TUNED AMPLIFIER

Tuned amplifier

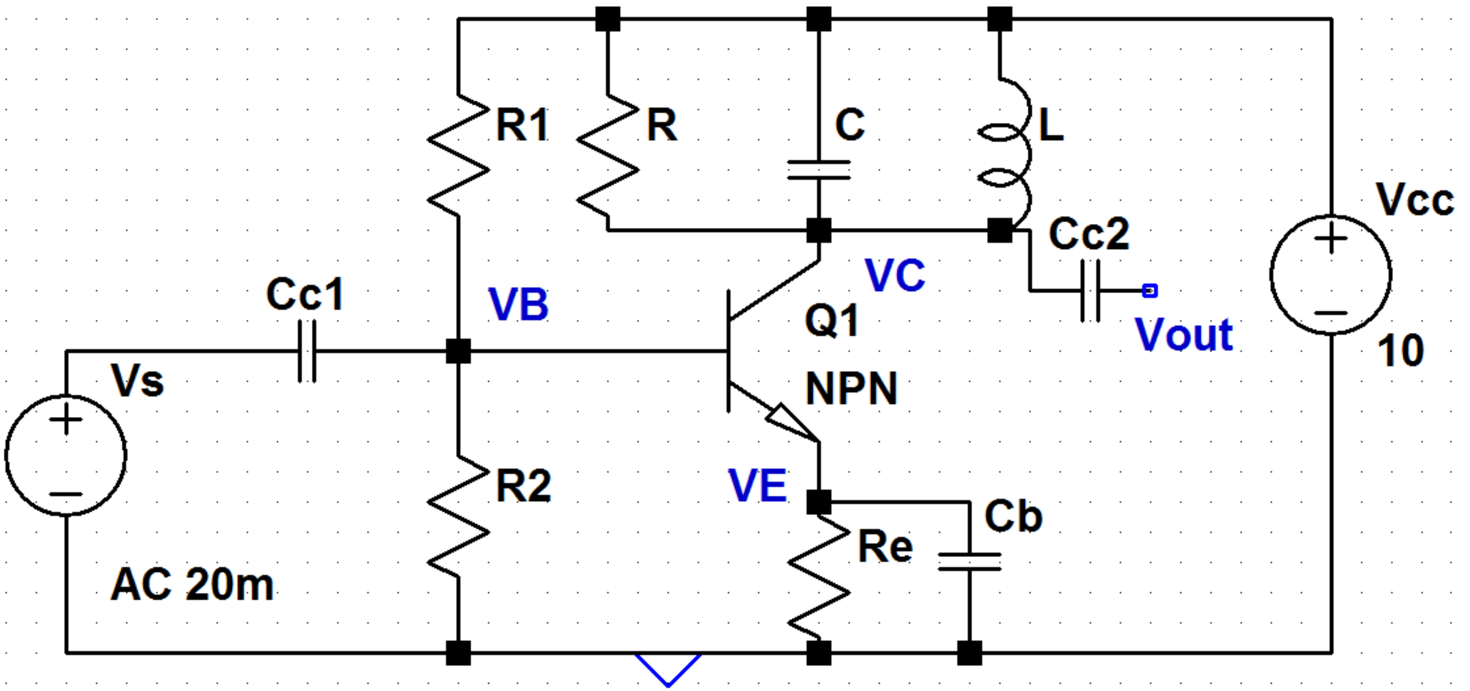
- Typically narrowband amplifiers

  Bandwidth small compared to the central frequency

  fo = 455.5 KHz : BW = 10 KHz

  fo = 10.7 MHz : BW = 200 KHz
- CE amplifier with parallel resonant circuit in the collector

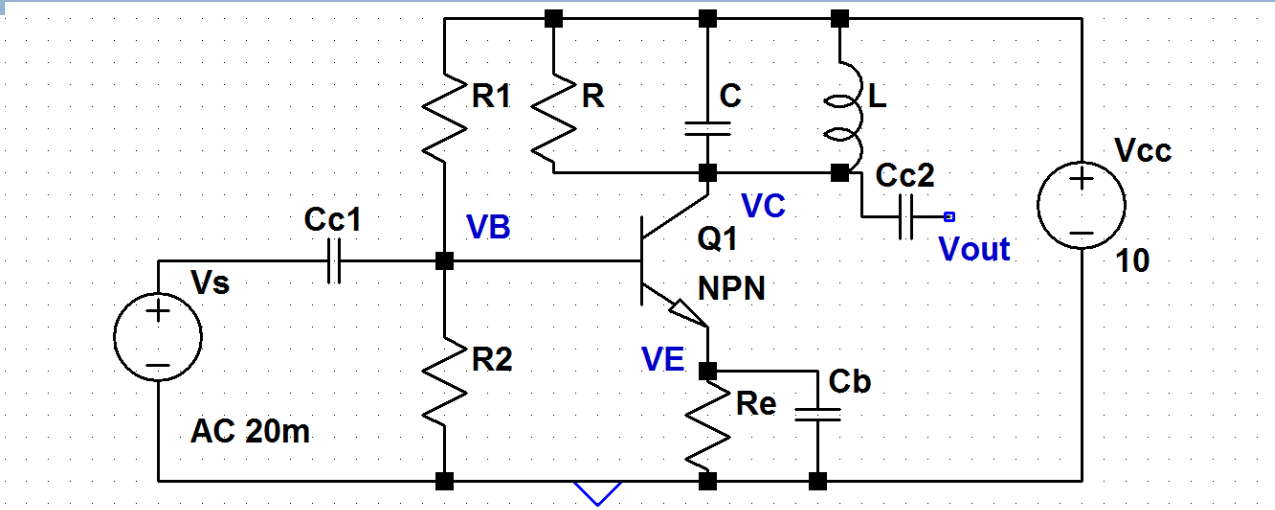
CE-Tuned amplifier



Function of various components

- R-L-C circuit provides for narrowband response
- R1 and R2 are used for biasing
- Cb is the by-pass capacitor which makes the configuration C-E
- Cc1 and Cc2 are the coupling capacitors used to block d.c.
- Vs is the input signal voltage
- Vcc is the d.c. supply voltage

D.C.Analysis



$$V_B = \frac{VccR_2}{R_1 + R_2} \quad volts$$

$$I_C \approx I_E$$

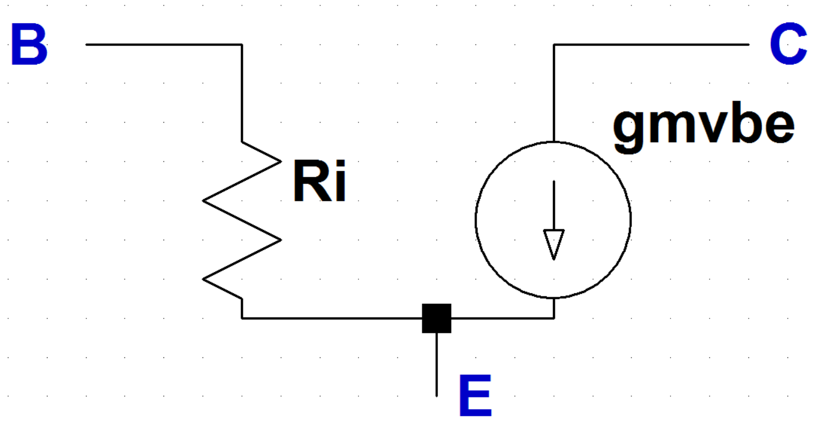
$$V_C = Vcc$$

$$V_E = V_B - 0.7 \quad volts$$

$$V_{CE} = V_{CC} - V_E$$

$$I_E = \frac{V_E}{\text{Re}}$$

A.C.Model of the transistor

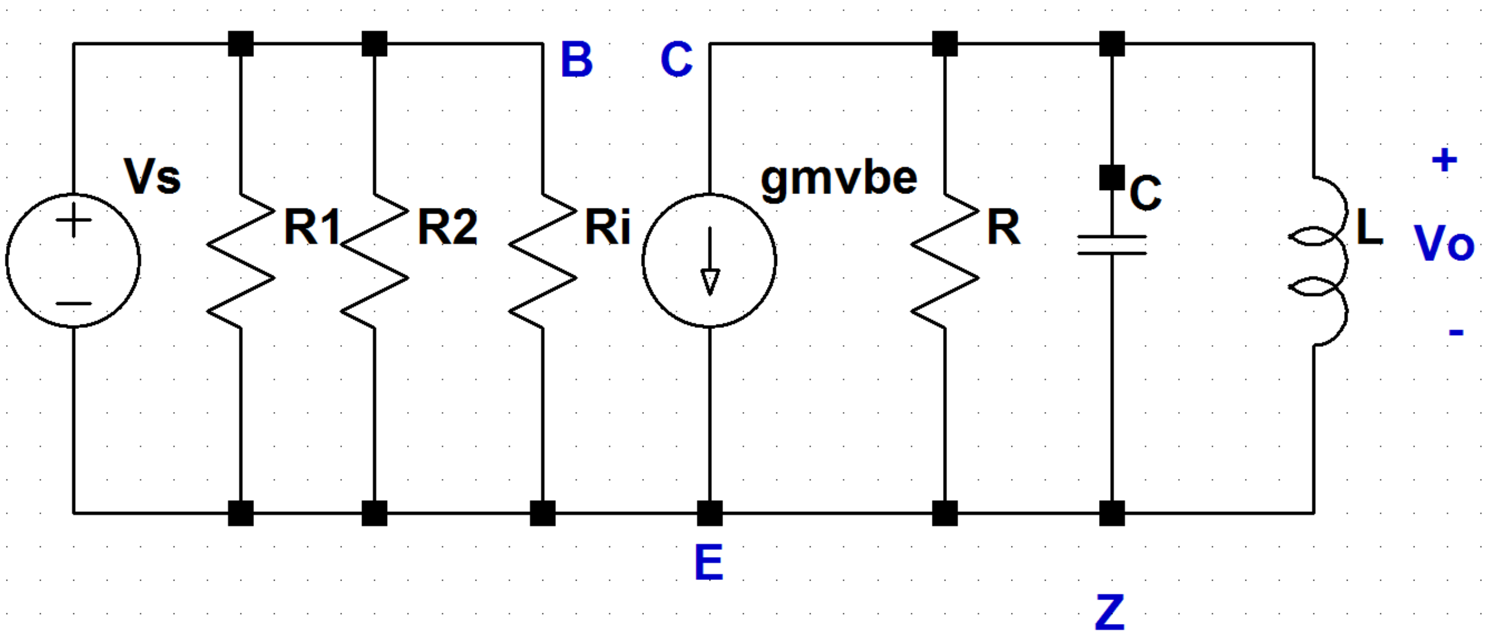


$$g_m = \frac{I_E(mA)}{26} \quad mhos \;:\; For\;\; example$$

$$I_E = 1mA : g_m = \frac{1}{26}\; mho$$

For a.c.analysis of the circuit the transistor is replaced by the above model and the d.c.supply is made zero.Also the by-pass and coupling capacitors are replaced by short circuits

A.C.Model of the amplifier



$$Voltage\ \ gain = \frac{v_o}{v_s} = \frac{v_o}{v_{be}} \qquad v_0 = -g_m v_{be} Z$$

$$Voltage\ \ gain = -g_m Z$$

Frequency response

- Gain is proportional to Z
- Z is that of parallel resonant circuit
- Hence bandpass response
- Center frequency gain = $-g_m R$
- $Q = R/\omega_0 L$
- $BW = f_0/Q$

Problem

- In the common emitter tuned amplifier the following values are given
- V_{cc} = 10 volts
- R1=R2=50 kohms
- Re = 4.3 kohms
- R = 4700 ohms
- L = 10 μH
- C = 1000pF

Find

(1) Resonant frequency

(2) Bandwidth

(3) Gain at resonant frequency

Answers

$$f_0 = 1.59 \ \ MHz$$

$$Q = \frac{4700}{2\pi \times 1.59 \times 10.0} = 47.04$$

$$BW = \frac{1.59}{47.04} = 0.0338 \ MHz$$

$$V_B = 5 \ \ volts$$

$$V_E = 4.3 \ volts$$

$$I_E = 1 \ mA$$

$$g_m = \frac{1}{26} \ \ mhos$$

$$A_0 = -\frac{4700}{26} = -180.7$$

Unbypassed Emitter resistance

- Remove Cb
- Gain at resonance = -R/Re
- Q and BW calculations are same as before

Cascaded Tuned Amplifiers

- Output of first stage is connected to the input of the second stage
- Output of the second stage is connected to the input of the third stage
- All stages use tuned circuits
- If the tuned circuits are identical the amplifier is called synchronously tuned stages

  Resonant frequencies and bandwidths are same

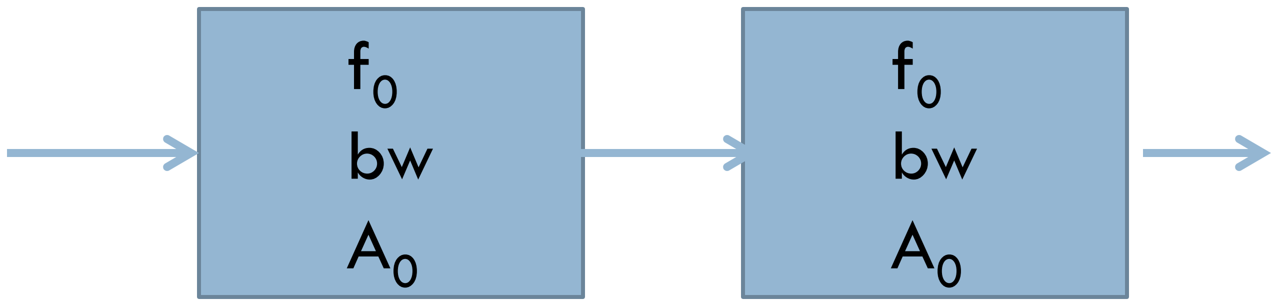
Stagger tuned stages

- Resonant frequencies are not same

Analysis of cascaded amplifier

- Overall gain is the product of individual gains
- Find the gain at resonant frequency
- Find the overall bandwidth

Synchronously tuned two stage amplifier



The maximum gain of the cascade occurs at fo

Overall gain at resonant frequency

Aoc = Ao.Ao

Next let the overall bandwidth be BW.

We want to find the expression for BW in terms of individual bandwidths bw

Analysis – single stage

$$A = \frac{A_0}{1 + jQ\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)}$$

$$A = \frac{A_0}{1 + jx}$$

$$|A| = \frac{A_0}{\sqrt{1 + x^2}}$$

$$Normalized\ cut\ of\ \ frequency\ is\ x = \pm 1$$

Analysis-Two stages

$$A_c = \frac{A_0}{1+jQ\left(\frac{\omega}{\omega_0}-\frac{\omega_0}{\omega}\right)} \times \frac{A_0}{1+jQ\left(\frac{\omega}{\omega_0}-\frac{\omega_0}{\omega}\right)}$$

$$A_c = \frac{A_0}{1+jx} \times \frac{A_0}{1+jx}$$

$$|A_c| = \frac{A_0{}^2}{1+x^2}$$

$$Now\ at\ x = x_c\ :|A_c| = \frac{A_0{}^2}{\sqrt{2}}$$

$$1+x_c^2 = \sqrt{2}$$

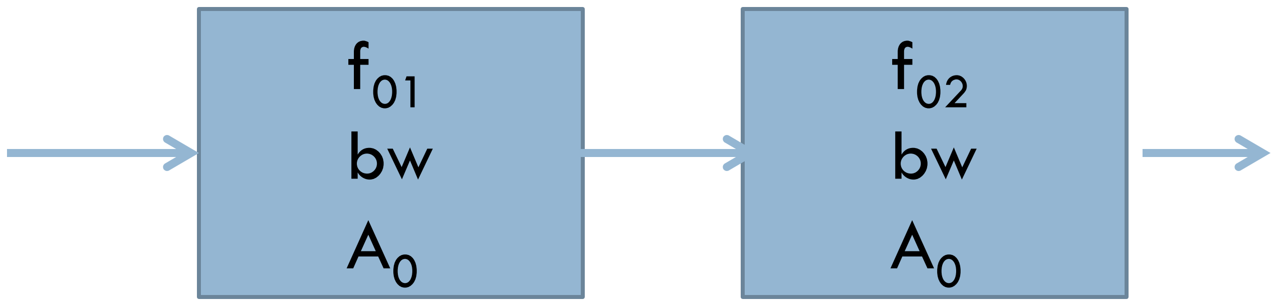
$$x_c^2 = \sqrt{2}-1 : x_c = \left(\sqrt{2}-1\right)^{0.5} = 0.64$$

$$Normalized\ cut\ of\ \ frequency\ is\ x = \pm 1$$

Overall bandwidth

- $BW = 0.64bw$

Stagger tuned stages



For Butterworth response OR

Maximallyf flat response

$$f_{01} = f_0 + \frac{BW}{2\sqrt{2}} \ : \ f_{02} = f_0 - \frac{BW}{2\sqrt{2}}$$

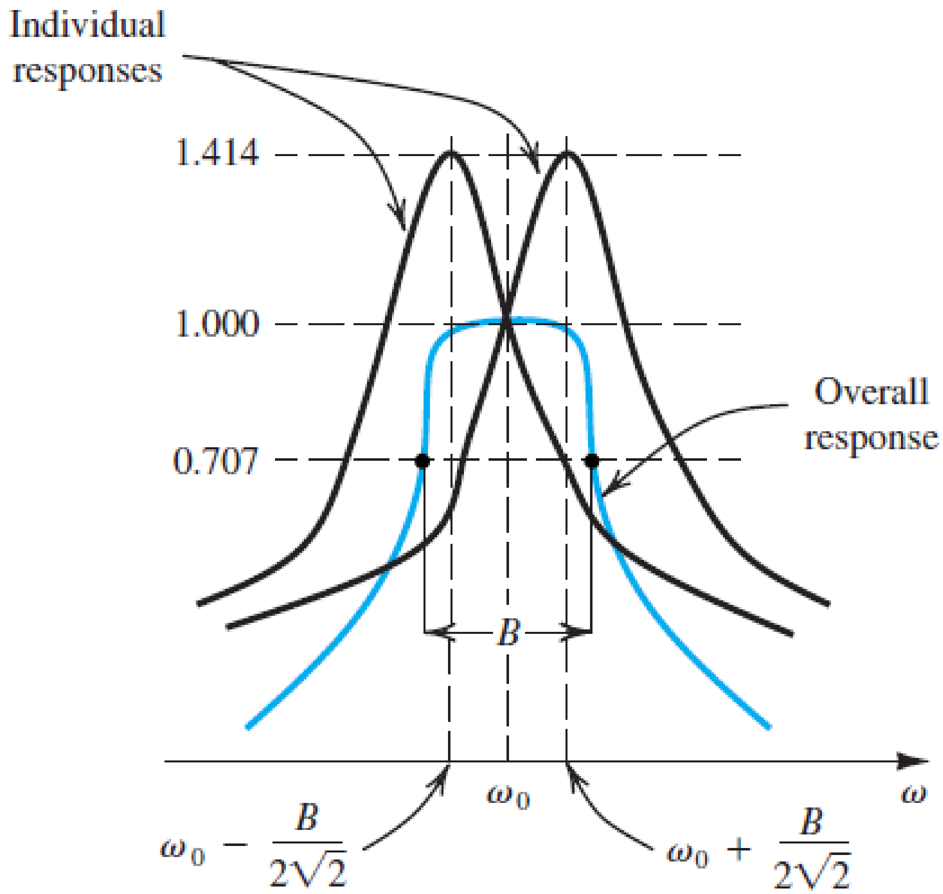
$$bw = \frac{BW}{\sqrt{2}}$$

$$A_{0c} = \frac{A_0 A_0}{2}$$

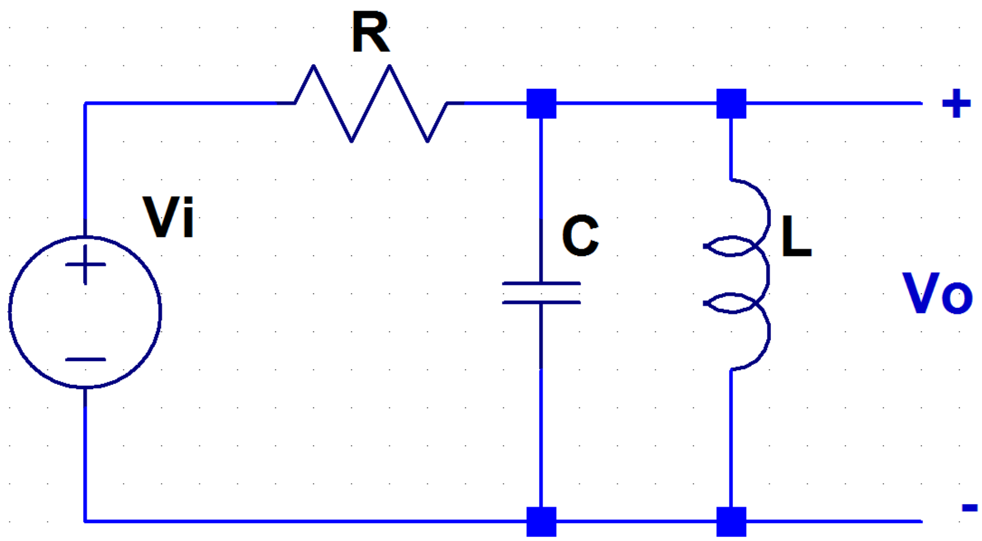
$$When\ A_0 = \sqrt{2} \ : \ A_{0c} = 1$$

$$When\ A_0 = 1 \ : \ A_{0c} = 0.5$$

Individual and composite response



Band pass filter with voltage input



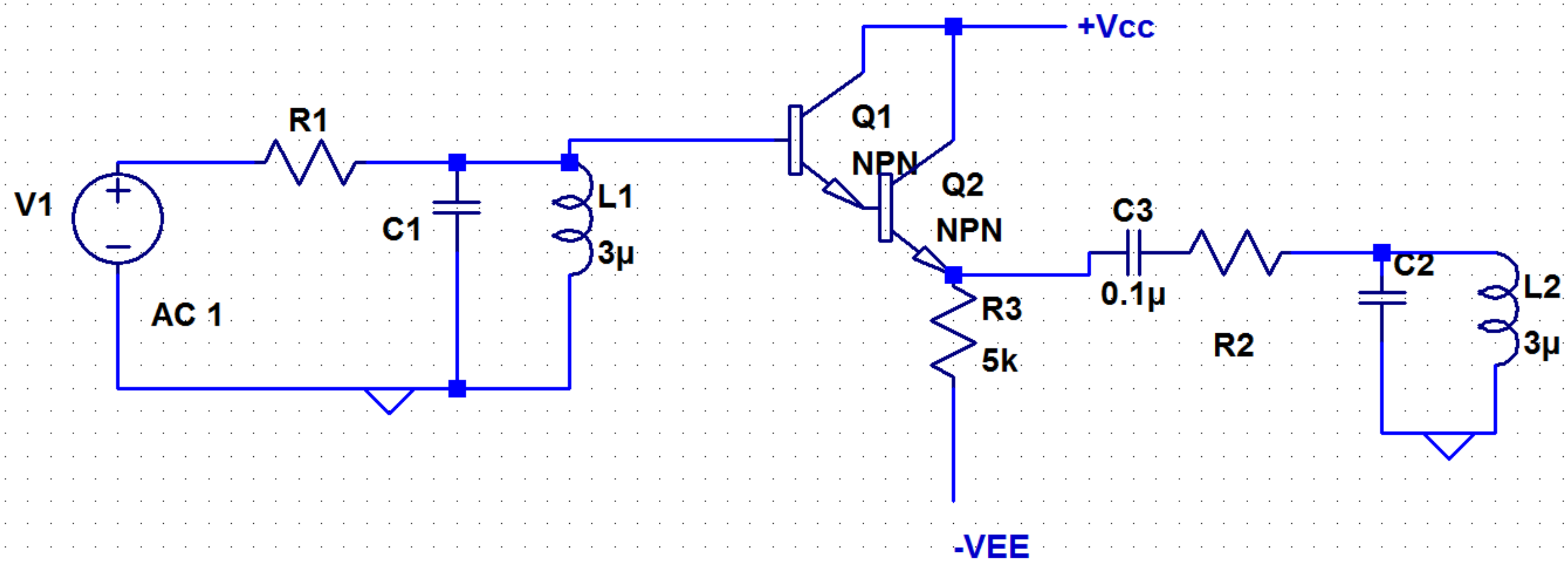
$$Show\ that\ voltage\ gain\ at\ resonance\ is\ 1$$

$$Also\ show\ that$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \quad and$$

$$BW = \frac{f_0}{Q} \quad where\ Q = \frac{R}{\omega_0 L}$$

Stagger tuned circuit using Darlington pair



Design the circuit for $f_0 = 10.7$ MHz:

BW : 200KHz and test using LTspice