

ECE 321 - Quiz #3 - Name _____

BJT Amplifiers & 2-Port Models

1) BJT Amplifier: DC Analysis. Determine the Thevenin equivalent of R1 and R2 as well as the Q-point. Assume ideal silicon transistors:

- $|V_{be}| = 0.7V$
- $\beta = 40$
- $R_2 = 1100 + 100 \cdot (\text{your birth month}) + (\text{your birth day})$. May 14th would give $R = 1614$ Ohms

R2 1100 + 100*mo + day	Vb	Rb	Vce	Ic
1614	1.668V	1390	9.17V	311uA

$$R_b = R_1 || R_2 = 1390\Omega$$

$$V_b = \frac{R_2}{R_1 + R_2} 12V = 1.668V$$

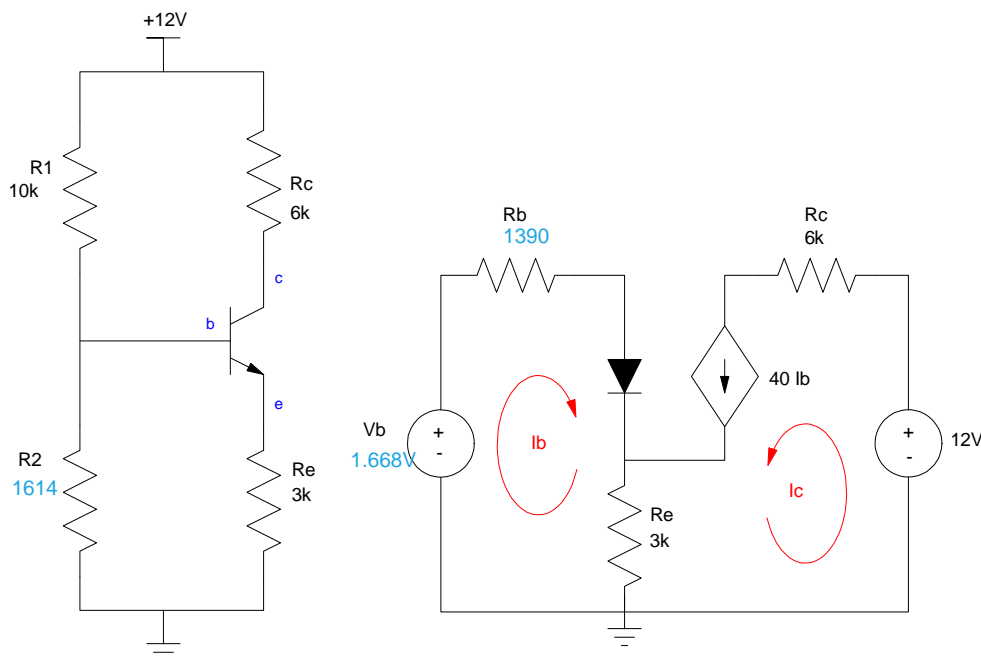
$$I_b = \frac{1.668V - 0.7V}{1390 + 41.3k} = 7.77\mu A$$

$$I_c = 40I_b = 311.1\mu A$$

$$V_c = 12 - 6k \cdot I_c = 10.133V$$

$$V_e = 3k \cdot (I_b + I_c) = 0.9568V$$

$$V_{ce} = V_c - V_e = 9.17V$$



2) BJT Amplifier: DC Design. Determine R1 and R2 so that

- The Q point is $V_{ce} = 6.00V$ and
- The Q point is stabilized for variations in β

Assume

- Ideal silicon transistors ($V_{be} = 0.7V$, $\beta = 40$)
- $R_c = 1100 + 100 * (\text{birth month}) + (\text{birth day})$. May 14th gives $R_c = 1614 \text{ Ohms}$

R_c 1100 + 100*mo + day	R1	R2	V_b	Rb
1614	22.43k	4.86k	2.1395V	4k $\ll 41k$

$$6V = R_c I_c + R_e (I_b + I_c)$$

$$I_c = \frac{6V}{1614 + 3000 + 1 + \frac{1}{40}} = 1.280mA$$

$$I_b = \frac{I_c}{40} = 31.99\mu A$$

To stabilize the Q-point

$$R_b \ll (1 + \beta)R_e = 41k\Omega$$

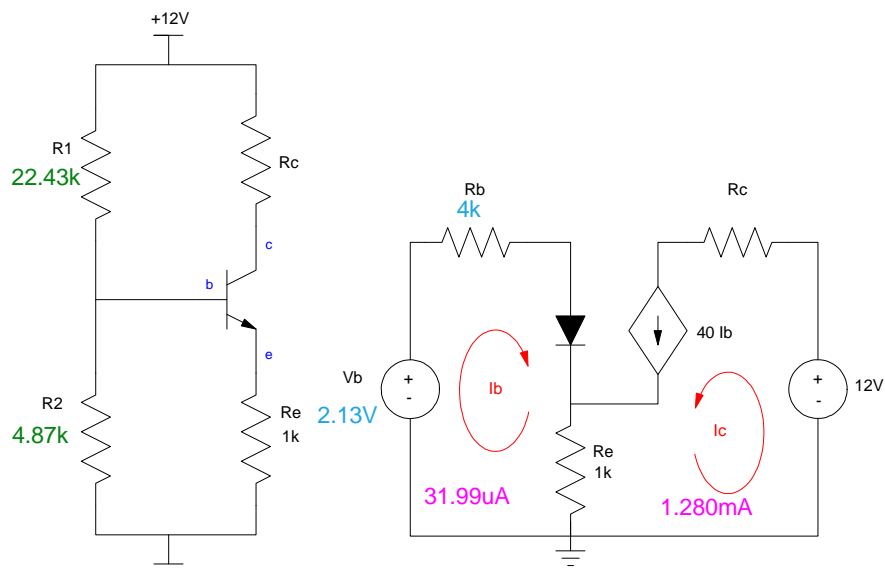
Let $R_b = 4k$

$$V_b = I_b R_b + 0.7 + R_e (I_e + I_c) = 2.1395V$$

Solve for R1 and R2

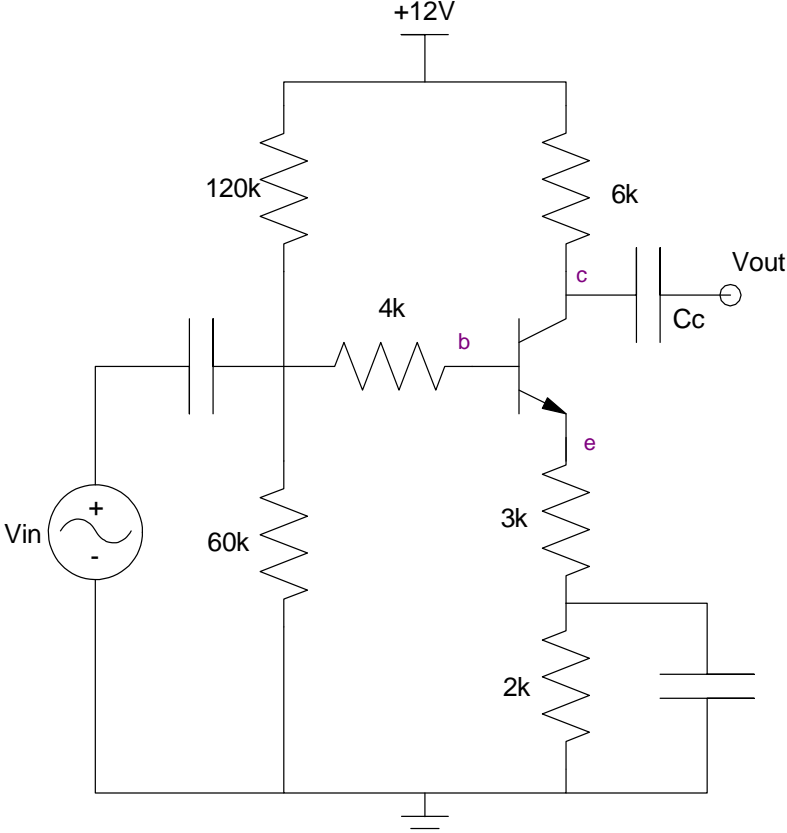
$$R_1 = \frac{12V}{2.1395V} 4k = 22.43k\Omega$$

$$R_2 = 4.8679k\Omega$$

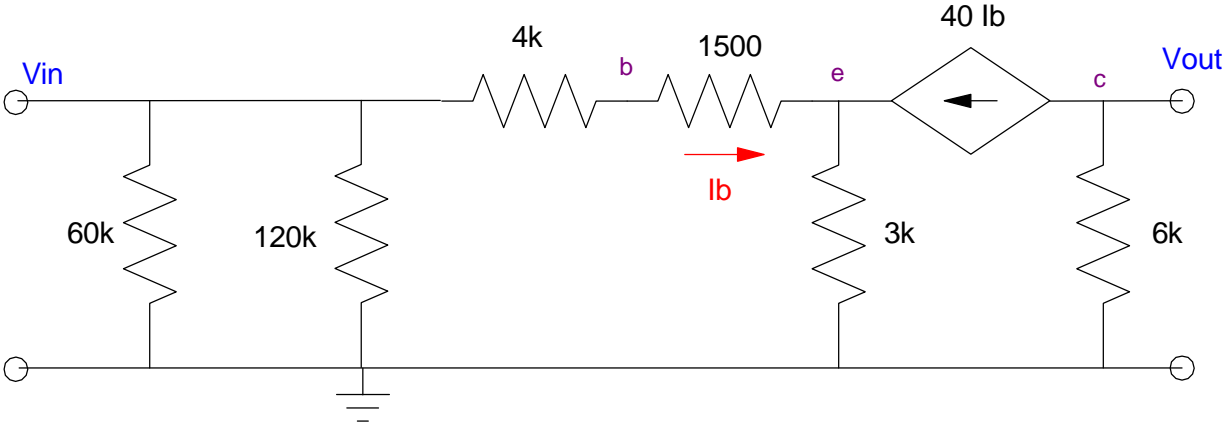


3) BJT: AC Analysis: Draw the small signal model for the following BJT amplifier. Assume

- $r_f = 1500\Omega$
- $\beta = 40$

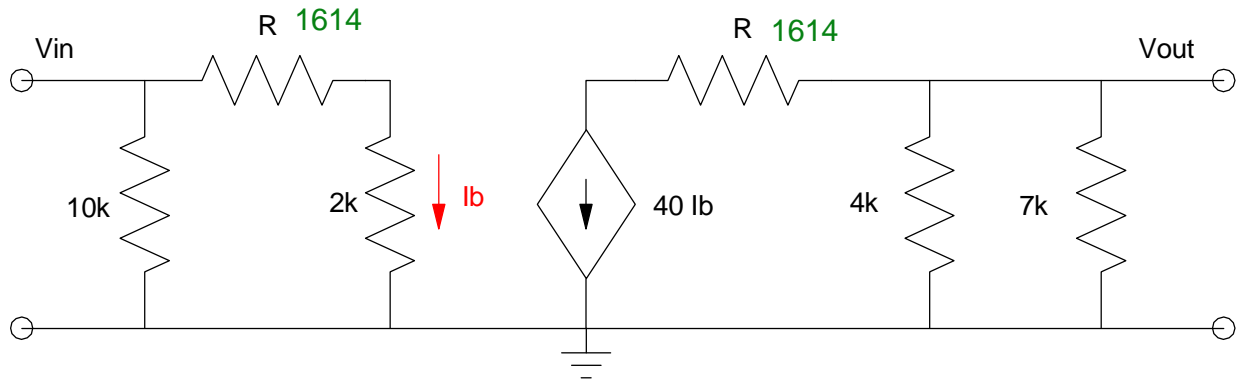


answer:



4) 2-Port Models. Determine the 2-port model for the following circuit:

R 1100 + 100*mo + day	R _{in}	A _{in}	R _{out}	A _o
1614	2655 varies with R	0	2524	-28.17 varies with R



$$R_{in} = 10k \parallel (1614 + 2000) = 2655\Omega$$

$$A_{in} = 0$$

$$R_{out} = 4k \parallel 7k = 2524\Omega$$

$$A_o = - \frac{1}{1614+2000} (40)(4k \parallel 7k) = -28.17$$

5) 2-Port model (experimental): Determine the 2-port parameters based upon the following experimental data:

Case 1:

- $V_{in} = 1\text{mV @ } 1\text{kHz}$
- $R_1 = 0\text{ Ohms}$
- $R_2 = 10\text{M Ohms}$

results in $V_{out} = 57\text{mV}$

Case 2:

- $V_{in} = 1\text{mV @ } 1\text{kHz}$
- $R_1 = X\text{ Ohms}$
- $R_2 = 10\text{M Ohms}$

results in $V_{out} = 43\text{mV}$

Case 3

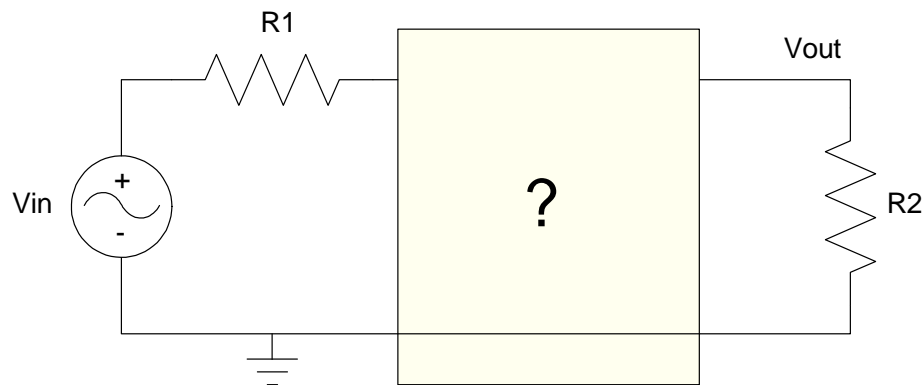
- $V_{in} = 1\text{mV @ } 1\text{kHz}$
- $R_1 = 0\text{ Ohms}$
- $R_2 = X\text{ Ohms}$

results in $V_{out} = 37\text{mV}$

Assume

- $X = 1100 + 100 * (\text{your birth month}) + (\text{your birth date})\text{ Ohms}$
- $A_i = 0$

X 1100 + 100*mo + day	R _{in}	A _i	R _{out}	A _o
1614	4957	0	872	57



A_o comes from case 1:

$$A_o \approx \frac{57\text{mV}}{1\text{mV}} = 57$$

R_{in} comes from case 2:

$$V_{out} = \frac{R_{in}}{R_1 + R_{in}} \cdot 57\text{mV} = 43\text{mV}$$

$$R_{in} = \frac{43\text{mV}}{57\text{mV} - 43\text{mV}} \cdot 1614 = 4957\Omega$$

R_{out} comes from case 3

$$V_{out} = \frac{R_2}{R_2 + R_{out}} \cdot 57\text{mV} = 37\text{mV}$$

$$R_{out} = \frac{57\text{mV} - 37\text{mV}}{37\text{mV}} \cdot 1614 = 872\Omega$$

6) Assume X and Y are related by the following transfer function

$$Y = \frac{100(s+m)}{s^3+ms^2+ds+10} X$$

$$x(t) = 4 + 5 \cos(mt) + d \sin(mt)$$

where

- m is your birth month (1..12), and
- d is your birth date (1..31)

Find y(t)

m birth month (1..12)	d birth date (1..31)	y(t)
5	14	$y(t) = 200 - 52 \cos(5t) - 64 \sin(5t)$

$$Y = \frac{100(s+5)}{s^3+5s^2+14s+10} X$$

$$x(t) = 4 + 5 \cos(5t) + 14 \sin(5t)$$

DC:

$$s = 0$$

$$Y = \frac{100(s+5)}{s^3+5s^2+14s+10} \Big|_{s=0} \cdot (4) = 200$$

AC:

$$s = j5$$

$$Y = \frac{100(s+5)}{s^3+5s^2+14s+10} \Big|_{s=j5} \cdot (5 - j14) = -52.00 + j64.00$$

$$y(t) = -52 \cos(5t) - 64 \sin(5t)$$

Total answer

$$y(t) = 200 - 52 \cos(5t) - 64 \sin(5t)$$