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SUBJECT: CMPE 314 Preliminary Report 1: Design and Analysis

Objective

Our objective was to design the two stages of the pre-amp stage of the common emitter amplifier. In total, we wanted our small signal voltage gain to be greater than 400. We did this by having a cascaded amplifier, meaning we had two transistor circuits connected to each other. The first circuit has a load resistor, which connects to the second transistor circuit. Each stage had to have a gain that we would then multiply, to get a gain greater than 400. The formula is something like this: $A_v = A_{v1} \times A_{v2}$.

Tools:

Utilize MATLAB script to determine theoretical and practical resistor values:

```
% Common Emitter Amplifier with Re
% Modifiers
k = 1000;
m = 10^-3;
u = 10^-6;

% Constraints
Vcc = 9;
B = 100;
Rs = 50;
Vce = 4.5;
Icq = 1 * m;
Ibq = 10 * u;

% Gain
A_v = 120;

% RE and RC calculations
Re = (Vcc - Vce) / ((A_v + 1) * Icq);
Rc = A_v * Re;

% Thevenin values
Rth = 0.1 * (B + 1) * Re;
Vth = (Ibq * Rth) + 0.7 + ((B + 1) * Ibq * Re);

% R1 and R2 calculations
R1 = Rth * (Vcc / Vth);
R2 = Rth * (Vcc / (Vcc - Vth));

% Resistances
rpi = (B * 0.026) / Icq;
Rib = rpi + (1 + B) * Re;
Ri = (Rth * Rib) / (Rth + Rib);

% Actual gain
Af = (-B * Rc) / (rpi + (B + 1) * Re) * (Ri / (Ri + Rs));
```

```matlab
% DISPLAY
fprintf('\nResistor w/ voltage gain A_v = %.1f:\n', A_v);
fprintf('R1 = %.2f Ohms\n', R1);
fprintf('R2 = %.2f Ohms\n', R2);
fprintf('RC = %.2f Ohms\n', Rc);
fprintf('RE = %.2f Ohms\n', Re);
fprintf('Ri = %.2f Ohms\n', Ri);
fprintf('Actual A_v gain = %.2f\n', Af);

% Practical Resistor Values(Utilize practical resistor values)
Rp1 = 10000 + 4700 ;
Rp2 = 1500;
RpC = 3300 + 1000;
RpE = 220 + 100;
Old_gain = Af;

% Practical RC calculation
Rpc = RpC;  % Replace Rc with practical resistor value RpC

% Practical Thevenin values
RPth = 0.1 * (B + 1) * RpE;
VPth = (Ibq * RPth) + 0.7 + ((B + 1) * Ibq * RpE);

% Practical resistances
rPpi = (B * 0.026) / Icq;
RPib = rPpi + (1 + B) * RpE;
RpI = (RPth * RPib) / (RPth + RPib);
RL = 1428.44;
% Practical actual gain
APf = (-B *  RpC) / (rPpi + (B + 1) * RpE) * (RpI / (RpI + Rs));

% DISPLAY
fprintf('\n Real Resistor w/ voltage gain A_v = %.1f:\n', Old_gain);
fprintf('Rp1 = %.2f Ohms\n', Rp1);
fprintf('Rp2 = %.2f Ohms\n', Rp2);
fprintf('RpC = %.2f Ohms\n', RpC);
fprintf('RpE = %.2f Ohms\n', RpE);
fprintf('Ri = %.2f Ohms\n', RpI);
fprintf('New A_v gain = %.2f\n', APf);
```

Process

Lab Project

Overall gain of $A_V > 400$

Two stage Common Emmitter

1st & 2nd

1st — R_L will be the R_i of 2nd transistor

2nd — R_L will be assumed untill last stage is Implemented.

To accont for Impedance loss A_{V_2} will be a gain of $A_{V_2} = 27$

Constraints given Assumed Condition 1

$V_{CC} = 9V$ $\beta = 100$, $R_S = 50$, $V_{CE} = 4.5$

$I_{CQ} = 1mA$, $R_{TH} \approx 0.1(1+\beta)R_E$ $I_{BQ} = \frac{I_{CQ}}{\beta} = 10\mu A$

Assumed condition 3

Utilize script to build up $R_1, R_2, R_C, R_E, \& R_i$ with $A_V = 27$ (estimated):

$R_1 = 16628.39\Omega$ $R_2 = 1798.31\Omega$ $R_C = 4339.29\Omega$ $R_E = 160.71\Omega$ $R_i = 1494.41$

$A_{V(practical)} = -22.30V$ Practical values

$R_1 = 10K + 6.8K$ $R_2 = 1K + 560 + 220$ $R_C = 3.3K + 1K$ $R_E = 100\Omega$

$R_i = 935.59\Omega$ New Av Gain $= -32.14V$

1st Stage Amplifier $A_{V(exp)} = 21$

R_S-Value Changed to 560

$R_L = 1428.44K$

$R_1 = 20764.49$, $R_2 = 2416.12$, $R_C = 4285.71$

$R_E = 214.29$ $R_i = 1986.90$ $A_{V(actual)} = -17.24$

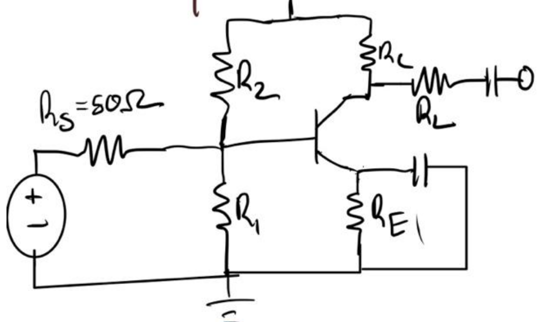
Practical Resistors

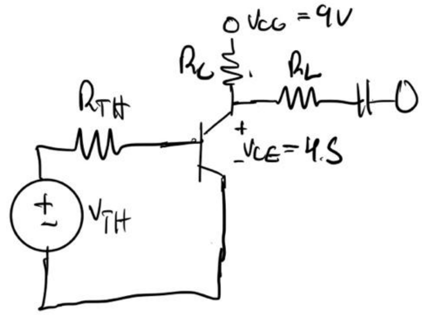
$A_{V_1} \cdot A_{V_2} \cong 512 > 400$

$R_1 \cong 14800 \approx 10K + 4.7K$ $R_C = 3.3 + 1K$

$R_2 = 1500 \approx 1K + 560$

DC Analysis

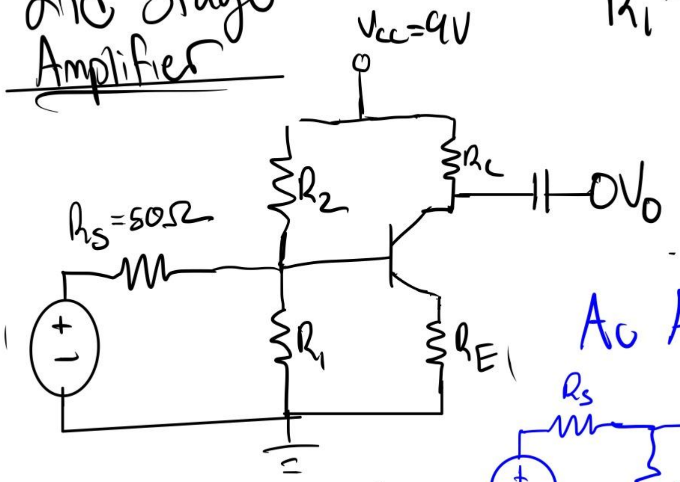




$R_{TH} = \left(\frac{R_1 \| R_2}{R_1 + R_2}\right) = 1.36k\Omega$ $r_\pi = \left(\frac{V_T}{I_{BQ}}\right) = 2600$ $V_{TH} = 0.84375V$

2nd Stage Amplifier

$R_1 = 16{,}800 \quad R_2 = 1780$

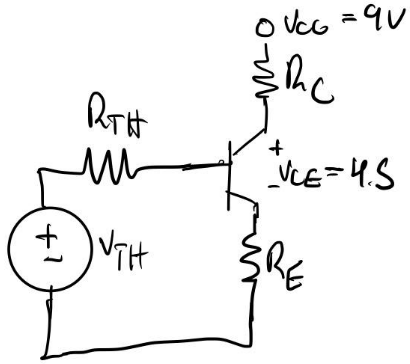


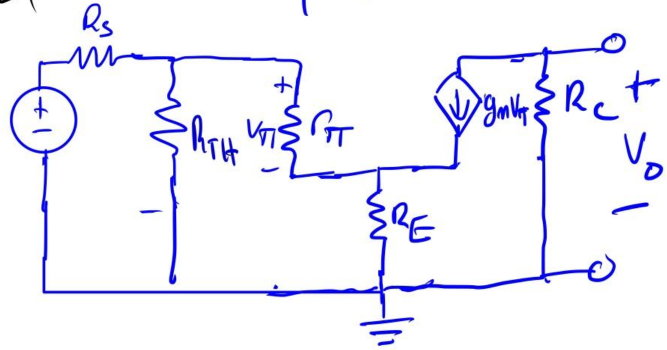
$$V_{TH} = \left(\frac{R_1}{R_1+R_2}\right) V_{CC}$$

$$= \left(\frac{16800}{16800+1780.00}\right) 9 = 0.904$$

AC Analysis

$R_{TH} = R_1 \| R_2 = 16903.47$





$$R_{ib_2} = \frac{V_{in}}{I_b} = \frac{I_b r_\pi + I_e R_E}{i_b} = \frac{I_b r_\pi + (\beta+1) I_b R_E}{I_b}$$

$$= r_\pi + (\beta+1) R_E = 12700\ \Omega$$

$$V_O = -\beta i_b R_C, \quad I_b = \frac{V_{in}}{R_{ib,2}} \qquad R_{i2} = (R_{TH} \| R_{ib_2}) = 1428.44$$

$$V_{in} = \left(\frac{R_{i2}}{R_s + R_{i2}}\right) V_s \qquad A_{V_2} = \frac{V_O}{V_S} = \frac{-\beta \frac{V_{in}}{R_{ib}} R_C}{V_s} = \frac{-\beta\left(\frac{R_{i2}}{R_s+R_{i2}}\right) V_s R_C}{V_s R_{ib_2}}$$

$$A_{V_2} = \left(\frac{-\beta R_C}{R_{ib_2}}\right)\left(\frac{R_{i2}}{R_s + R_{i2}}\right) = -32.713\ V \ \checkmark$$

In our process, we found out that shorting the emitter terminal resistor would result in a higher voltage gain. To short out the resistor, we placed a capacitor in parallel with the resistor, so that in the AC analysis, the resistor got shorted. Considering our total gain, we see that the total gain is over 900. We will continue to evaluate our theory and see if we can improve our designs.