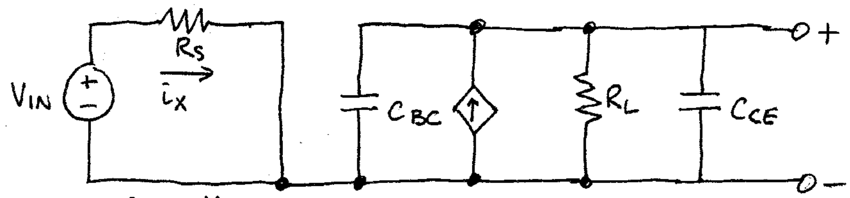
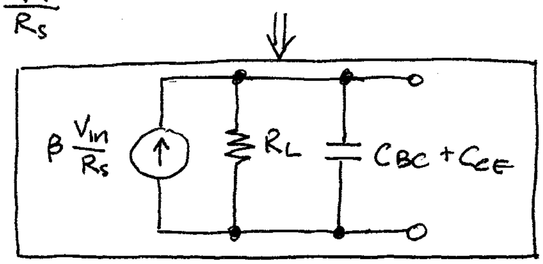
MT#2 Problem 3

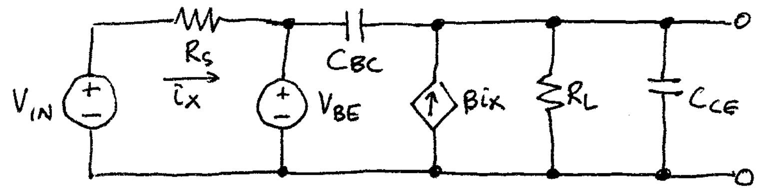
(a) <u>assuming V_{BE} is a DC voltage:</u> $\rightarrow$ it becomes a short circuit



$$i_X = \frac{V_{in}}{R_S}$$

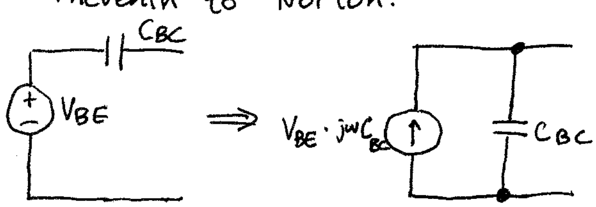


<u>assuming V_{BE} is an AC voltage:</u>

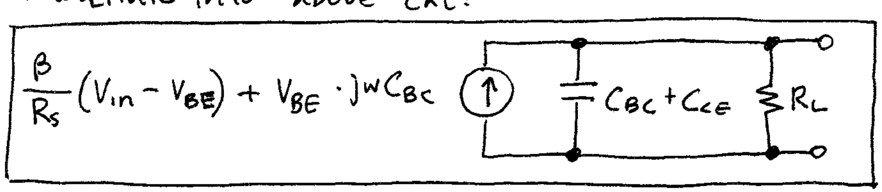


$$i_X = \frac{V_{IN} - V_{BE}}{R_S}$$

Thevenin to Norton:



Substitute into above ckt:



(b) <u>V_{BE} is DC</u>

$$V_{out} = \frac{\beta}{R_S} \cdot V_{in} \cdot \left(R_L \parallel \frac{1}{j\omega(C_{BC} + C_{CE})} \right) \Rightarrow \boxed{\frac{V_{out}}{V_{in}} = \frac{\beta}{R_S}\left[\frac{R_L}{1 + j\omega(C_{BC} + C_{CE})R_L}\right]}$$

<u>V_{BE} is AC</u>

$$V_{out} = \left[\frac{\beta}{R_S} \cdot V_{in} - \frac{\beta}{R_S} \cdot V_{BE} + V_{BE} \cdot j\omega C_{BC}\right] \cdot \left[\frac{R_L}{1 + j\omega(C_{BC} + C_{CE})R_L}\right]$$

In this case, the output voltage is a function of both V_{in} and V_{BE}. By superposition, the total output is:

$$V_{out} = H_1(\omega) \cdot V_{in} + H_2(\omega) \cdot V_{BE} \quad \text{where} \quad \begin{cases} H_1(\omega) \triangleq \left.\frac{V_{out}}{V_{in}}\right|_{V_{BE}=0} \\ H_2(\omega) \triangleq \left.\frac{V_{out}}{V_{BE}}\right|_{V_{in}=0} \end{cases}$$

$\longrightarrow$

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(b) continued...

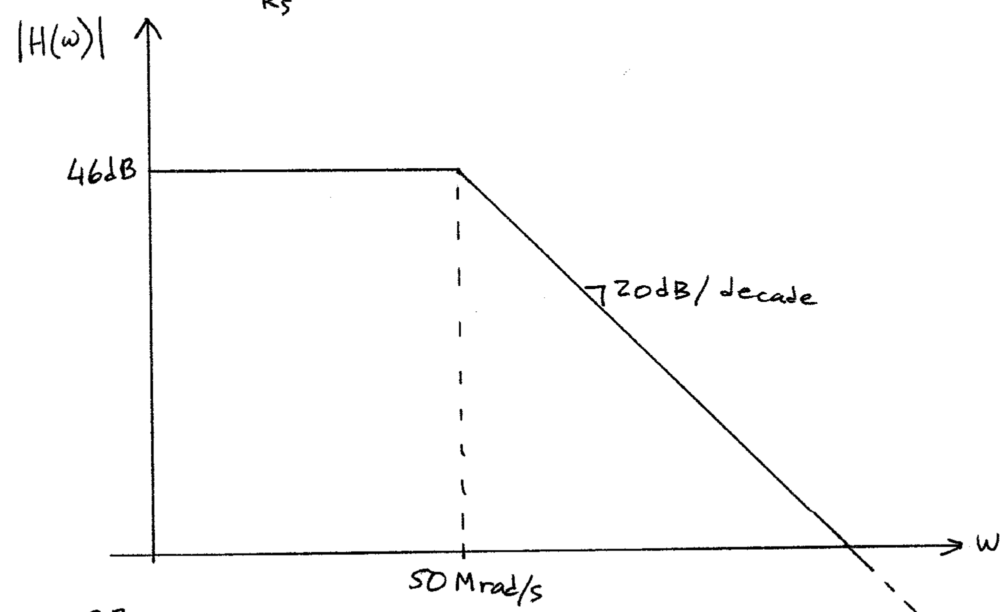
The question asked for $\frac{V_{out}}{V_{in}}$, which is $H_1(\omega)$. So, we only need to write that transfer function:

$$V_{out}\Big|_{V_{BE}=0} = \left[\frac{\beta}{R_S}\cdot V_{in}\right]\cdot\left[\frac{R_L}{1+j\omega(C_{BC}+C_{CE})R_L}\right]$$

$$\boxed{H_1(\omega) = \frac{V_{out}}{V_{in}}\Big|_{V_{BE}=0} = \left[\frac{\beta}{R_S}\right]\left[\frac{R_L}{1+j\omega(C_{BC}+C_{CE})R_L}\right]}$$

(this is the same as the answer in the DC case above)

(c) The transfer function is a single-pole lowpass with DC gain equal to $\frac{\beta R_L}{R_S}$ and the pole located at $\omega = \frac{1}{(C_{BC}+C_{CE})R_L}$



$$\frac{\beta R_L}{R_S} = 200$$

$$20\log(200) = 46\text{ dB}$$

$$\frac{1}{(C_{BC}+C_{CE})R_L} = 50\text{ Mrad/s} = 8\text{ MHz}$$