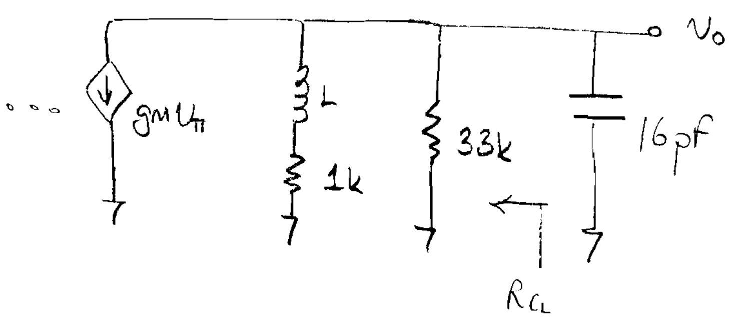
HW#3 Solutions 2008

EE 411/511

1) a) The transistor is an ideal NPN $\Rightarrow C_{be} = 0,\ C_{bc} = 0$

Since C_1, C_2 and C_3 are very large they do not affect the upper cutoff frequency and will be short circuited as mentioned in Open-Circuit time constants method.



$L = 0 \Rightarrow R_{CL} = 1k\Omega // 33k\Omega \simeq 1k\Omega$

$\tau_{CL} = R_{CL} \cdot C_L = 16ns$

$$w_{h,est} = \frac{1}{\tau_{CL}} \Rightarrow w_{h,est} = \frac{1}{16\times10^{-9}} = 62{,}5\times10^{6}\ \text{rad/sec}$$

$$\boxed{f_{h,est} \cong 9{,}95\ MHz}$$

b) In order to extend the upper cutoff frequency shunt peaking technique is utilized for this amplifier.

The impedence of the RLC network can be written as:

$$Z(s) = (sL + 1k) // \frac{1}{sC} // 33k \simeq (sL + 1k) // \frac{1}{sC}$$

↑ assuming that 33k is large compared to $(sL + 1k)$

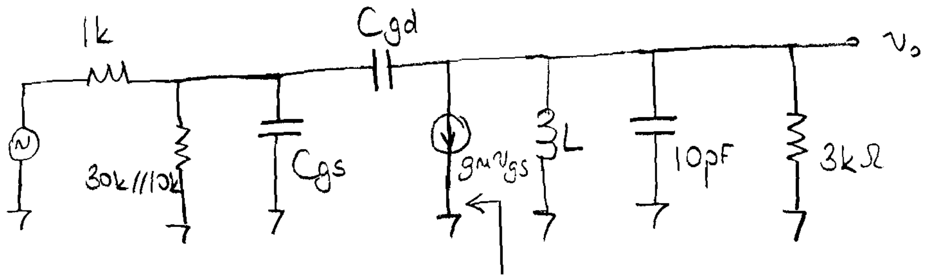
Now, as explained in Section 8.2.1 of the course book, an expression for $\frac{w_{h,new}}{w_{h,old}}$ can be derived from this impedance $Z(s)$:

$$\frac{w_{h,new}}{w_{h,old}} = \sqrt{\left(-\frac{m^2}{2} + m + 1\right) + \sqrt{\left(-\frac{m^2}{2} + m + 1\right)^2 + m^2}}\ ,\quad \text{where } m = \frac{RC}{L/R},\ R = 1k\Omega$$

Then, maximum -3dB frequency ($w_{h,new}$) is found as 1,85 times $w_{h,old}$, when $m = \sqrt{2}$.

$$\Rightarrow m = \frac{RC}{L/R} = 1{,}41 = \frac{10^3 \cdot 16\times10^{-12}}{L/10^3} \Rightarrow \boxed{L = 11{,}3\ \mu H}$$

2) a)



$$2\pi f_o = \frac{1}{\sqrt{L\,C_{TOTAL}}}$$

$$\Rightarrow L = \frac{1}{C_{TOTAL} \times (2\pi f_o)^2}$$

$$= \frac{1}{11{,}86 \times 10^{-12} \times (2\pi\, 50 \times 10^{6})^2}$$

$$\Rightarrow L = \boxed{0{,}854\,\mu H}$$

If we use a test voltage source to find the admittance seen by the tank circuit, we end up with an equivalent resistance in parallel with an equivalent capacitance:

$$C_{eq} = C_{gd}\left[1 + g_m(\overbrace{1k /\!/ 10k /\!/ 30k}^{882\Omega})\right]$$

$$= 0{,}1 \times 10^{-12}\left[1 + 20 \times 10^{-3} \times 882\right]$$

$$= 1{,}86\,pF$$

$$\Rightarrow C_{TOTAL} = 11{,}86\,pF$$

b)

$$C_{input} = C_{gs} + C_{gd}(1 + g_m R_L)$$

$$= 0{,}2 \times 10^{-12} + 0{,}1 \times 10^{-12}(1 + 20 \times 10^{-3} \times 3 \times 10^{3})$$

$$= \boxed{6{,}3\,pF}$$

* See lecture notes (Tuned Amplifiers)

* Assuming Cin is large compared to transistor capacitances. (not included)

c)

$$R_{Cin} = 1k /\!/ 10k /\!/ 30k = 882\Omega$$

Using Open Circuit time constants estimation:

$$\omega_{h,est} = \frac{1}{\tau_{Cin}} = \frac{1}{R_{Cin} C_{in}} = \frac{1}{882 \times 6{,}3 \times 10^{-12}} = 1{,}8 \times 10^{8}\ \text{rad/sec}$$

$$\Rightarrow f_{h,est} = \boxed{28{,}6\ MHz}$$