Pre-Lab 9: BJT Amplifier Design

ECEN 325 - 511

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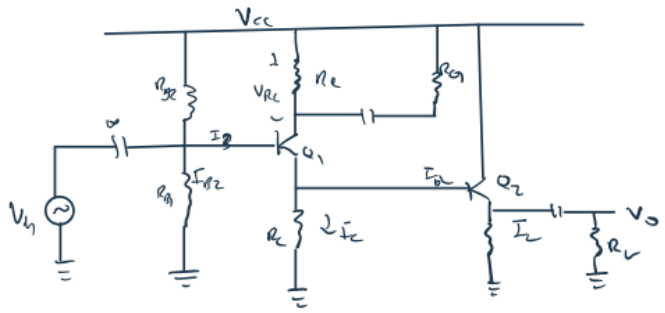
Due Date: November 9, 2021

Calculations



$|A_V| = 20$ $\quad B = 100$

$V_{o,pk} = 0.9V$ $\quad I \le 10\%$

THD 5% $\quad R_i \ge 1k\Omega$ $\quad R_L = 1k\Omega$

$\Delta i_C < 10\%$

$V_{RE} \ge 1V$

$|A_V| = |A_{V1}||A_{V2}| \cong |A_{V1}|$

$= \dfrac{R_C \| R_{i2}}{r_{e1} + \beta_G \| R_{e1}} \rightarrow (1)$

$R_{i2} = (1+\beta)(r_{e2} + R_H \| R_2)$

$R_{i2} \Rightarrow R_L$

$|A_V| \cong R_L / r_{e1} + \beta_e \| R_G$

$V_{CQ} - V_{pk} \ge 0 \Rightarrow V_{CQ} \ge 0.9V$

$V_{CQ} + V_{opk} \le V_{CC} - V_{RE} - V_{CE\,sat}$

$\Rightarrow V_{CQ} \le 3.6V - V_{RE}$

$V_{CQ} - 0.7V - V_{opk} \ge 0 \Rightarrow V_{CQ} \ge 1.6V$

$V_{CQ} - 0.7V + V_{opk} \le V_{CC} - V_{CE}$

$V_{pk} = 0.9$

$V_{CC} = 5$

$V_{CE\,sat} = 0.3$

$V_{CQ} \le 4.3V$

$1.6 < V_{CQ} < 3.6V - V_{RE}$

$3.0 \rightarrow V_{RE} = 1V$

$V_{CQ} = 2.6V$

$\therefore (i_H + i_L)_{min} = \dfrac{V_{CQ} - 0.7 - V_{opk}}{R_H} - \dfrac{V_{opk}}{R_L} \ge 0$

$R_H \le \dfrac{V_{CQ} - 0.7V - V_{opk}}{V_{opk}} R_L = \dfrac{2.60 - 0.7 - 0.9}{0.9} 1k\Omega$

$= 111.1k\Omega$

$\boxed{R_H = 110}$

$I_{CQ2} = \dfrac{V_{CQ} - 0.7}{R_H} = \dfrac{0.9 + 0.7}{R_H} = \dfrac{1.8V}{111\Omega}$

$\boxed{I_{CQ2} = 17mA}$

$$R_{i2} = (1+\beta)\left(\frac{25mV}{I_{EQ2}} + R_M \| R_L\right)$$

$$= 100\left(\frac{25}{17} + 110 \| 100\right)$$

$$\boxed{R_{i2} = 5.39k\Omega}$$

$$R_C \ll R_{i2} = 540\Omega$$

$$\boxed{R_C = 540\Omega}$$

now $I_{CQ} = \frac{V_{CQ}}{R_C} = \frac{2.6}{540} = 4.81mA$

$$R_e = \frac{V_{RE}}{I_E} = \frac{1V}{4.81} = 207.9\Omega$$

$$A_V = \frac{R_C}{\frac{25}{4.81} + 207.9 \| R_{C1}} \Rightarrow 20 = \frac{540}{5.197 + \frac{200R_{C1}}{200+R_{C1}}}$$

$$= 5.197 + \frac{200R_{C1}}{200+R_{C1}} = 27$$

$$\Rightarrow \boxed{R_{C1} = 24.467\Omega}$$

now

$$R_i = (R_{B1} \| R_{B2}) \| (1+\beta)(r_{e1} + R_E \| R_{C1})$$

$$= (R_{B1} \| R_{B2}) \| 100\left(\frac{540}{20}\right)$$

$$= 2.7k\Omega$$

$R_i \geq 1k\Omega$ $\rightarrow V_{TH} = \frac{R_{B2}}{R_{B1}+R_{B2}} V_{CC}$

$$V_{TH} = V_{CC} - V_{BE} - 0.7V$$

$$\frac{R_{B2}}{R_{B1}+R_{B2}} 5V = 3.3V$$

$$= 0.66$$

from a $\rightarrow$ $1k\Omega = (R_{B1} \| R_{B2}) \| 2.7k\Omega$

$$1k\Omega = 0.66 \| 2.7k\Omega$$

$$1k\Omega = \frac{0.66R_{B1} \cdot 2.7k\Omega}{0.66R_{B1} + 2.7k\Omega}$$

$$\boxed{R_{B1} = 2.406k\Omega}$$

so $\frac{R_{B2}}{2.4k + R_{B2}} = 0.66$

$$1.58k + 0.66R_{B2} = R_{B2}$$

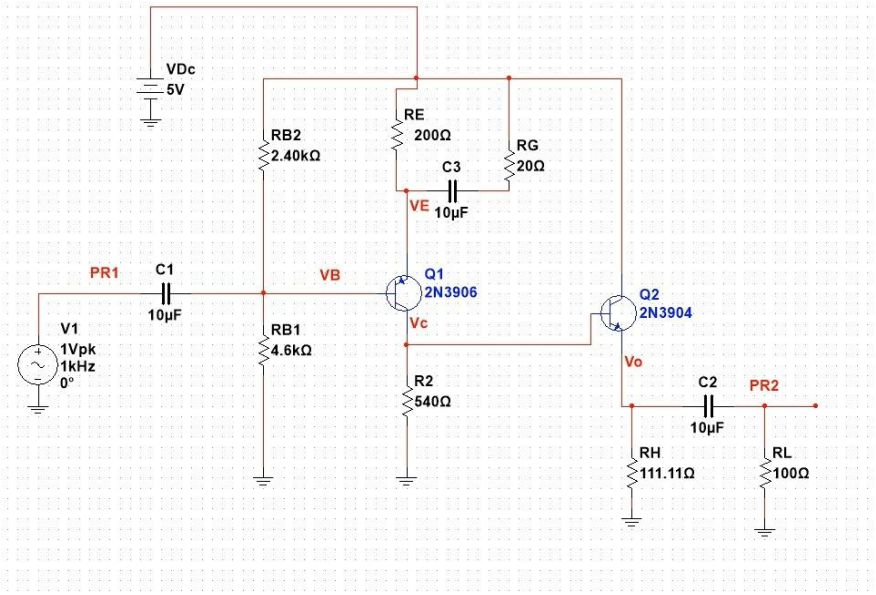
$$\boxed{R_{B2} = 4.67k\Omega}$$

$\therefore$

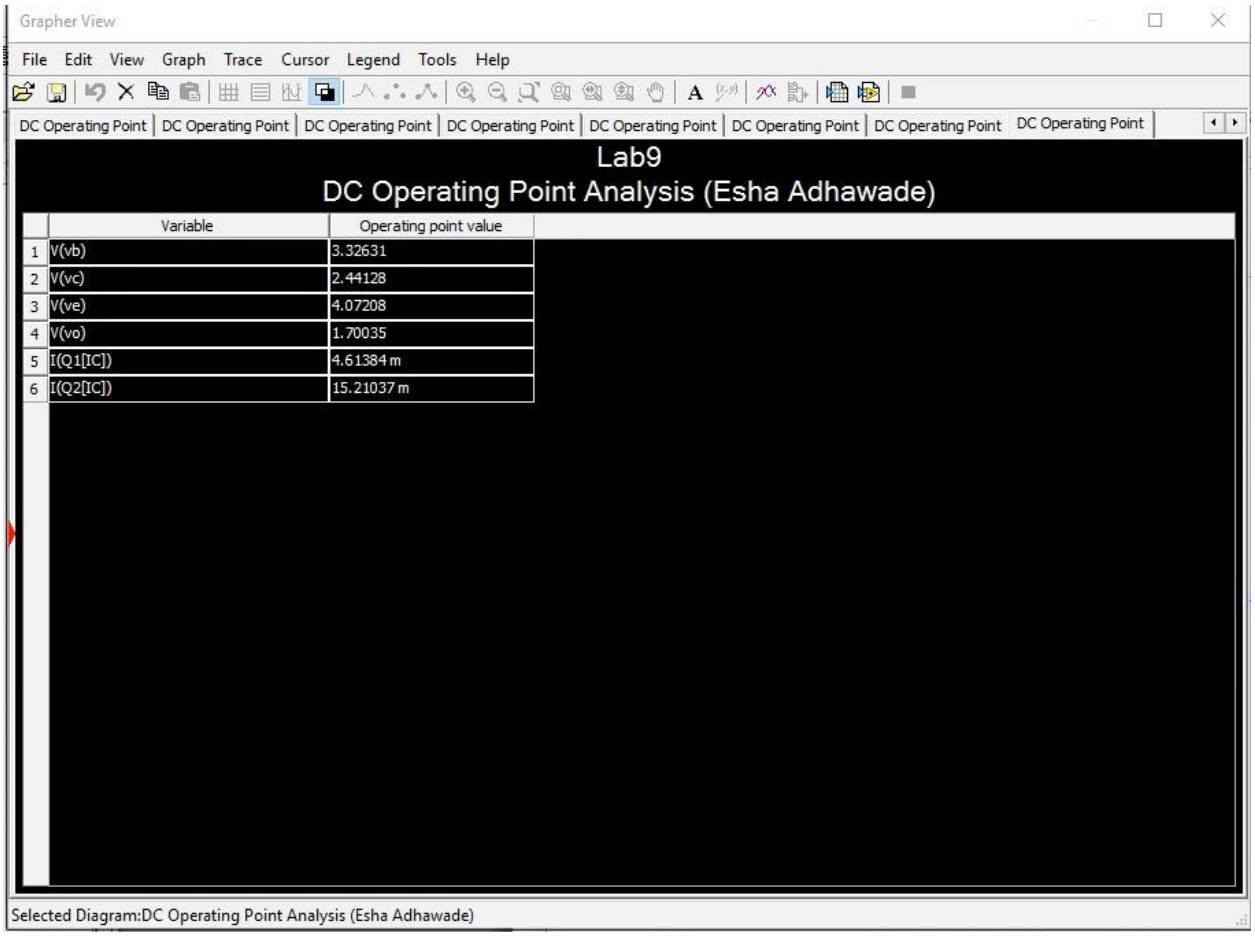
$R_{B1} = 2.406k\Omega$
$R_{B2} = 4.67k\Omega$
$R_{C1} = 24.467\Omega$
$R_L = 540\Omega$
$R_M = 110\Omega$

Simulations (on Multisim)

Schematic

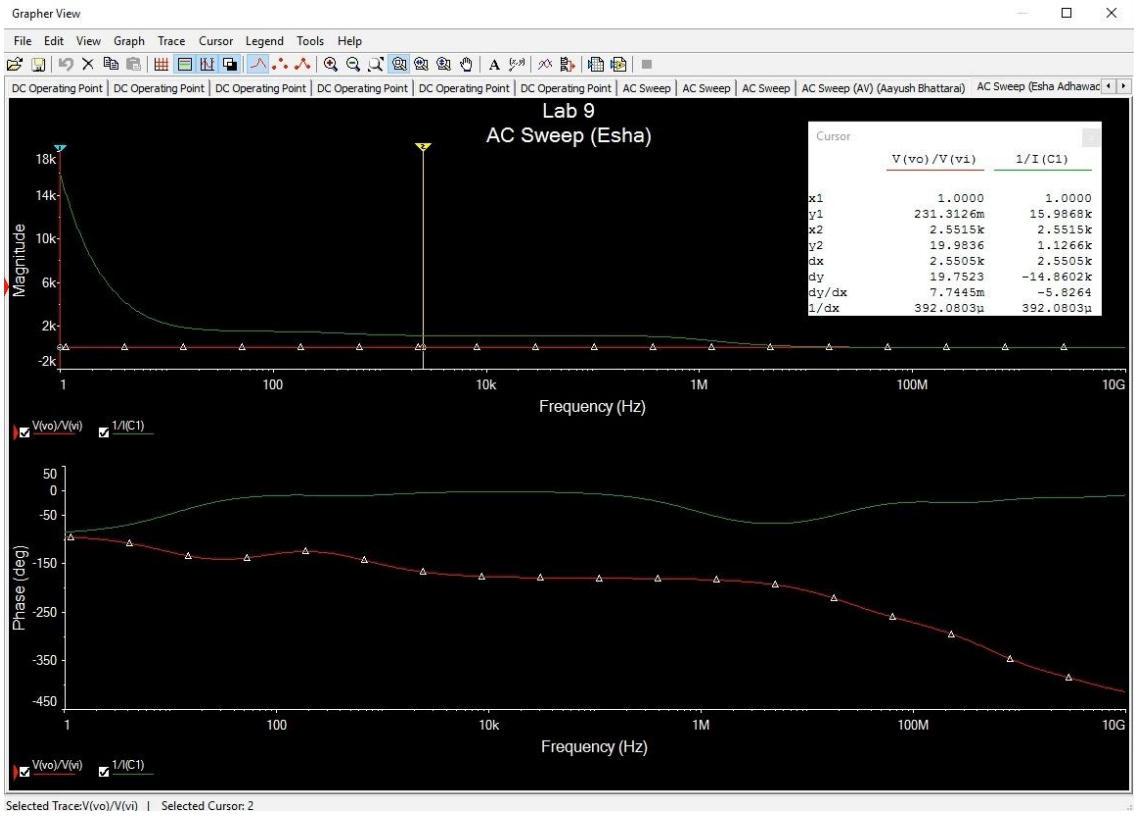


DC Operating Point

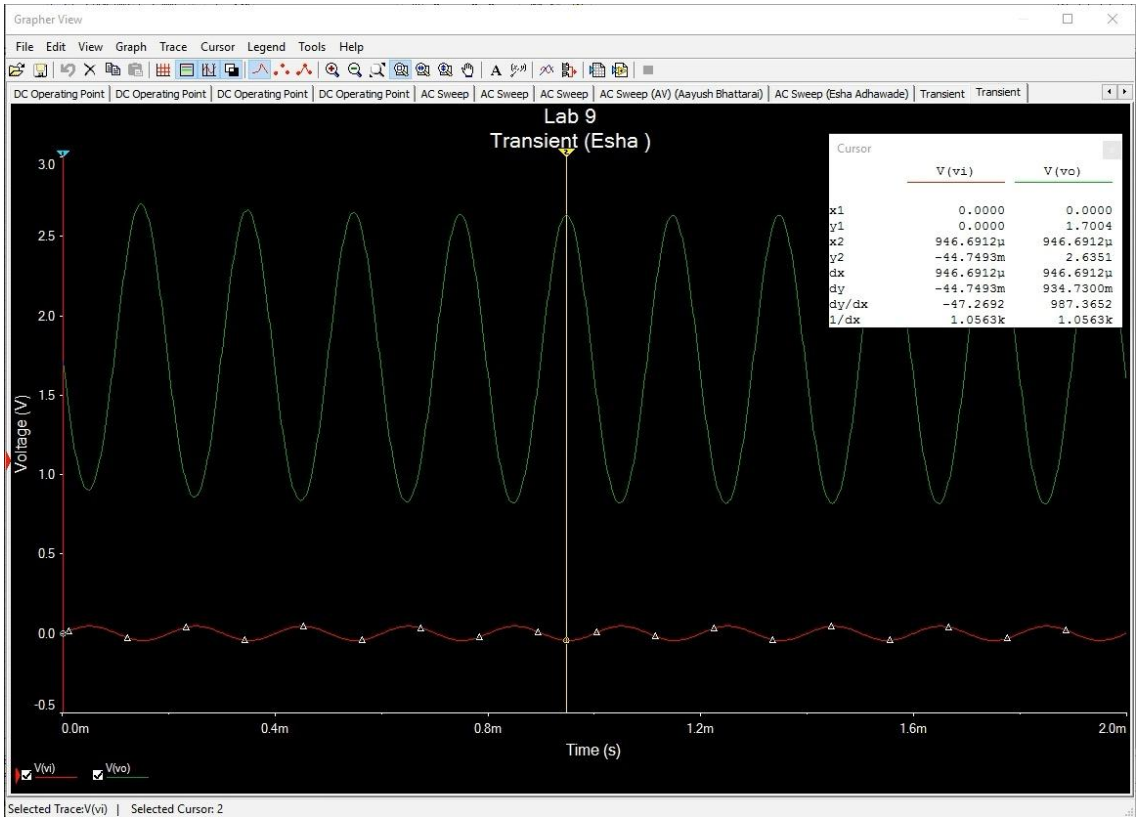


	Variable	Operating point value
1	V(vb)	3.32631
2	V(vc)	2.44128
3	V(ve)	4.07208
4	V(vo)	1.70035
5	I(Q1[IC])	4.61384 m
6	I(Q2[IC])	15.21037 m

A_v / R_i



Transient



Fourier

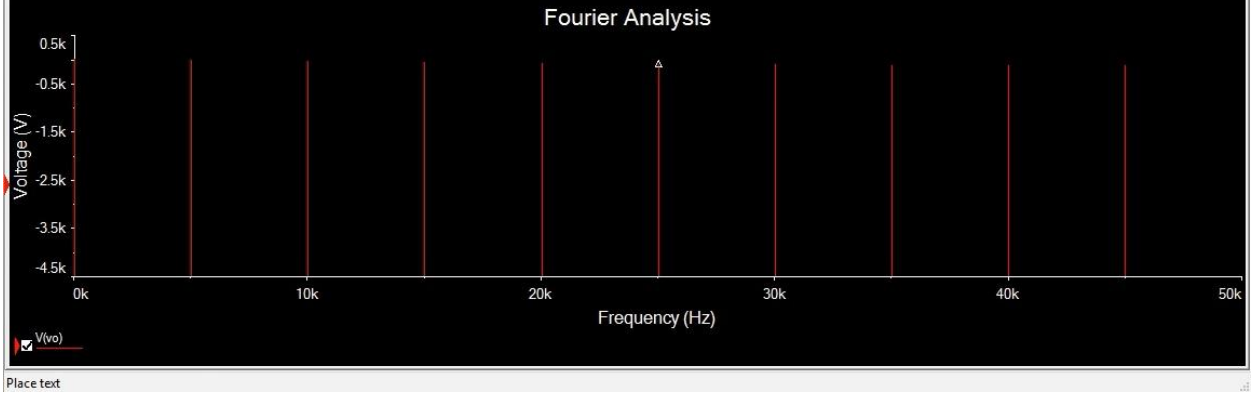
Grapher View

File Edit View Graph Trace Cursor Legend Tools Help

DC Operating Point | DC Operating Point | DC Operating Point | AC Sweep | AC Sweep | AC Sweep | AC Sweep (AV) (Aayush Bhattarai) | AC Sweep (Esha Adhawade) | Transient | Transient | Fourier | Fourier | Fourier | Fourier

Design1

1	Fourier analysis for V(vo):					
2	DC component:	1.70353				
3	No. Harmonics:	9				
4	THD:	2.3239 %				
5	Grid size:	256				
6	Interpolation Degree:	1				
7						
8	Harmonic	Frequency	Magnitude	Phase	Norm. Mag	Norm. Phase
9	0	0	1.70353	0	1.87423	0
10	1	5000	0.908922	-173.86	1	0
11	2	10000	0.021006	-74.857	0.0231108	99.0017
12	3	15000	0.00220587	-160.96	0.00242691	12.8969
13	4	20000	0.000198054	109.871	0.0002179	283.729
14	5	25000	2.42396e-05	23.5988	2.66685e-05	197.458
15	6	30000	5.72983e-06	-15.997	6.30398e-06	157.862
	7	35000	3.5549 1e-06	-0.32252	3.91112e-06	173.536



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