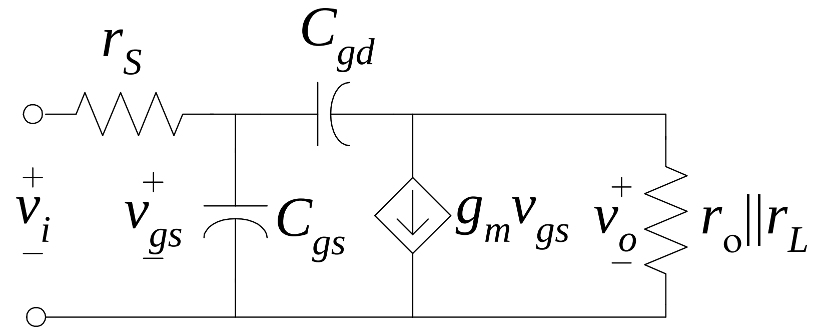
$$C_1 = C(1 - A_V)$$

$$C_2 = C\left(\frac{A_V - 1}{A_V}\right)$$

Miller Effect

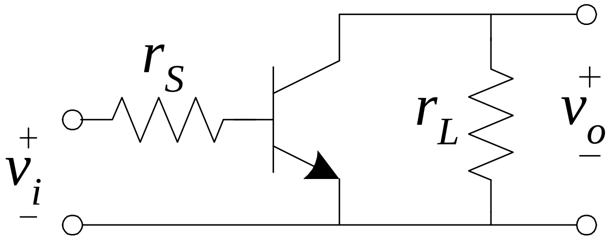
Common Source

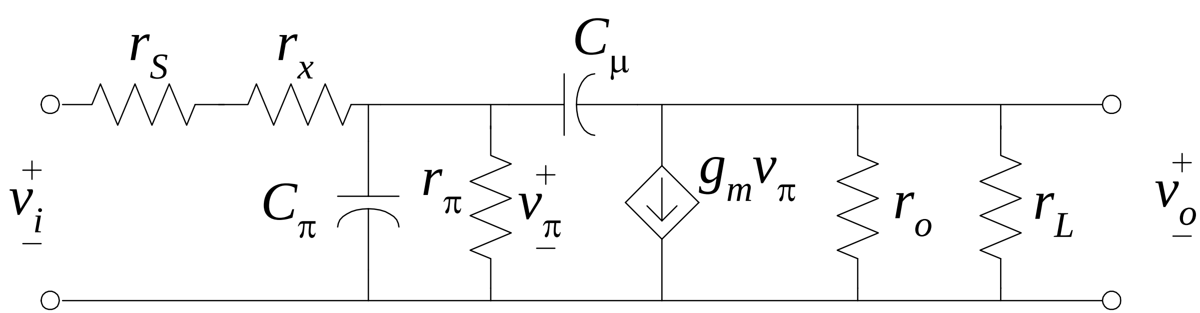




$$R_{gd} = r_S[1 + (r_o \| r_L)(g_m + 1/r_S)]$$

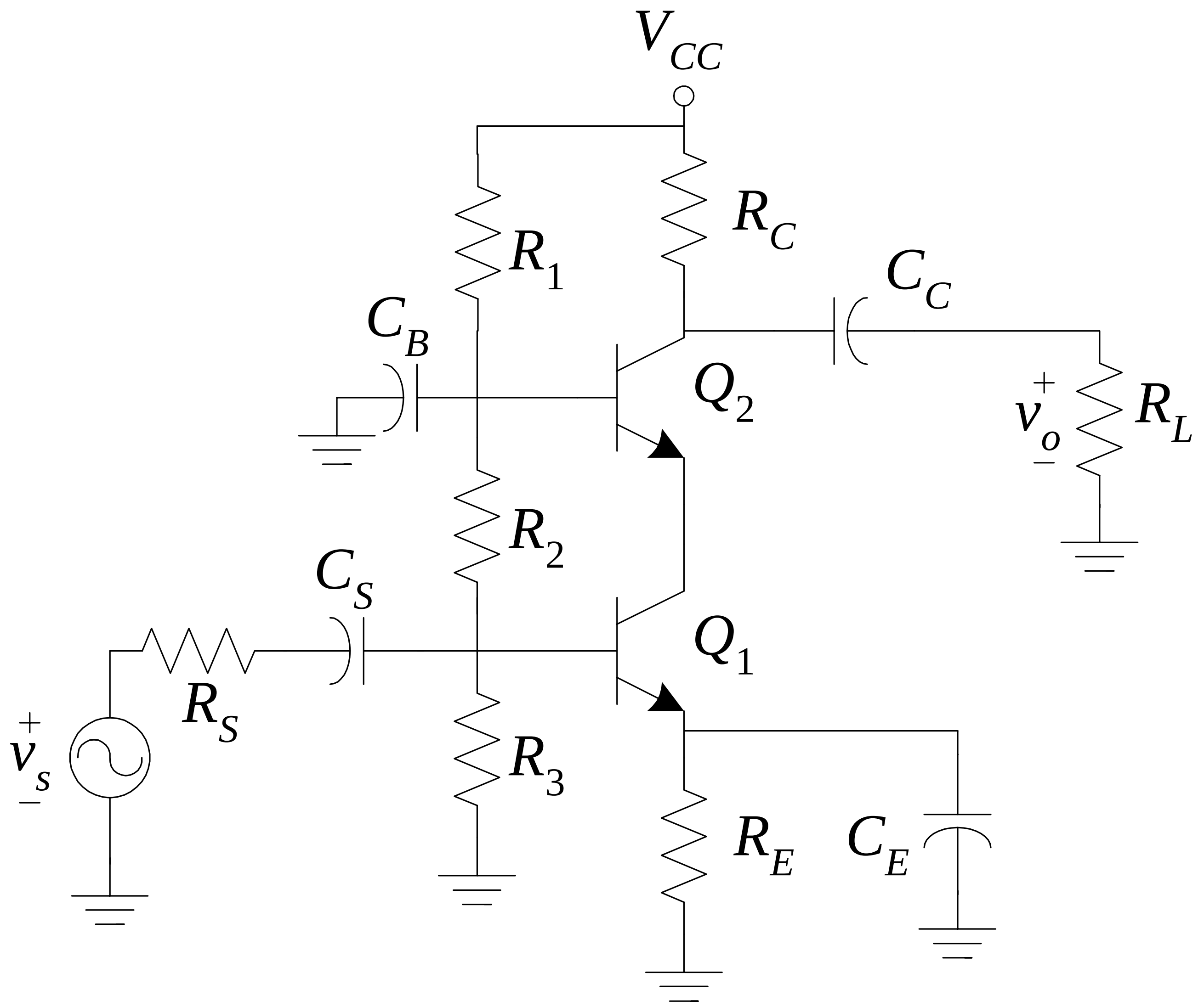
Common Emitter



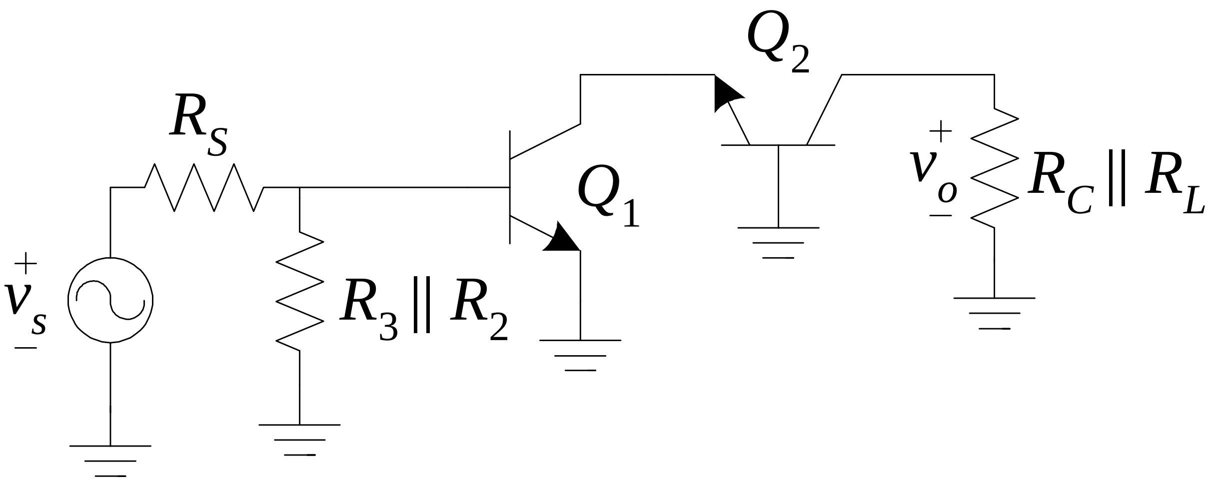


$$R_\mu = R_\pi[1 + (r_o \| r_L)(g_m + 1/R_\pi)]$$

The Cascode Configuration

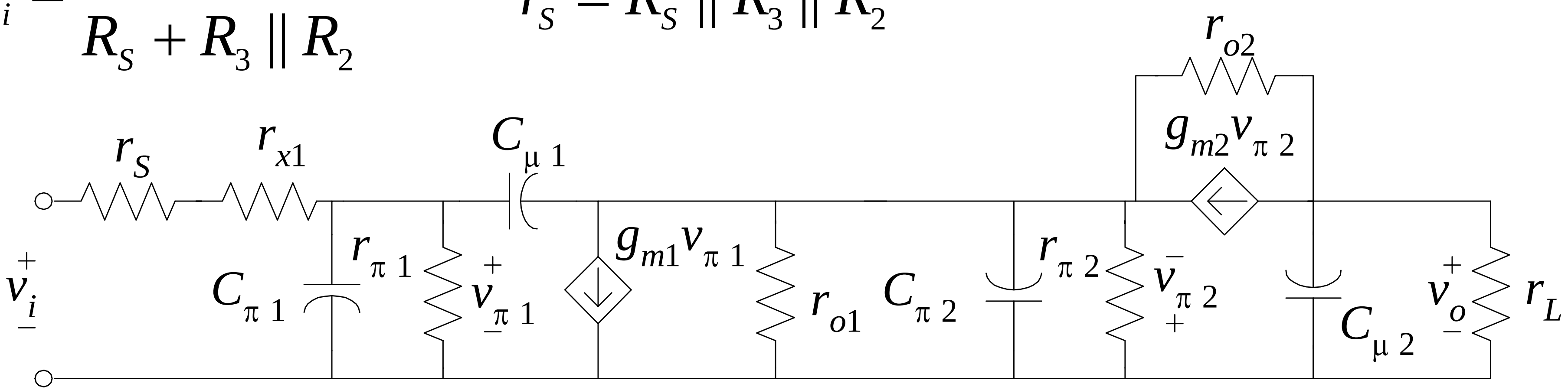


The Cascode Configuration (cont)

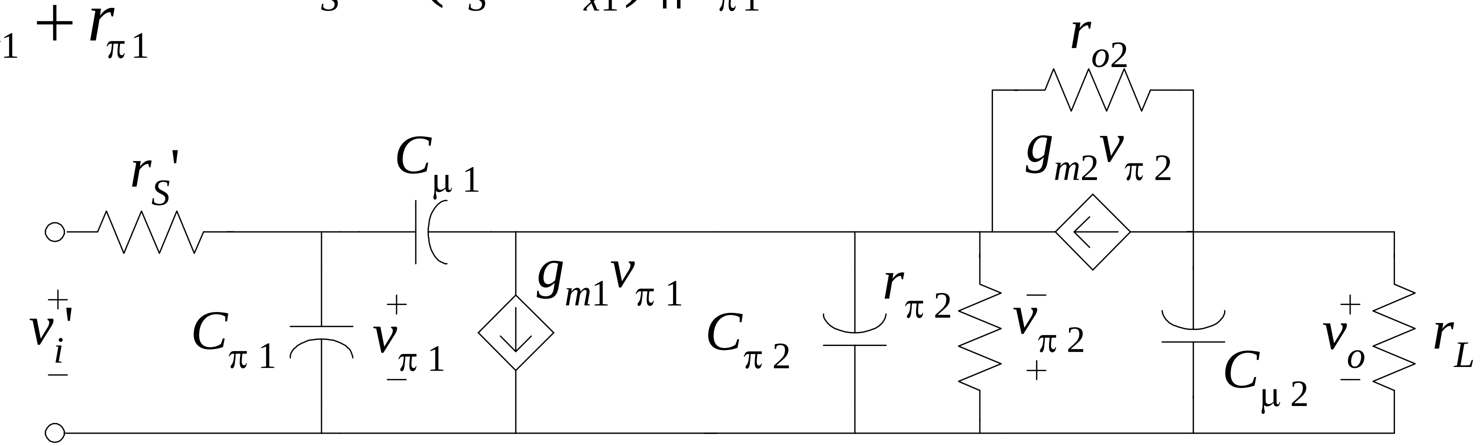


The Cascode Amplifier at High Frequencies

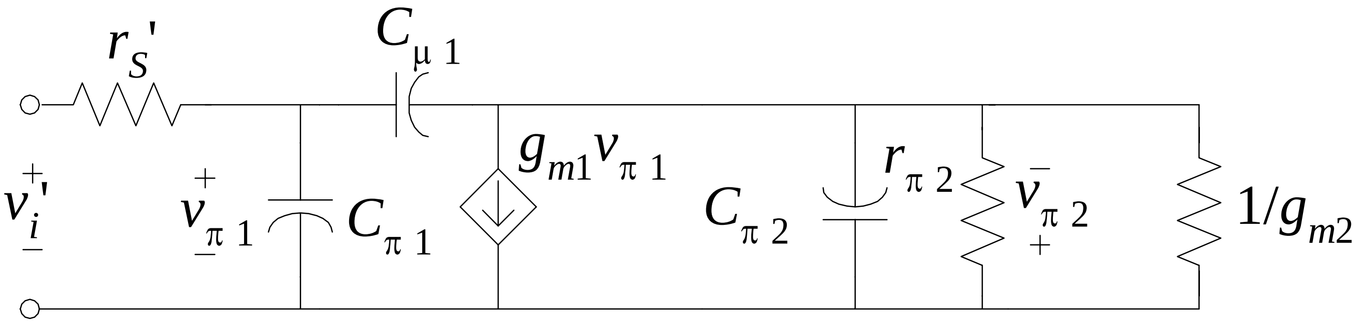
$$v_i = \frac{v_s (R_3 \| R_2)}{R_S + R_3 \| R_2} \qquad r_S = R_S \| R_3 \| R_2$$



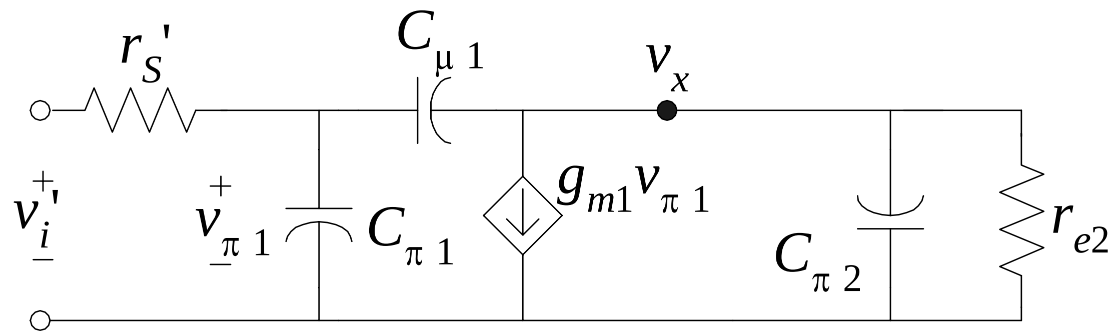
$$v_i' = \frac{v_i r_{\pi 1}}{r_S + r_{x1} + r_{\pi 1}} \qquad r_S' = (r_S + r_{x1}) \| r_{\pi 1}$$



The Cascode Amplifier at High Frequencies



$$r_{\pi 2} \| \frac{1}{g_{m2}} = r_{e2}$$



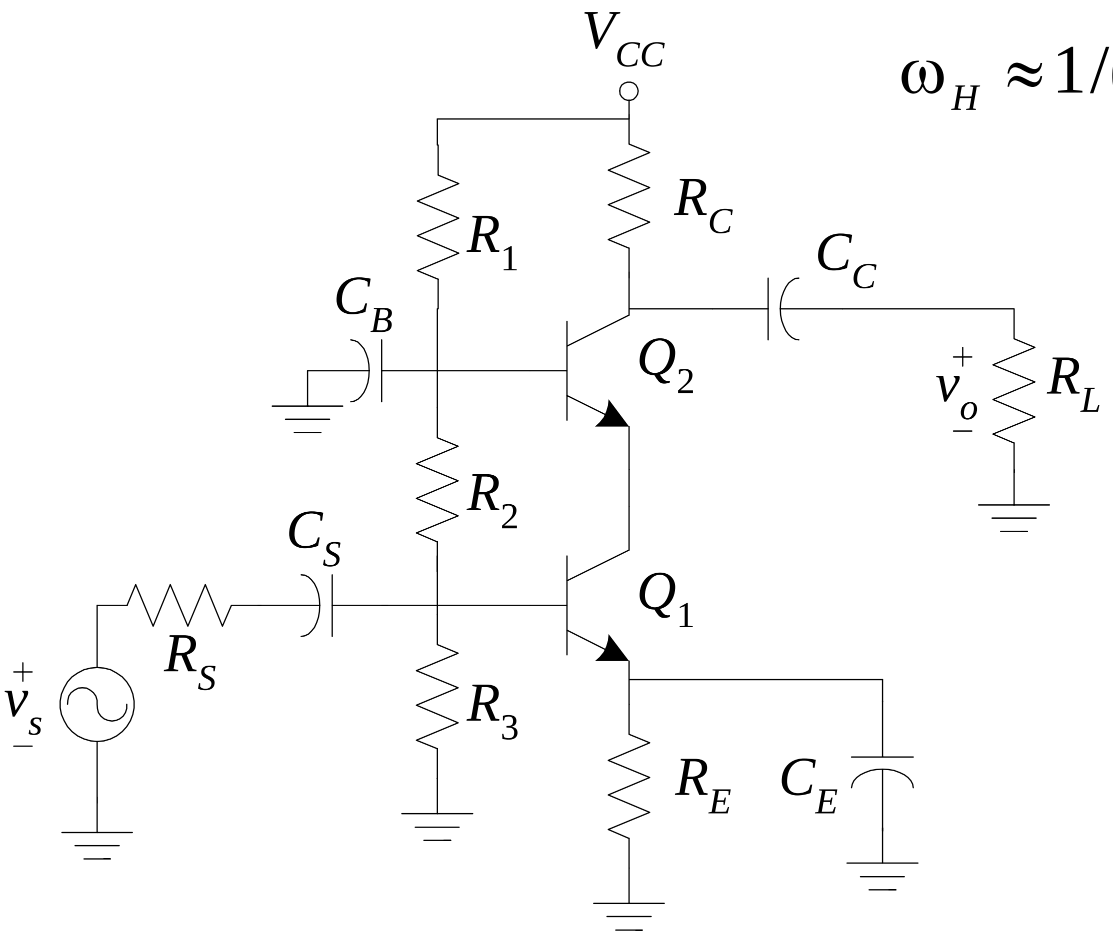
$$R_{\pi 1} = r_S' \qquad R_{\pi 2} = r_{e2}$$

$$R_{\mu 1} = \frac{v_{\pi 1} - v_x}{v_{\pi 1}/r_S'} = r_S'(1 - \frac{v_x}{v_{\pi 1}})$$

$$v_x = -(\frac{v_{\pi 1}}{r_S'} + g_{m1}v_{\pi 1})r_{e2}$$

$$R_{\mu 1} = r_S'(1 + g_m r_{e2} + \frac{r_{e2}}{r_S'}) \approx 2r_S' + r_{e2}$$

The Cascode Configuration - Summary



$$\omega_H \approx 1/(R_{\pi 1}C_{\pi 1} + R_{\pi 2}C_{\pi 2} + R_{\mu 1}C_{\mu 1})$$

$$R_{\pi 1} = r_S' \qquad R_{\pi 2} = r_{e2}$$

$$R_{\mu 1} = 2r_S' + r_{e2}$$

$$r_S' = (r_s + r_{x1}) \parallel r_{\pi 1}$$

$$r_S = R_S \parallel R_3 \parallel R_2$$

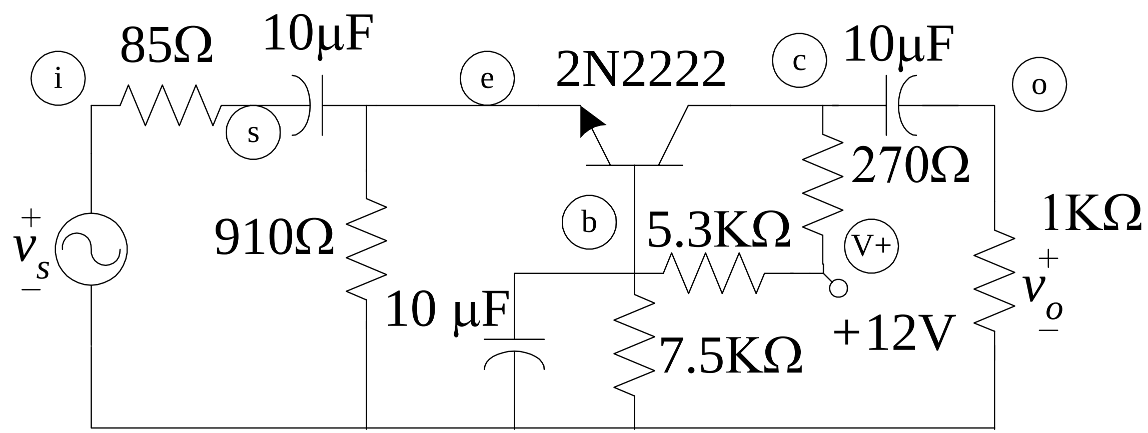
Assignment

Solve problems 7.58 and 7.63 from the textbook

A CB Amplifier Simulation

```
Common Base Amplifier

Vs   in  0   DC 0   AC 1   SIN(0 0.1 1E3)
Vcc  vp  0   DC 12
Q1   c   b   e  Q2N2222
RS   in  s   85
RE   e   0   910
RC   c   vp  270
R1   b   vp  5.3K
R2   b   0   7.5K
RL   out 0   1K
CE   e   s   10uF
CB   b   0   10uF
CL   c   out 10uF
```



A CB Amplifier Simulation (cont)

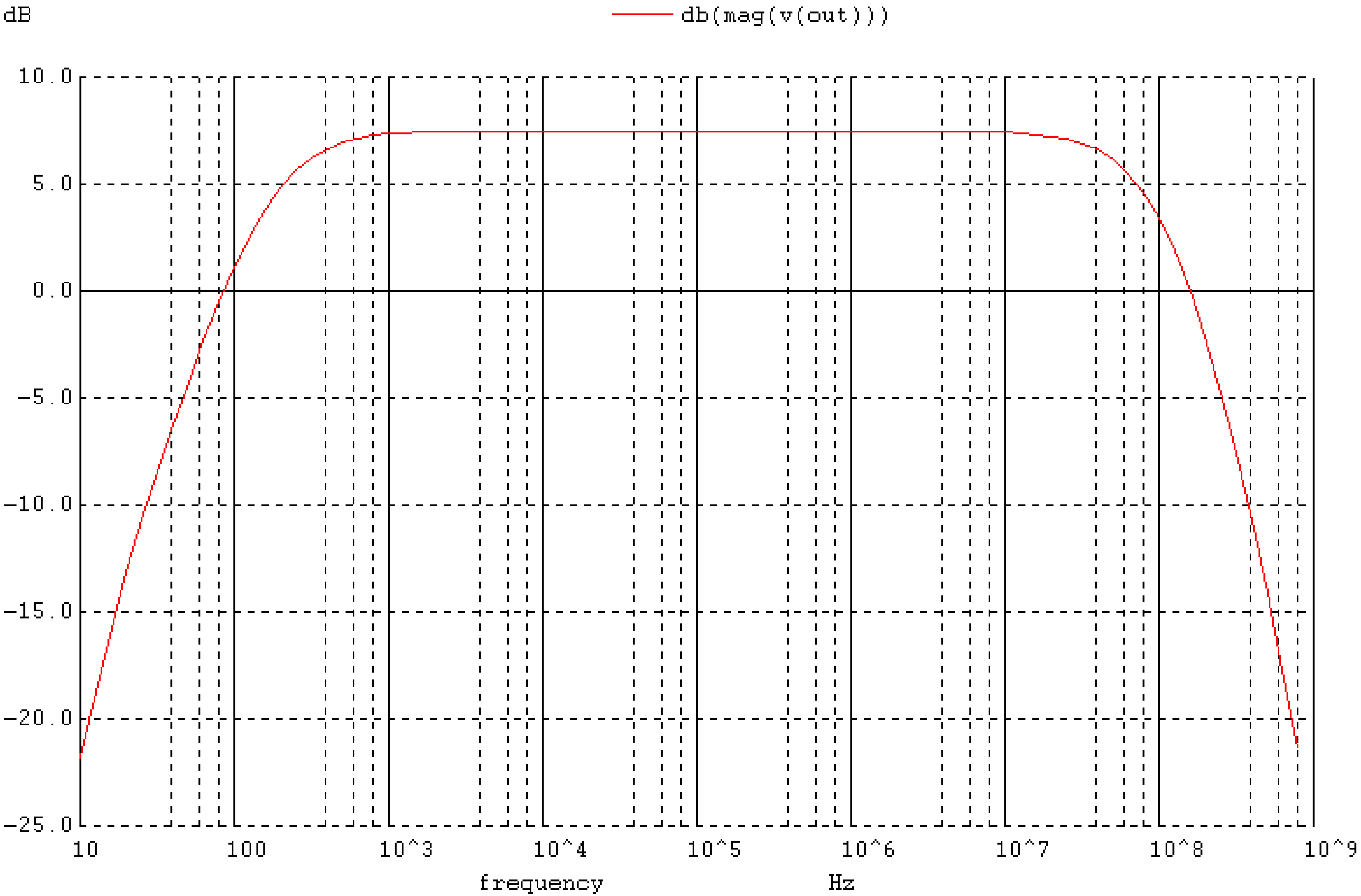
```
.MODEL Q2N2222 NPN
+(IS=3.108E-15 XTI=3 EG=1.11 VAF=131.5 BF=217.5
+ NE=1.541 ISE=190.7E-15 IKF=1.296 XTB=1.5 BR=6.18
+ NC=2 ISC=0 IKR=0 RC=1 CJC=14.57E-12 VJC=.75
+ MJC=.3333 FC=.5 CJE=26.08E-12 VJE=.75 MJE=.3333
+ TR=51.35E-9 TF=451E-12 ITF=.1 VTF=10 XTF=2)
```

A CB Amplifier Simulation (cont)

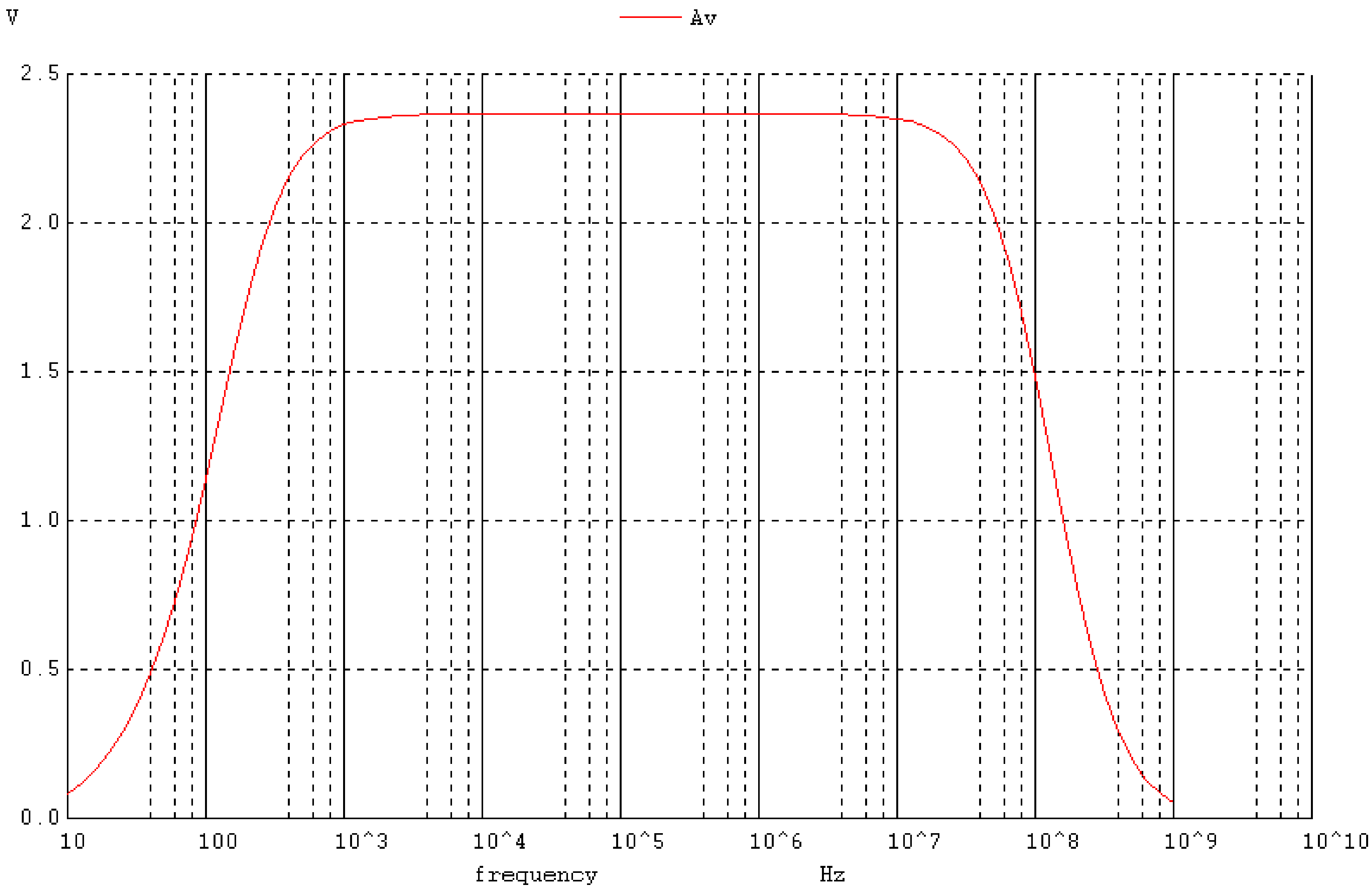
```
.control
DC Vs -1 +1 0.1
AC DEC 10 10 900MEGHZ
plot vdb(out)
Av = vm(out)/vm(in)
plot Av
Is = (vm(in)-vm(s))/85
Zin = vm(in)/Is
plot Zin
TRAN 10E-6 5E-3
plot v(in) v(out)
.endc

.end
```

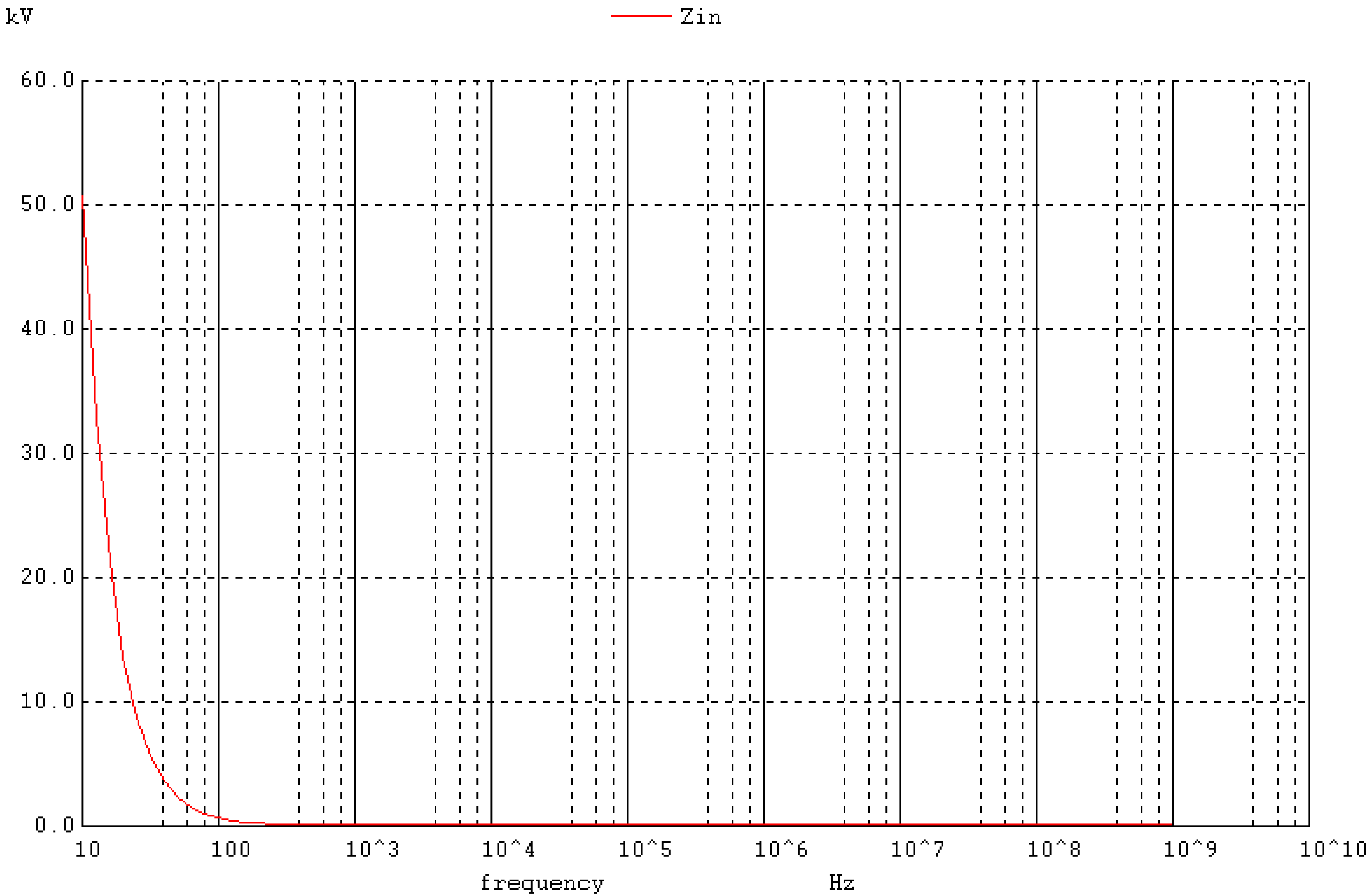
A CB Amplifier Simulation (cont)



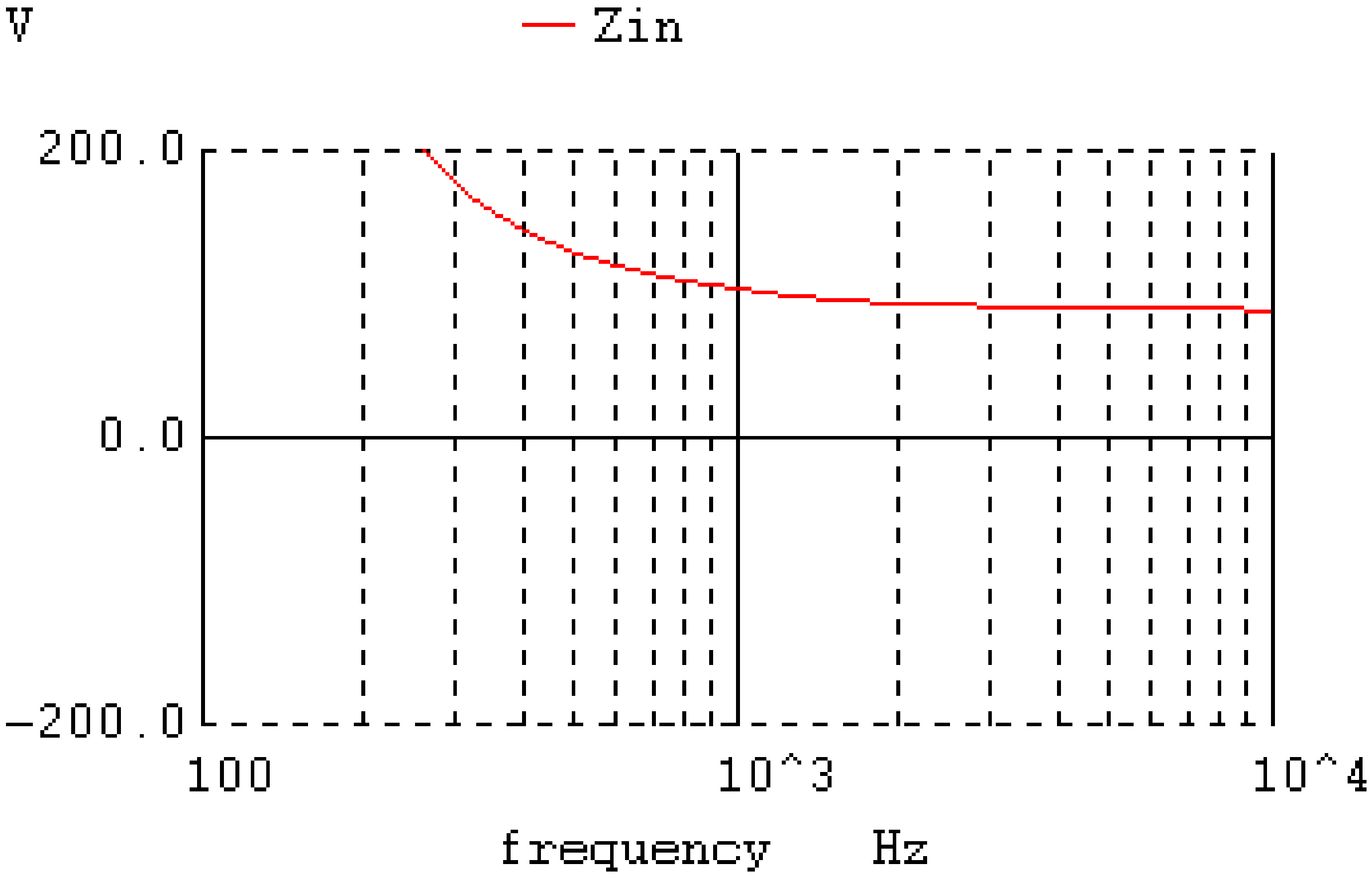
A CB Amplifier Simulation (cont)



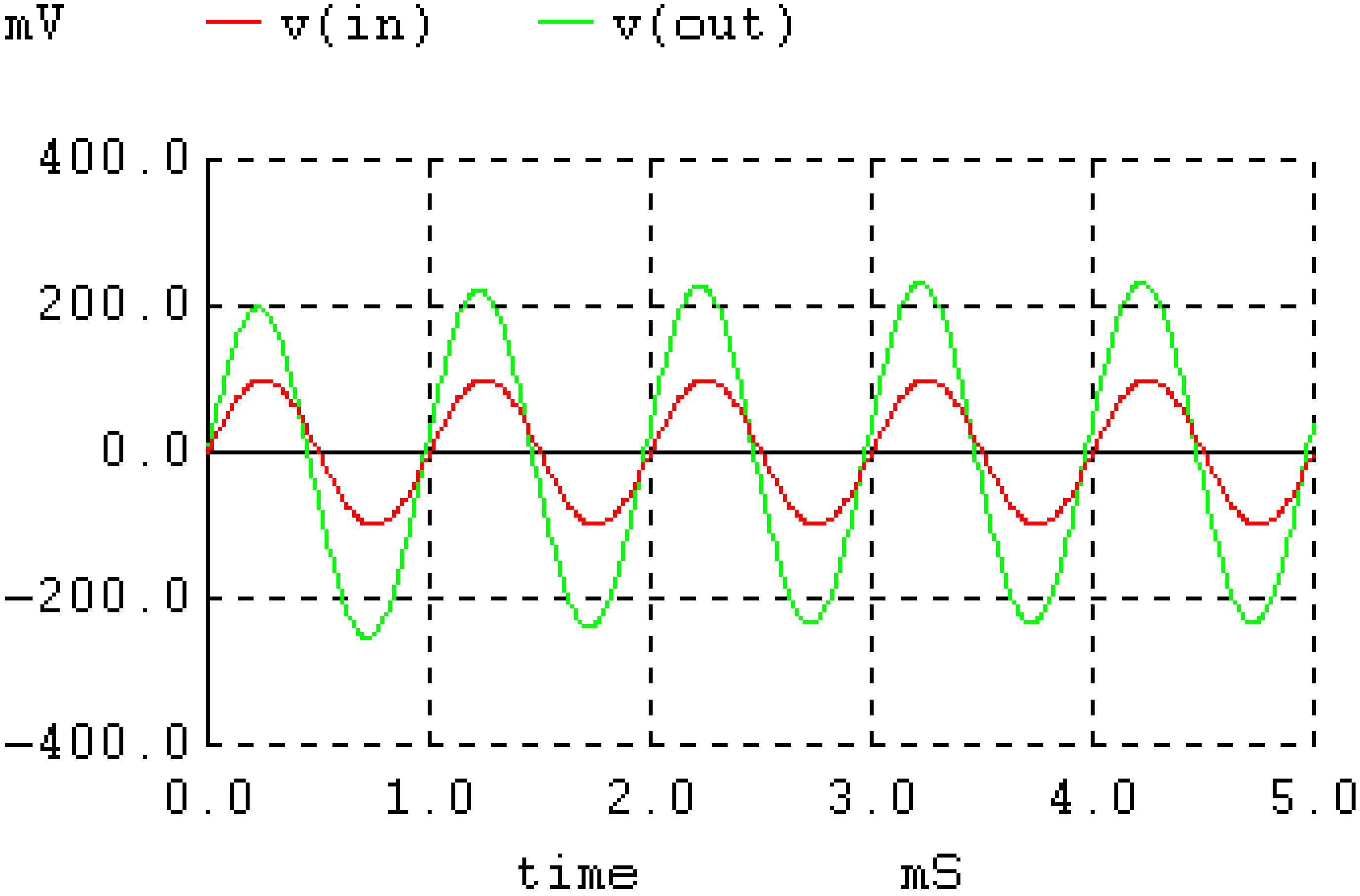
A CB Amplifier Simulation (cont)



A CB Amplifier Simulation (cont)

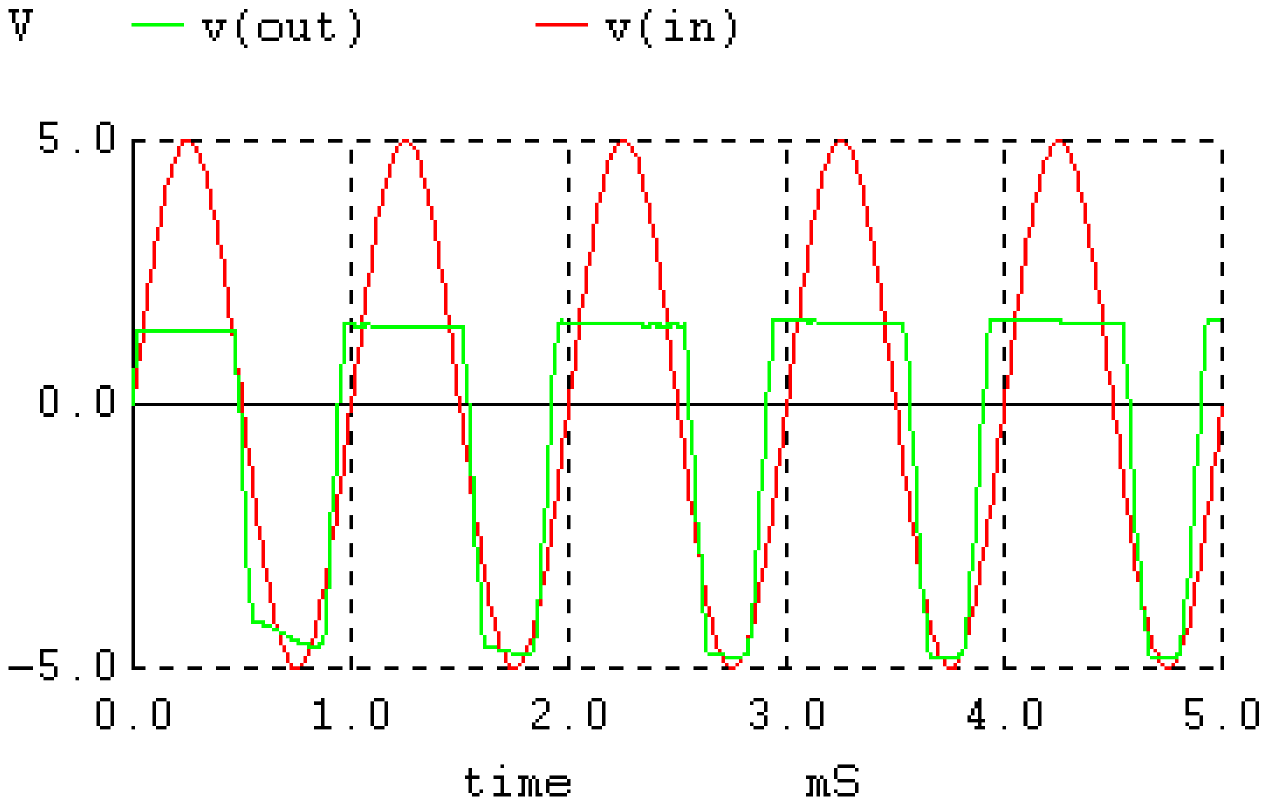


A CB Amplifier Simulation (cont)



A CB Amplifier Simulation (cont)

Replacing `SIN(0 0.1 1E3)` by `SIN(0 5 1E3)`



Region of Interest in Most Amplifiers