AUDIO AMPLIFIER

Supervisor by: Dr. Eman Sawires

references From: [1] Floyd, “Electronic Devices”, 9th-edition.

Team Members:

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3- Mosab Mohamed Sayed
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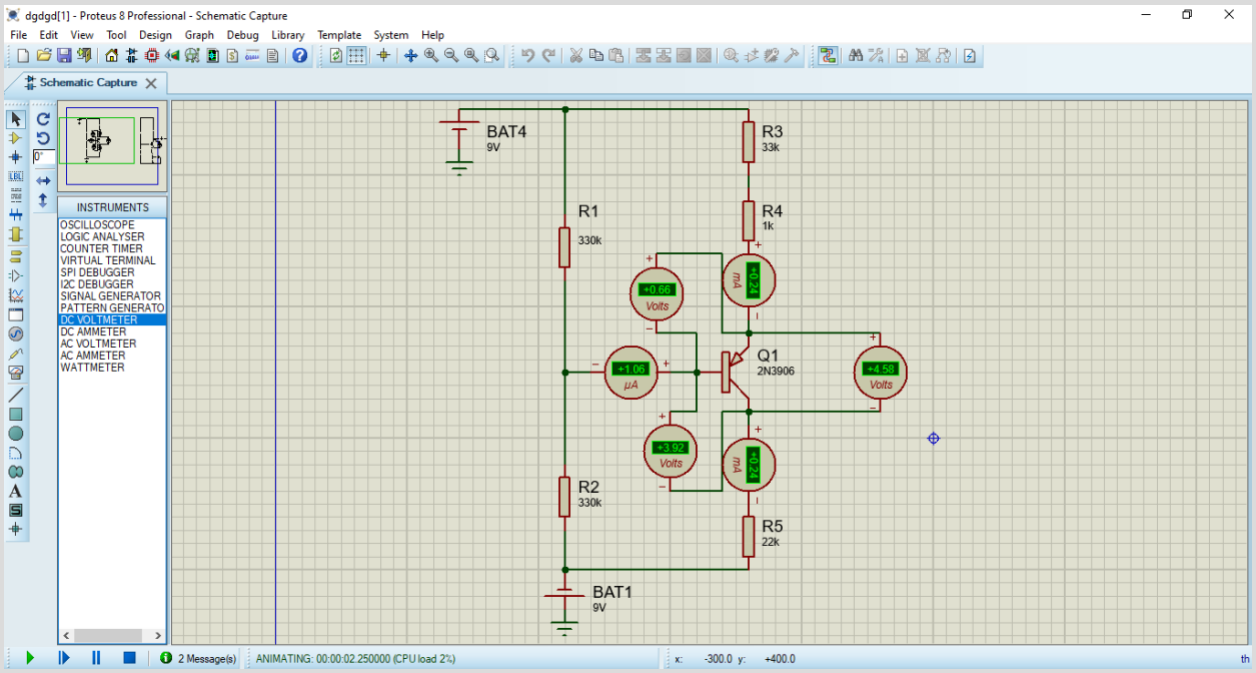
5- Abd El Rahman Yahia Sayed

Content →

Steps →

1- We do DC Analysis to make Q point in mid-point.
2- We do DC Analysis on proteus.
3- We calculate Gain and Frequency response and AC Analysis
4- And we apply them in proteus.
5- We calculate DC analysis for power amplifier.
6- We apply the circuit on testboard and it works.
7- Finally, we apply it on PCP.


dgdgd[1] - Proteus 8 Professional - Schematic Capture
File Edit View Tool Design Graph Debug Library Template System Help
Schematic Capture
INSTRUMENTS
OSCILLOSCOPE
LOGIC ANALYSER
COUNTER TIMER
VIRTUAL TERMINAL
SPI DEBUGGER
I2C DEBUGGER
SIGNAL GENERATOR
PATTERN GENERATO
DC VOLTMETER
DC AMMETER
AC VOLTMETER
AC AMMETER
WATTMETER
BAT4
9V
R3
33k
R1
330k
R4
1k
+0.66
Volts
+2.24
mA
+1.06
µA
Q1
2N3906
+4.58
Volts
+3.92
Volts
+0.24
mA
R2
330k
R5
22k
BAT1
9V
2 Message(s)
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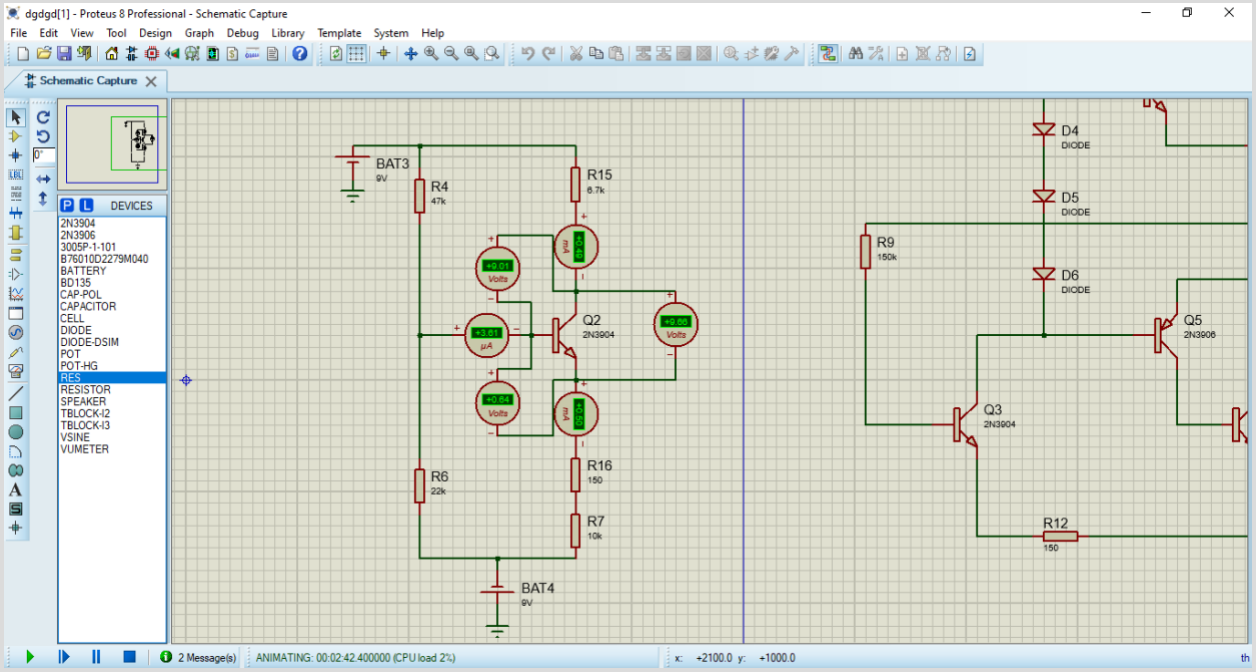
x: -300.0 y: +400.0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Schematic Capture
DEVICES
2N3904
2N3906
3005P-1-101
B76010D2279M040
BATTERY
BD135
CAP-POL
CAPACITOR
CELL
DIODE
DIODE-DSIM
POT
POT-HG
RES
RESISTOR
SPEAKER
TBLOCK-I2
TBLOCK-I3
VSINE
VUMETER
BAT3
9V
R4
47k
R15
6.7k
+8.01
Volts
+2.24
mA
+3.61
µA
Q2
2N3904
+8.68
Volts
+0.64
Volts
+0.24
mA
R6
22k
R16
150
R7
10k
BAT4
9V
D4
DIODE
D5
DIODE
D6
DIODE
R9
150k
Q5
2N3906
Q3
2N3904
R12
150
2 Message(s)
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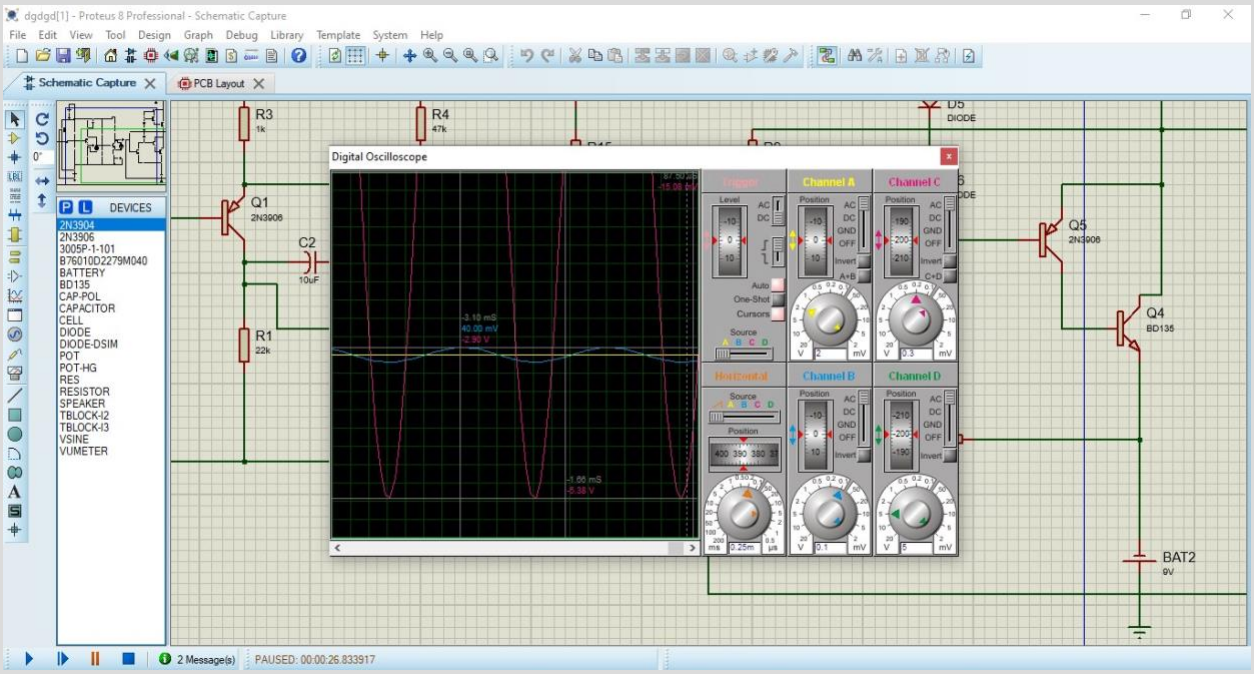
dgdgd[1] - Proteus 8 Professional - Schematic Capture
File Edit View Tool Design Graph Debug Library Template System Help
Schematic Capture
PCB Layout
DEVICES
2N3904
2N3906
3005P-1-101
B76010D2279M040
BATTERY
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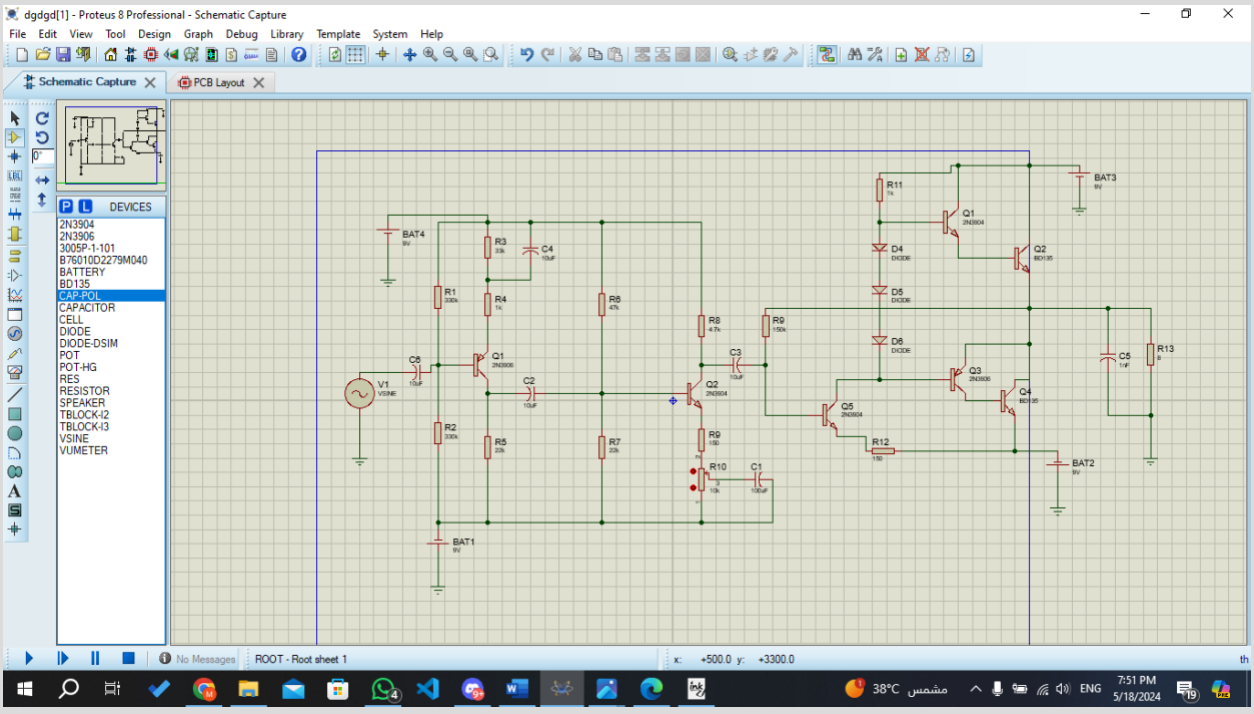
CAP-POL
CAPACITOR
CELL
DIODE
DIODE-DSIM
POT
POT-HG
RES
RESISTOR
SPEAKER
TBLOCK-I2
TBLOCK-I3
VSINE
VUMETER
Digital Oscilloscope
Trigger
Channel A
Channel C
Channel B
Channel D
Horizontal
R3
1k
R4
47k
R1
22k
C2
10uF
Q1
2N3906
Q5
2N3906
Q4
BD135
D5
DIODE
BAT2
9V
2 Message(s)
PAUSED: 00:00:26.833917


dgdgd[1] - Proteus 8 Professional - Schematic Capture
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Schematic Capture
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DEVICES
2N3904
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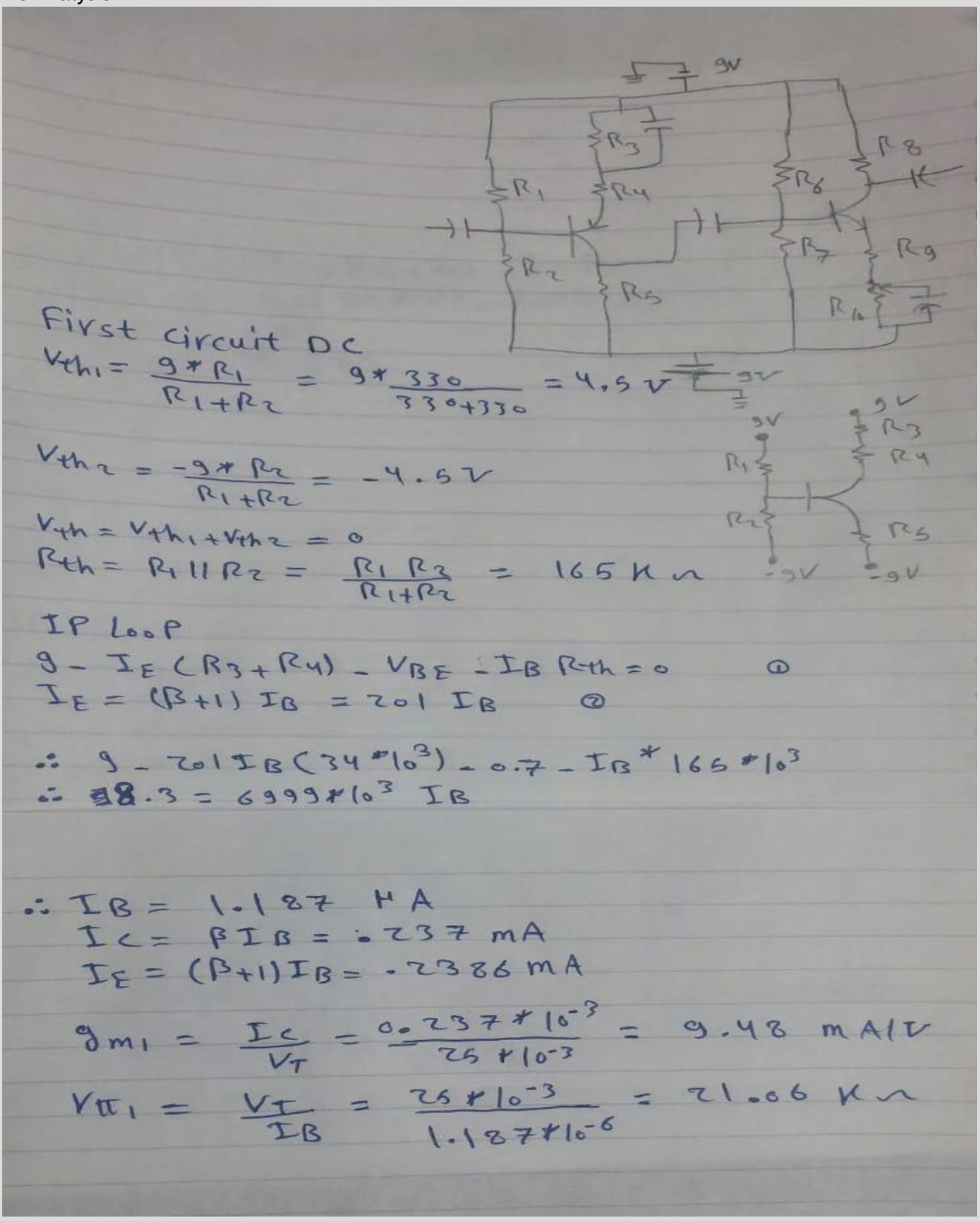
RESISTOR
SPEAKER
TBLOCK-I2
TBLOCK-I3
VSINE
VUMETER
BAT4
BAT3
BAT2
BAT1
V1
VSINE
R11
D4
D5
D6
Q1
Q2
Q3
Q4
Q5
C5
R13
R12
No Messages
ROOT - Root sheet 1
x: +500.0 y: +3300.0
38°C مشمس
ENG
7:51 PM
5/18/2024

DC Analysis



First circuit DC

$V_{th_1} = \frac{9 * R_1}{R_1 + R_2} = 9 * \frac{330}{330+330} = 4.5\ V$

$V_{th_2} = \frac{-9 * R_2}{R_1 + R_2} = -4.5\ V$

$V_{th} = V_{th_1} + V_{th_2} = 0$

$R_{th} = R_1 \,||\, R_2 = \frac{R_1 R_2}{R_1 + R_2} = 165\ K\Omega$

IP Loop

$9 - I_E (R_3 + R_4) - V_{BE} - I_B R_{th} = 0$ ①

$I_E = (\beta + 1) I_B = 201\ I_B$ ②

$\therefore\ 9 - 201 I_B (34 * 10^3) - 0.7 - I_B * 165 * 10^3$

$\therefore\ 8.3 = 6999 * 10^3\ I_B$

$\therefore I_B = 1.187\ \mu A$

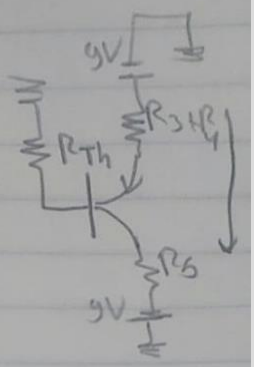
$I_C = \beta I_B = .237\ mA$

$I_E = (\beta + 1) I_B = .2386\ mA$

$g_{m_1} = \frac{I_C}{V_T} = \frac{0.237 * 10^{-3}}{25 * 10^{-3}} = 9.48\ mA/V$

$r_{\pi_1} = \frac{V_T}{I_B} = \frac{25 * 10^{-3}}{1.187 * 10^{-6}} = 21.06\ K\Omega$

OP loop



$9 + 9 - I_E(R_3 + R_4) + V_{CE} - I_C R_5 = 0$

$\therefore -V_{CE} = 18 - I_E(34 * 10^3) - I_C(22 * 10^3)$

$-V_{CE} = 4.673$

$\therefore V_{EC} = 4.673$

$\therefore V_{EB} = 0.7$

$\therefore V_{CB} = V_{EB} - V_{EC} = 0.7 - 4.67 = -3.97V$

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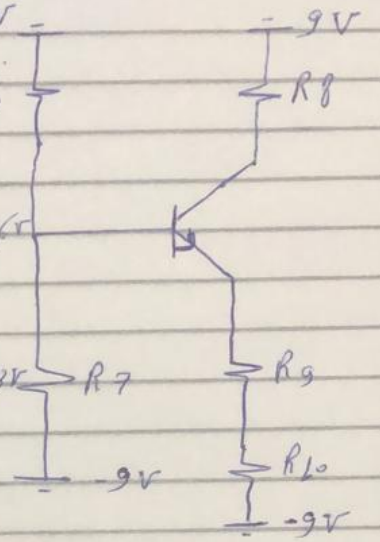
second stage DC :

$$R_{th} = R_6 // R_7 = \frac{R_6 * R_7}{R_6 + R_7} = 14.98 K\Omega$$

$$V_{th_1} = 9 * \frac{R_7}{R_7 + R_8} = 9 * \frac{22}{22 + 47} = 2.86 V$$

$$V_{th_2} = -9 * \frac{R_6}{R_6 + R_7} = -9 * \frac{47}{22 + 47} = -6.13 V$$

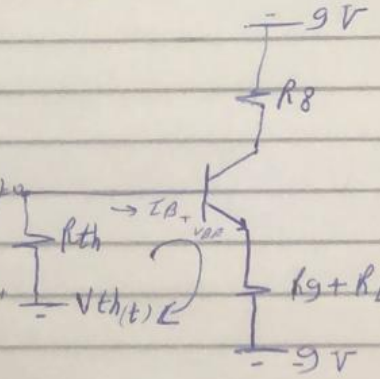
$$V_{th(t)} = V_{th_1} + V_{th_2} = -3.2704 V$$



INPUT Loop :

$$V_{th(t)} + 9 - I_B(R_{th}) - V_{BE} - I_E(R_g + R_{Lo}) = 0$$

$$-3.2704 + 9 - I_B(14.98 * 10^3) - 0.7 - (201 I_B)(1.0 * 10^3) = 0$$



$$I_B = 2.447 \mu A$$

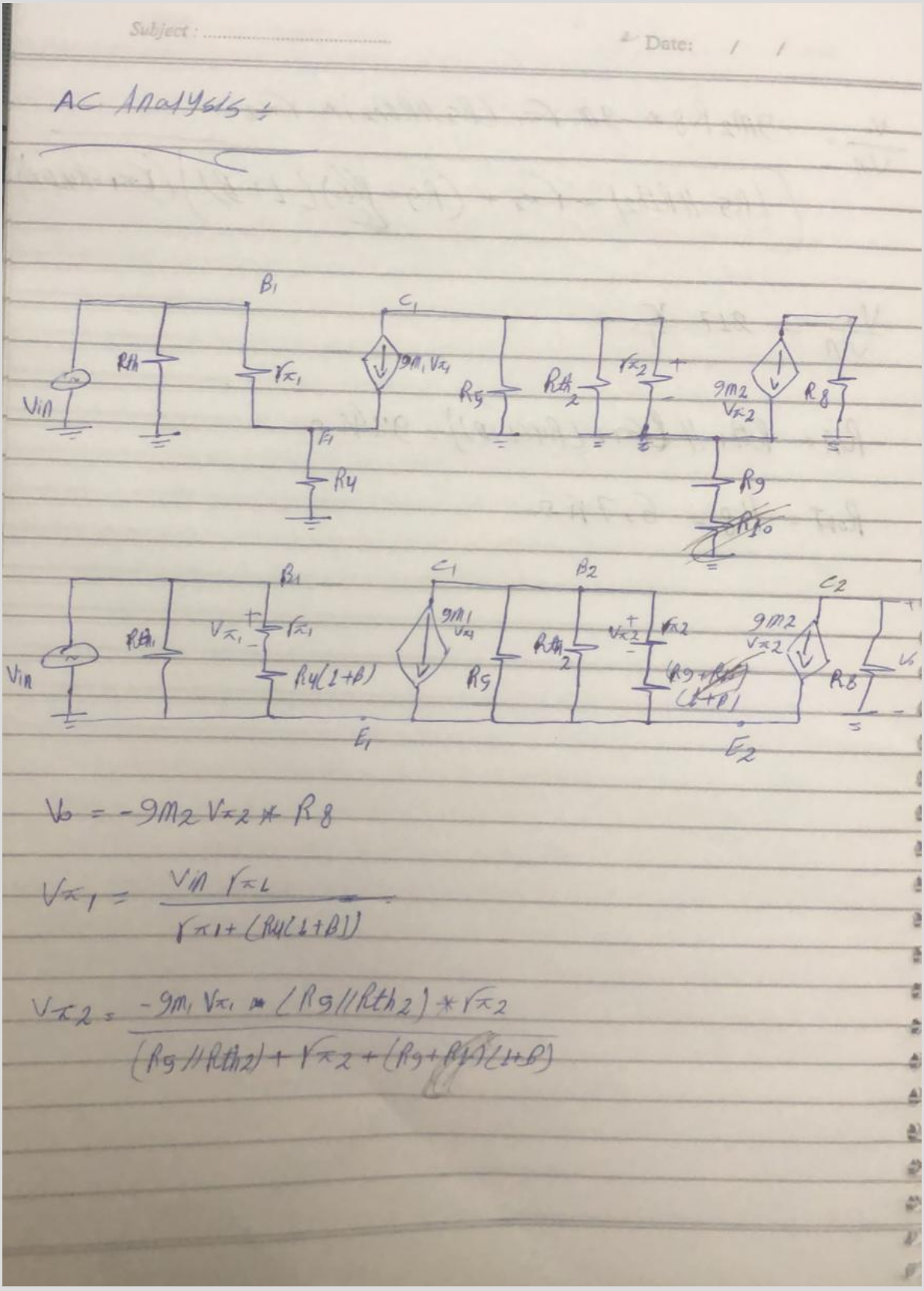
$$I_C = \beta I_B = 4.89 * 10^{-4} A$$

$$I_E = (1 + \beta) I_B = 4.91 * 10^{-4} A$$

$$g_{m2} = \frac{I_C}{V_t} = \frac{4.89 * 10^{-4}}{0.025} = 0.0195 A/V = 19.56 mA/V$$

$$r_{\pi 2} = \frac{V_t}{I_B} = \frac{0.025}{2.447 * 10^{-6}} = 10.216 K\Omega$$

AC Analysis



$$V_o = -g_{m2} V_{\pi 2} * R_8$$

$$V_{\pi 1} = \frac{V_{in}\, r_{\pi 1}}{r_{\pi 1} + (R_4(1+\beta))}$$

$$V_{\pi 2} = \frac{-g_{m1} V_{\pi 1} * (R_5 // R_{th2}) * r_{\pi 2}}{(R_5 // R_{th2}) + r_{\pi 2} + (R_9 + R_{10})(1+\beta)}$$

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$$\frac{V_o}{V_{in}} = \frac{-g_{m2} R_8 \cdot -g_{m1} r_{\pi 1} (R_5 \| R_{th2}) \cdot r_{\pi 2}}{\left((R_5 \| R_{th2}) + r_{\pi 2} + (R_9 + R_{10})(1+\beta) \right) (r_{\pi 1} + R_4(1+\beta))}$$

$$\frac{V_o}{V_{in}} = 217 \frac{V}{V}$$

$$R_{in} = R_{th1} \| (r_{\pi 1} + (R_4(1+\beta)) = 94.6 k\Omega$$

$$R_{out} = R_8 = 6,7 k\Omega$$

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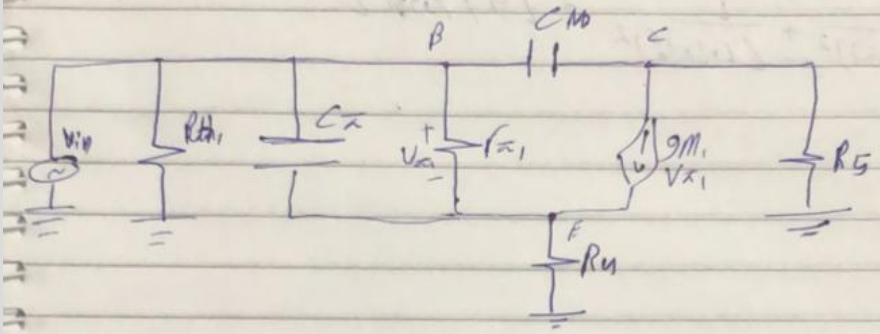
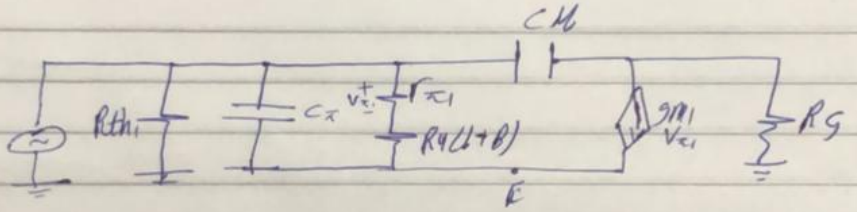
fH in first stage :

C_π in data sheet is : 12 PF

C_M in data sheet is : 4 PF

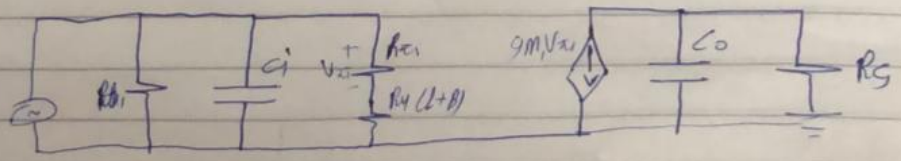




$A_{@F=0} \sim A = -g_{m_1} V_{\pi_1} R_S = -g_{m_1} R_S$

$C_i = C_\pi + C_1 = 12 + 4(1 + g_{m_1} R_S) = 850.2\,PF$

$C_o = C_{\pi} = C_M\left(1 - \frac{1}{-g_{m_1} R_S}\right) = 4.019\,PF$



$R_{th_1} = \left(R_{th_1} // \left(r_{\pi_1} + R_4(1+\beta)\right)\right) = 94.66\,K\Omega$

$f_{H_1} = \frac{1}{2\pi (94.66 * 10^3)(850.2 * 10^{-12})} = 1977.57\,Hz$

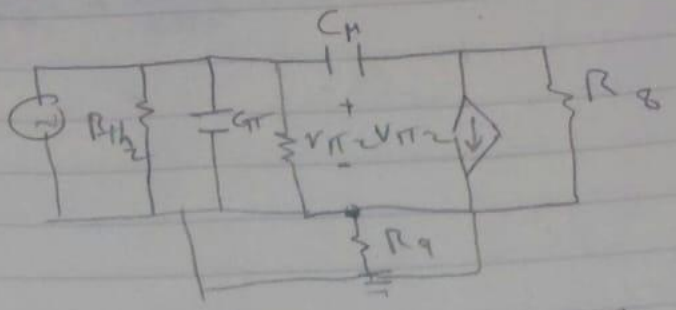
$$f_{L\,Total} = \sqrt{(9.18)^2 + (8.75)^2} = 12.686\ Hz$$

Using Miller

$C_1 = C_M(1 - A)$

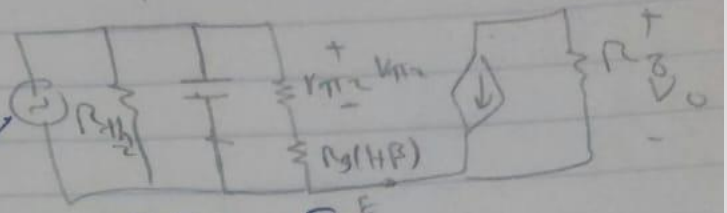
$C_2 = C_M\left(1 - \frac{1}{A}\right)$

$A = \frac{V_o}{V_{\pi 2}}$



$V_o = -g_{m_2} V_{\pi 2} R_8$

$A = -g_{m_2} R_8 = -92\ V/V$



$C_1 = C_M(1 + 92) = 0.372\ nF$

$C_2 = C_M\left(1 + \frac{1}{92}\right) = 4.04\ PF$

C_M in data sheet is 4 PF

C_π in datasheet is 8 PF

$\therefore C_{in} = C_1 + C_\pi = $ ~~17.04 PF~~ 380 PF

$C_{o1} = C_2 = 4.04\ PF$

$$f_{P1} = \frac{1}{2\pi C_{in} R_{eq}}$$

$R_{eq} = R_{th_2} \parallel (r_{\pi 2} + R_g(1+\beta))$

$= 10.9\ K\Omega$

$f_{P1} = 38.33\ KHz$

$f_{P2} = \frac{1}{2\pi C_o R_{eq}}$, $R_{eq} = R_8 = 4.7\ K\Omega$

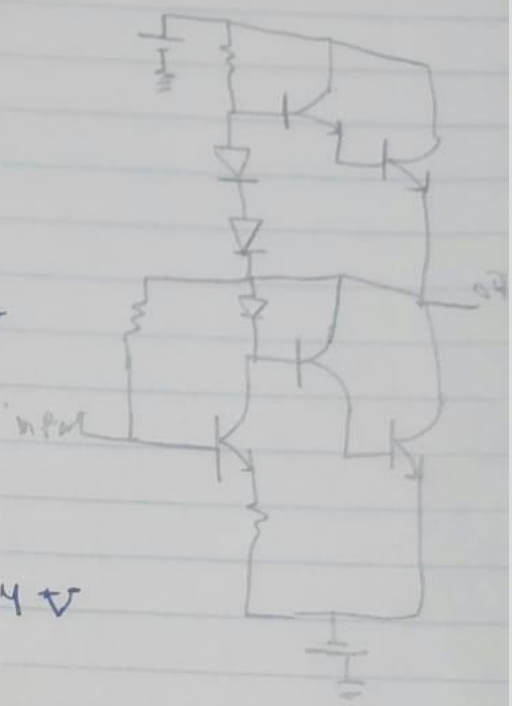
$f_{P2} = 8.38\ MHz$

$$F_{H_2} = 1 / \sqrt{\frac{1}{F_{P_1}} + \frac{1}{F_{P_2}}} = 38.33 \text{ KHZ}$$

$$\therefore F_{H_{total}} = \frac{1}{\sqrt{\frac{1}{F_{H_1}^2} + \frac{1}{F_{H_2}^2}}} = 1974.9 \text{ HZ}$$

$$F_{H2} = 1/\sqrt{\frac{1}{F_{P1}} + \frac{1}{F_{P2}^2}} = 38.33 \text{ KHZ}$$

$$\therefore F_{H_{tot}} = \frac{1}{\sqrt{\frac{1}{F_{H1}^2} + \frac{1}{F_{H2}^2}}} = 1974.9 \text{ HZ}$$



$V_{B3} = 3 - 0.7 = -2.1V$

$V_{E3} = V_{EB} + V_B$

$V_{E3} = 0.7 - 2.1 = -1.4V$

$V_{E1} = V_{B1} - V_{BE1}$

$= 2.8 - 0.7 = 1.4 V$

$V_o = V_E$ of Q_1 and $Q_3 = 1.4 V$

Curren of R_2

$I_{R2} = \frac{9 - 1.4}{1K} = 7.6 \text{ mA} \therefore I_{C1} = 7.6 \text{ mA}$

$I_{R3} = \frac{1.4 + 9}{220} = 47.2 \text{ mA} \therefore I_{C3} = 47.2 \text{mA}$

Assuming $\beta = 100 \therefore I_{B2} = \frac{I_{C2}}{\beta} = 76 \text{ MA}$

$I_{B4} = \frac{I_{C4}}{\beta} = 472 \text{ MA}$

$I_{C_1} = 7.6\ mA$, $I_{B_1} = 38\ \mu A$

$I_{E_1} = 7.64\ mA$

$I_{B_2} = I_{E_1} = 7.64\ mA$, $I_{C_2} = 1.52\ A$

$I_{E_2} = 1.53\ A$

$I_{C_3} = 47.2\ mA$, $I_{B_3} = 236\ \mu A$

$I_{E_3} = 47.43\ mA$

$I_{B_4} = I_{C_3} = 47.2\ mA$, $I_{C_4} = 9.44\ A$

$I_{E_4} = 9.5\ A$

$I_{C_5} = I_{B_3} = 236\ \mu A$, $I_{B_5} = 1.18\ \mu A$

$I_{E_5} = 1.2\ \mu A$

Comparison between DC, AC in proteus and Analysis :

DC, AC values	Proteus	Analysis
I_{b1}	1.06 micro	1.16 micro
I_{e1}	.245 m	.237 m
I_{C1}	.243 m	.238 m
I_{b2}	3.61 micro	2.44 micro
I_{e2}	.50 m	.489 m
I_{C2}	.49 m	.49 m
V_{ec1}	4.58 v	4.67 v
V_{bc1}	3.92 v	3.97 v
V_{eb1}	.66 v	.7 v
V_{ce2}	9.66 v	9.56 v
V_{cb2}	9.01 v	8.81 v
V_{be2}	.64 v	.7 v
G_v	154	200