Amplifier Design

احمد حسين عبدالعال علي

- Required Specifications:

Gain	40 db	$= 10^{40/20} \approx 100$
Bandwidth	1M Hz	At $C_L = 1nF$
Power consumption	20μW	At $V_{CC} = 1.5V$

- Since $BW = \frac{1}{2\pi C_{out} R_{out}}$ (Where the dominant pole is the output's)

Assuming direct coupling ($f_o \approx 0$),

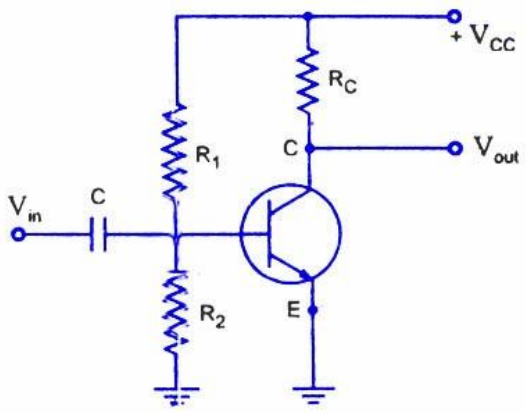
$C_{out} \cong C_L$ or $1.05C_L$ (Taking in consideration C_{BC})

So, $R_{out(MAX)} = \frac{1}{2\pi C_{out} BW} = \frac{1}{2\pi \times 1.05 \times 10^{-9} \times 10^6} = 151.57\ \Omega$

- BW stage:

CE stage with $R_C = R_{out} = 100\ \Omega$ (Leaving margin for the other stages).

- For R_1, R_2:
  $V_{th} = I_B R_{th} + V_{BE}$
  $V_{CC} \times \frac{R_2}{R_1 + R_2} = I_B \times \frac{R_1 R_2}{R_1 + R_2} + V_{BE}$
  And since $I_B = \frac{I_S}{\beta} e^{\frac{V_{BE}}{V_t}}$



- So, for $R_2 = 1000K\Omega, R_1 = 1650K\Omega$ (for min current consumption in this branch).

$$|A_{VBWstage}| = g_m R_C = \frac{I_C}{V_t} R_C = \frac{12.2\times10^{-6}\times100}{0.026} = 0.046923$$

$$|A_{VTotal}| = |A_{Vgainstage}|^n \times |A_{VBWstage}| = 100$$

$|A_{Vgainstage}|^n$ must be = 2131.14

For The Gain Stages:

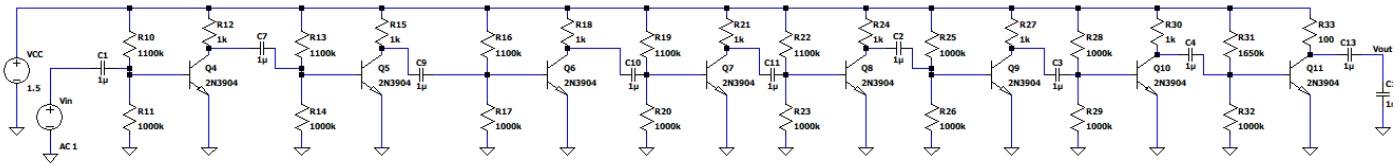
CE Stages for gain:

- First, we need to make sure that the output pole is the dominant so that the gain stages don't affect the BW
- Since C_{in} is based on the transistors parasitic capacitance which is in the pico range (Assuming 50pF)
  so $R_{C(Stages(max))} = \frac{1}{2\pi\times50\times10^{-12}\times10^6} = 3.183K\Omega$
- We'll be using 1.1kΩ and 1kΩ.

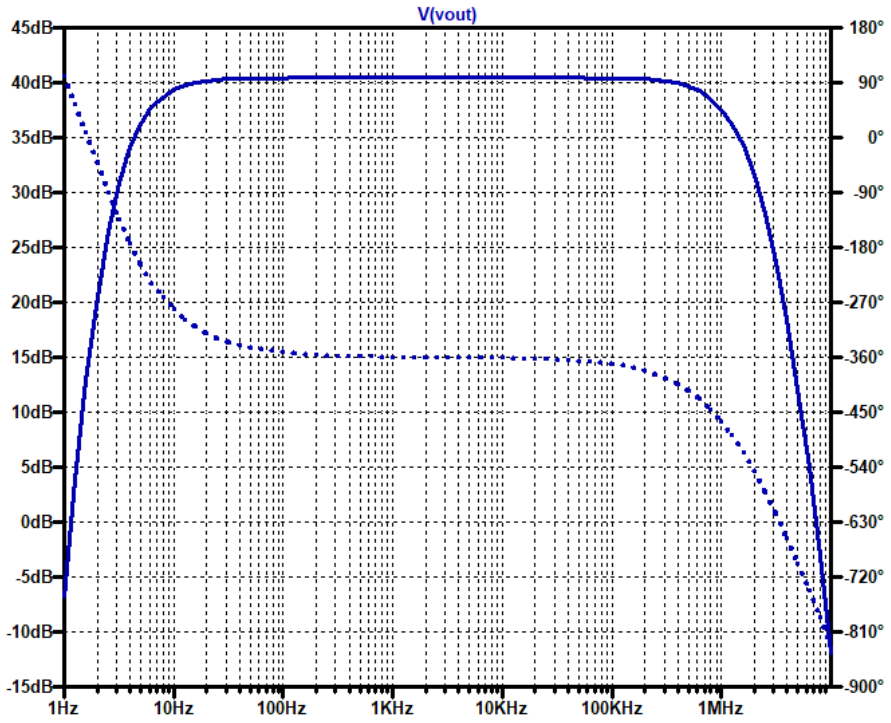
- $|A_{Vgainstage}| = \sqrt[n]{2131.14} = \sqrt[7]{2131.14} \cong 3$ (for 7 stages)
  But $|A_{Vgainstage}| = g_m R_C = g_m \times 1100$ must be 3
  So $g_m = \frac{3}{1100} = 2.727\ mS$, $g_m = \frac{I_C}{V_t} = 2.727 \times 10^{-3}$
  $I_C = 0.026 \times 2.727 \times 10^{-3} = 70.9\mu A$

- By using the same analysis method as before,
  for $R_2 = 1000K\Omega, R_1 = 1100K\Omega$ (for min current consumption in this branch).

Final Circuit:



Simulation Results:



Gain	Bandwidth	Power consumption
40.437 db	1.0429 Mhz	861.15 μW

Results:

Spec	Required	Achieved
Gain	40 db	40.437 db
Bandwidth	1 MHz	1.0429 Mhz
Power consumption	20 μW	861.15 μW