

## ECE 3113

### BIASING AN ACTIVE RF TRANSISTOR

#### Objective

This project asks you to design three different types of biasing networks for the npn BJT BFR92A. The three architectures under RF operation are shown in Figure 1.

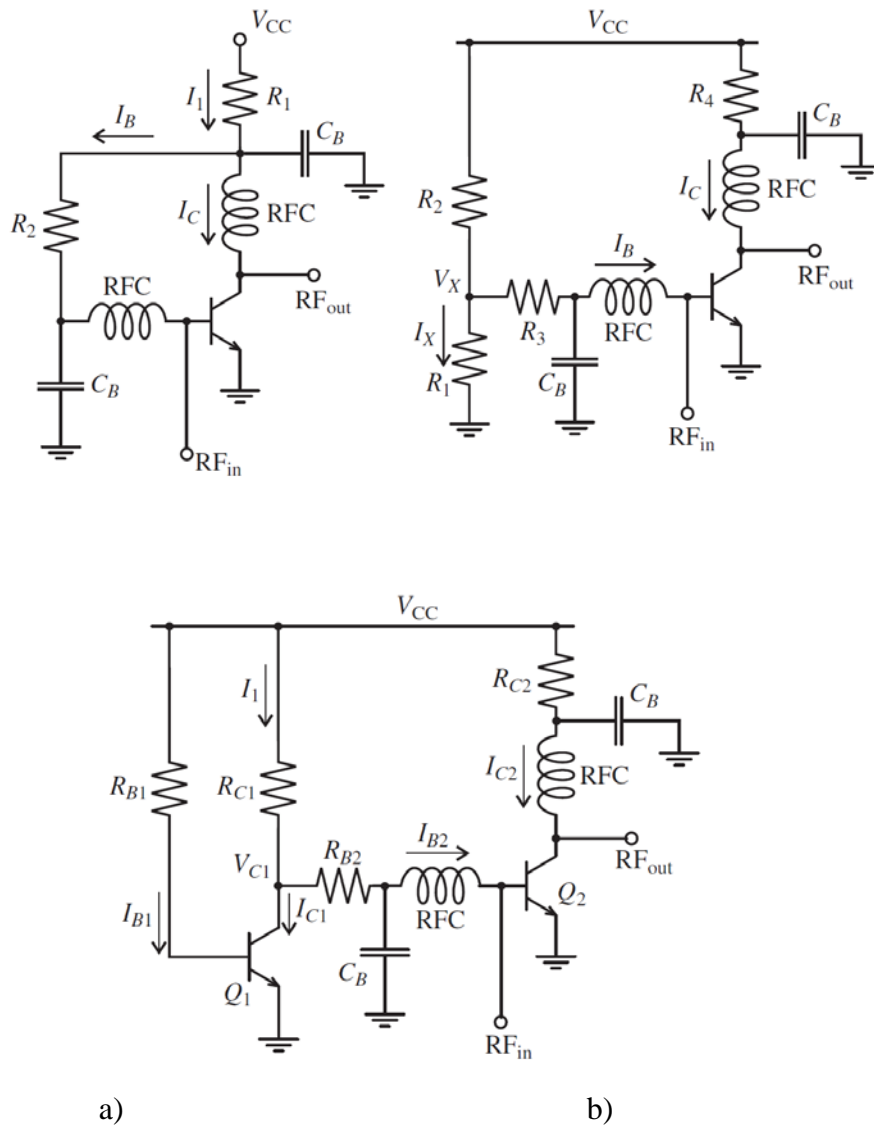
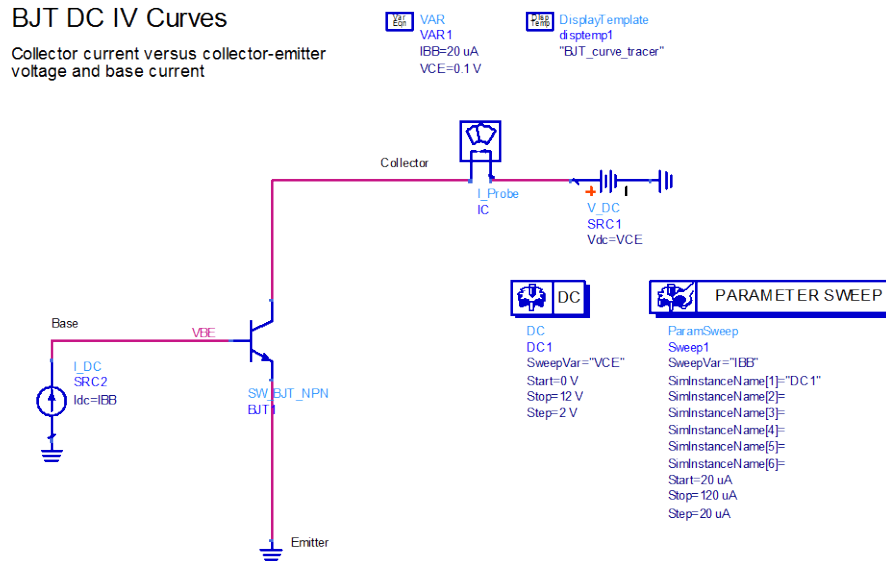


Figure 1. Three different biasing networks for an npn RF BJT: a) passive two resistor network, b) passive voltage divider network with  $I_X=10I_B$ , and c) active biasing network.

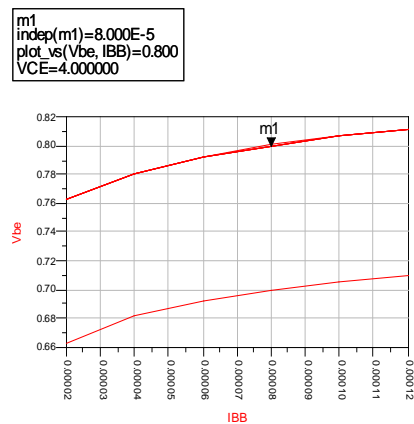
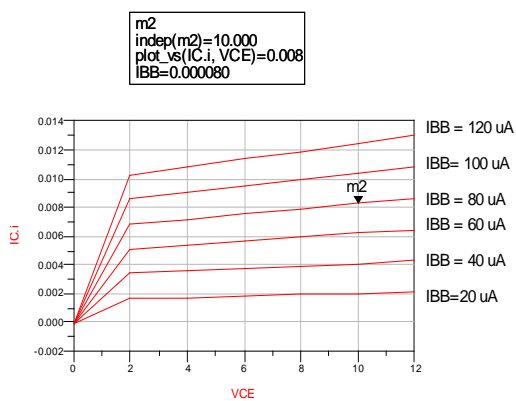
## Approach

1. Select the device from the ADS library and insert it into the BJT DC curve tracer.

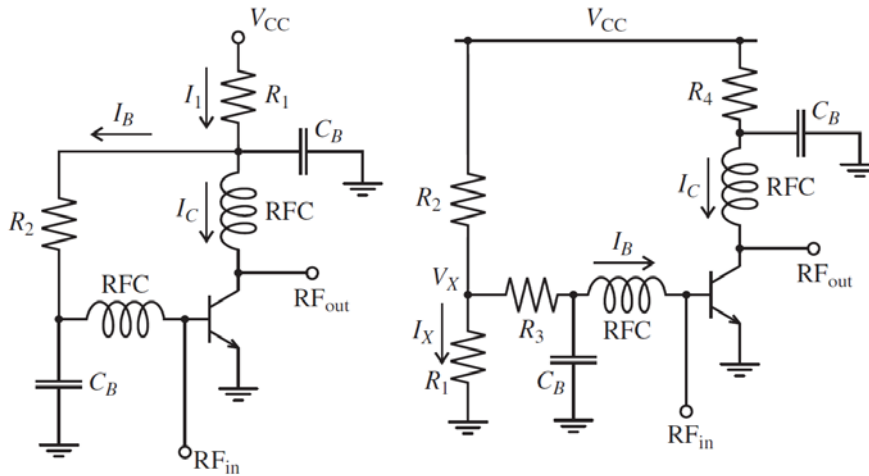


Pick reasonable upper and lower values for  $V_{CE}$  and  $I_{BB}$  so that you can identify your target parameters.

2. Plot the IV curve and record all relevant parameters that you need to compute the resistors for  $V_{CC}=15V$ .



3. Design the bias networks consistent with Figure 1. Determine all resistive values. For  $Q_1$  use the same devices as for  $Q_2$ . Show all your work!



Select  $V_{ce} = 10\text{ V}$ ,  $I_b = 80\text{ }\mu\text{A}$ , and you will get  $I_c = 8.3\text{ mA}$  and  $V_{be} = 0.8\text{ V}$

a)  $I_1 = I_c + I_b = 8.4\text{ mA}$   

$$R_1 = \frac{V_{cc} - V_{ce}}{I_1} = \frac{15 - 10}{8.4} = 595\text{ }\Omega$$
  

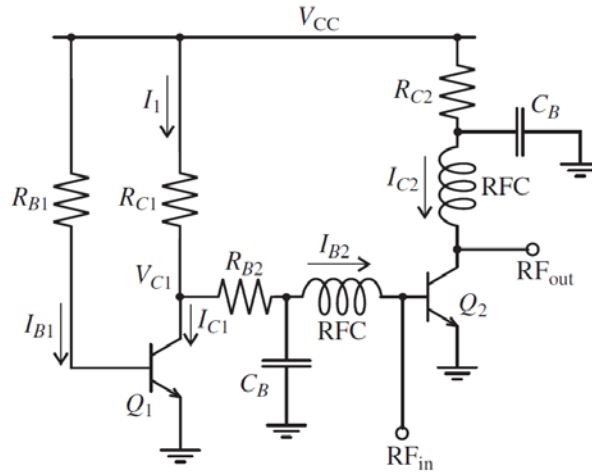
$$R_2 = \frac{V_{ce} - V_{be}}{I_b} = \frac{10 - 0.8}{0.08} = 115\text{ k}\Omega$$

b)  $R_4 = \frac{V_{cc} - V_{ce}}{I_c} = \frac{15 - 10}{8.3} = 602\text{ }\Omega$   
 $I_x = 10 I_b$   
 Set  $V_x = 5\text{ V}$   

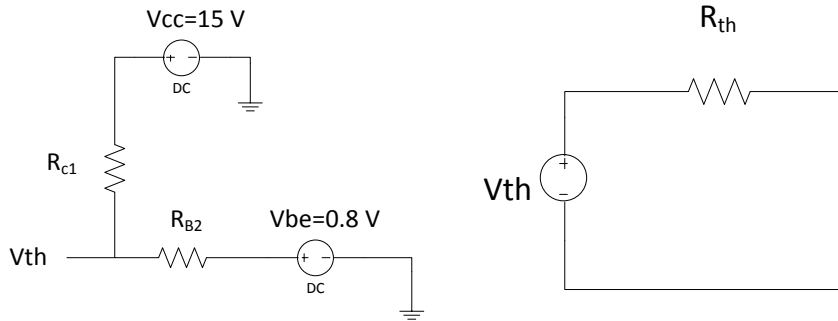
$$R_2 = \frac{V_{cc} - V_x}{I_x + I_b} = \frac{15 - 5}{11 \times 0.08} = 11.4\text{ k}\Omega$$
  

$$R_1 = \frac{V_x}{10 I_b} = \frac{5}{10 \times 0.08} = 6.25\text{ k}\Omega$$
  

$$R_3 = \frac{V_x - V_{be}}{I_b} = \frac{5 - 0.8}{0.08} = 52.5\text{ k}\Omega$$



c)



In order to compute  $V_{C1}$ , we need a Thevenin equivalent circuit.

$V_{th}$  is the open circuit voltage

$$V_{th} = \frac{R_{B2}}{R_{C1} + R_{B2}} V_{CC} + \frac{R_{C1}}{R_{C1} + R_{B2}} V_{Be}$$

$$R_{th} = R_{C1} // R_{B2}$$

$$V_{C1} = V_{th} - R_{th} I_{C1} \quad (1)$$

$$I_{C1} = \beta I_{B1} = \beta \frac{V_{CC} - V_{be}}{R_{B1}} \quad (2)$$

$$I_{C2} = \beta I_{B2} = \beta \frac{V_{C1} - V_{be}}{R_{B2}} \quad (3)$$

Substituting (1) and (2) into (3), we get

$$I_{C2} = \frac{\beta(R_{B1} - \beta R_{C1})}{R_{B1}(R_{C1} + R_{B2})} (V_{CC} - V_{Be})$$

Then set the derivative of  $I_{C2}$  to zero, we get

$$R_{C1} = \frac{R_{B1}}{2\beta} \quad \beta = 104$$

$$I_{C1} = 10 I_B = 0.8 \text{ mA} \quad I_{B1} = \frac{I_{C1}}{\beta} = 7.7 \text{ uA}$$

$$R_{B1} = \frac{V_{CC} - V_{be}}{I_{B1}} = 1.8 \text{ M}\Omega \quad R_{C1} = \frac{R_{B1}}{2\beta} = 9 \text{ k}\Omega$$

$$V_{C1} = V_{CC} - (I_{C1} + I_B) R_{C1} = 7 \text{ V}$$

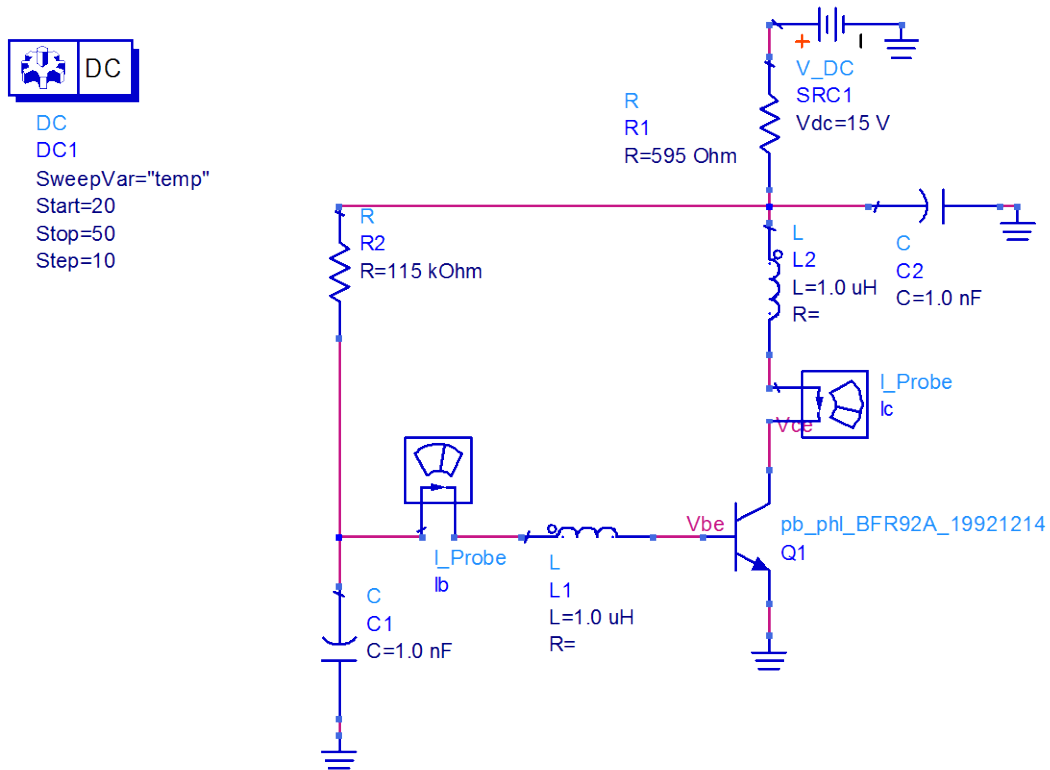
$$R_{B2} = \frac{V_{C1} - V_{BE}}{I_B} = \frac{7 - 0.8}{0.08} = 77.5 \text{ k}\Omega$$

$$R_{C2} = \frac{V_{CC} - V_{CE}}{I_C} = 602 \text{ }\Omega$$

4. Insert your design values and run a complete DC analysis for all three circuit schematics as a function of temperature. Specifically, provide a table that shows  $V_{CE}$ ,  $I_C$ ,  $V_{BE}$ ,  $I_B$  for  $T = 20^{\circ}$ ,  $30^{\circ}$ ,  $40^{\circ}$ , and  $50^{\circ}$ . Comment on your results.

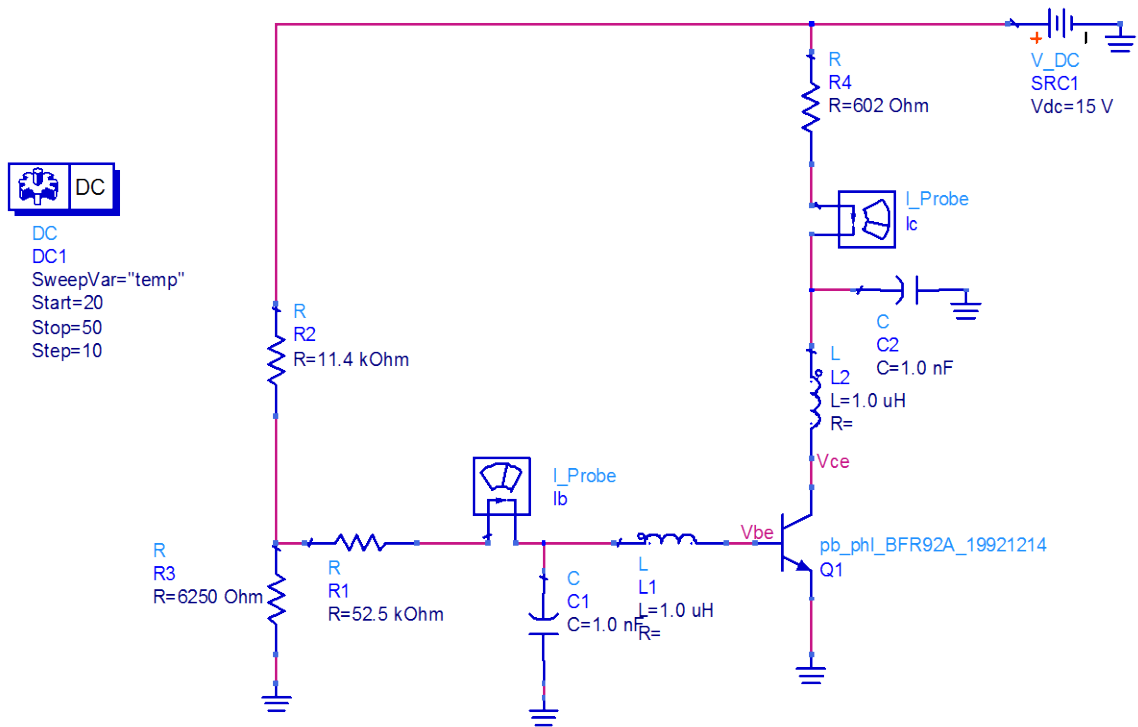
Note: For RFC and  $C_B$  you may use  $1\mu\text{H}$  and  $1\text{nF}$ .

(a)



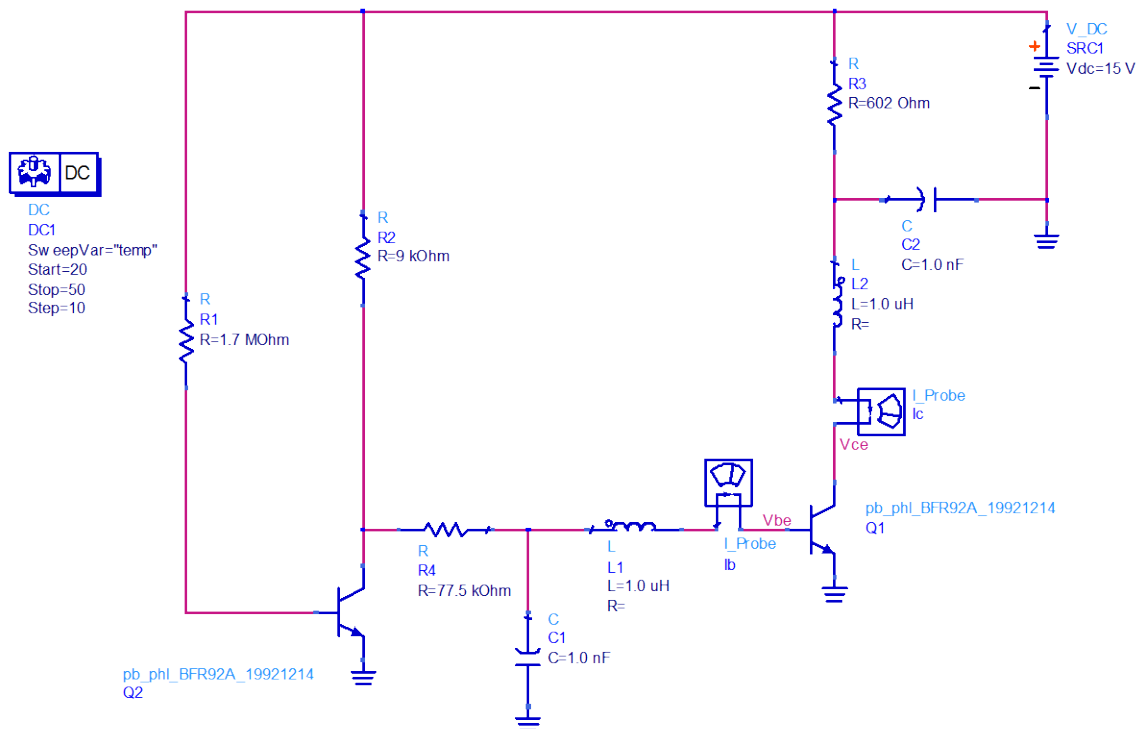
temp	Ib.i	Ic.i	Vbe	Vce
20.000	80.05 $\mu$ A	8.335 mA	787.0 mV	9.993 V
30.000	80.16 $\mu$ A	8.268 mA	813.9 mV	10.03 V
40.000	80.28 $\mu$ A	8.201 mA	840.7 mV	10.07 V
50.000	80.39 $\mu$ A	8.134 mA	867.6 mV	10.11 V

(b)



temp	Ib.i	Ic.i	Vbe	Vce
20.000	80.03 uA	8.331 mA	787.0 mV	9.985 V
30.000	79.56 uA	8.210 mA	813.6 mV	10.06 V
40.000	79.09 uA	8.089 mA	840.3 mV	10.13 V
50.000	78.62 uA	7.969 mA	866.9 mV	10.20 V

(c)



temp	I <sub>b</sub>	I <sub>c</sub>	V <sub>be</sub>	V <sub>ce</sub>
20.000	83.33 $\mu$ A	8.643 mA	788.1 mV	9.797 V
30.000	83.83 $\mu$ A	8.611 mA	815.1 mV	9.816 V
40.000	84.34 $\mu$ A	8.577 mA	842.2 mV	9.837 V
50.000	84.84 $\mu$ A	8.541 mA	869.2 mV	9.858 V