interferences.
Process of using reactive elements to channel the distortion caused by...

18/01/2022

Solution to Test Question

1.) Design Assumptions
↓
Design Equations
↓
Design Calculations
↓
Prototype

(i)
→ The presence of design specifications imply the presence of design assumptions.

Assumption 1

(i) VCE must be $\frac{50}{100}$ Vcc

(a) VCE = 50% of Vcc

* Vcc is the rail voltage.

Assumption 2:
Voltage across the emitter
$V_E = \frac{10}{100} \times V_{cc}$

To obtain amplification,
$V_{RC} = \frac{40}{100} \times V_{cc}$

(ii) the design equation will stem directly from the design assumptions.

(1.) $V_{CE} = 0.5V_{cc}$
(2.) $V_{RC} = 0.4V_{cc}$
(3.) $V_{RE} = 0.1V_{cc}$
(4) $\beta = h_{FE} = \frac{I_C}{I_B}$
(current gain)

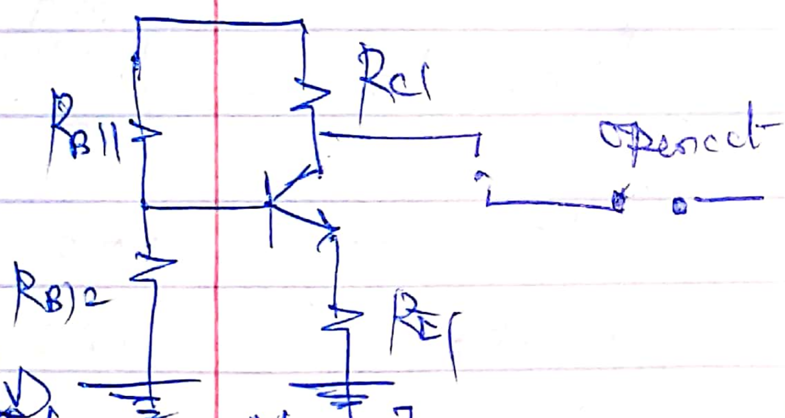
The design equations

* Two kinds of analysis performed:
(i) D/C & AC analysis

* To perform DC analysis, we have to first draw the DC equivalent cct.

→ All capacitors must be open circuited and all inductors must be shorted.

(iii) DC Equivalent Cct:



(iv) $[V_{RE1} = V_{RE2}]$

$[V_{RC1} = V_{RC2}]$

$[V_{CE1} = V_{CE2}]$ → NOTE

∴ From the given questions

$V_{CC} = +12V$

$V_{CE} = \frac{50}{100}(12V) = 6V$

→ Design Calculations

∴ $V_{CE1} = V_{CE2} = 6V$

$V_{RC} = \frac{40}{100}(12) = 4.8V$

∴ $V_{RC1} = V_{RC2} = 4.8V$

$V_{RE} = \frac{10}{100}(12) = 1.2V$

∴ $V_{E1} = V_{E2} = 1.2V$

(v) $\frac{12 - 4.8}{10mA} = R_{C1}$

→ $R_{C1} = \left(\frac{V_C}{I_C}\right) = 720\Omega$

NOTE: Do not assume that $I_C \approx I_E$

$R_E = \frac{V_E}{I_E} = \frac{V_E}{I_B + I_C}$

$\beta = \frac{I_C}{I_B}$

→ $I_B = I_C/\beta$

Given current gain $(\beta) = 100$

$I_B = \frac{10mA}{100} = 0.1mA$

$I_B + I_C = 10 + 0.1 = 10.1mA$

→ $R_E = \frac{V_E}{10.1mA} = \frac{1.2V}{10.1mA}$

$R_E = 0.118k\Omega$

Note: $\left[\begin{array}{l} R_{C1} = R_{C2} \\ R_{E1} = R_{E2} \end{array}\right]$

(vi) $\cancel{I_{B1} = \frac{V_{E1}}{R_{E1}} = I_{B} = \frac{V_{E2}}{R_{E2}}}$

$=$

$I_B = I_e/\beta = I_{B1} = I_{B2}$

$= 0.1mA$

(vii) For silicon transistors,
$V_{BE} = 0.7V$

$V_{RB12} = V_{BE} + V_{RE1}$
$= 0.7 + 1.2$

$V_{RB12} = 1.9V$

$\underline{V_{RB12}} = \underline{V_{RB22}} = \underline{1.9V}$

(viii) I_{RB12} is normally 10 times the base current $(I_B) \to I_{RB12} = 10I_B$

$\to I_{RB12} = I_{RB22} = 10 I_B$
$= 10(0.1mA)$
$= \underline{1mA}$

(ix) $R_{B12} = \frac{V_{RB12}}{I_{RB12}}$

$R_{B22} = \frac{V_{RB22}}{I_{RB22}}$

And $R_{B12} = R_{B22}$

$\to R_{B12} = R_{B22} = \frac{1.9V}{1mA}$

$R_{B12} = R_{B22} = \underline{1.9K\Omega}$

(x) $V_{CC} = V_{RB11} + V_{RB12}$

$\therefore V_{RB11} = V_{CC} - V_{RB12}$

$\therefore V_{RB11} = 12 - 1.9$

$V_{RB11} = \underline{10.1V}$

And $\underline{V_{RB11}} = \underline{V_{RB21}} = \underline{10.1V}$

(xi) $I_{RB11} = I_B + I_{RB12}$
$= 0.1 + 1$

$\underline{I_{RB11}} = \underline{1.1mA} = \underline{I_{RB21}}$

(xii) $R_{B11} = \frac{V_{RB11}}{I_{RB11}} = R_{B21}$

$R_{B11} = R_{B21} = \frac{10.1V}{1.1mA}$

$= 9.18k\Omega$

→ Marks the end of the DC Analysis.

Onto the AC Analysis ↓

(xiii) To draw the AC equivalent cct:

→ For AC equivalent cct,

Capacitor → short cct

Inductor — open cct

→ The AC equivalent cct will helps to calculate the value of ~~the capacitor~~ too.

C_{IN1} → i/p coupling for 1st stage

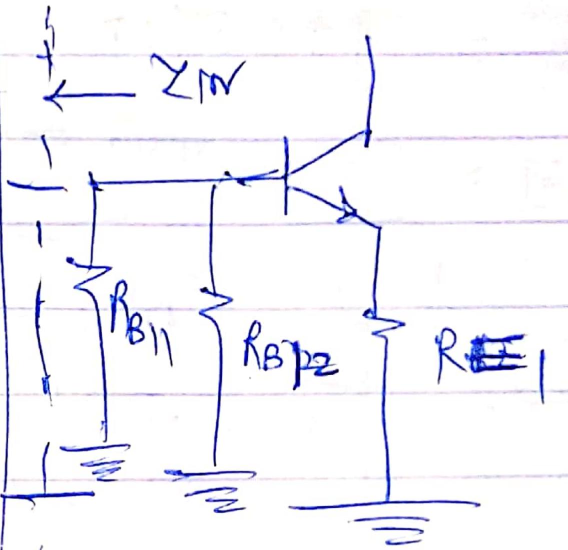
C_{IN2} → i/p coupling for 2nd stage

C_{E1}, C_{E2} } By-pass capacitors

C_{OUT} → o/p coupling capacitor

$[C_{IN1} = C_{IN2}]$

∴ Draw AC equivalent cct:



$Z_{IN} = (R_{B11} \| R_{B12} \| \underbrace{R_{BE}}_{\beta r_e})$

(xiv) $C_{E1} = \frac{1}{2\pi f_{3dB} X_C}$

→ X_C is usually not given; so, assumption works:

$[X_C \approx \frac{1}{10} R_E]$

And recall $R_E = 0.118k\Omega$

$X_C \approx \frac{1}{10}(0.118k\Omega)$

$X_C = 11.8\Omega$

→ f used is frequency at 3dB = 30MHz

$C_{E1} = \dfrac{1}{2\pi(30mHz)(11.8)}$

$C_{E1} = 449.59pF$

$\underline{C_{E1}} = \underline{C_{E2}} = \underline{449.59pF}$

To calculate C_{IN}, we obtain the input impedance of the ckt:

$$C_{IN} = \frac{1}{2\pi f_{3dB} Z_{IN}}$$

Z_{IN}: input impedance as seen by the source (which is the signal generator).

$Z_{IN} = (R_{B11} \parallel R_{B12} \parallel R_{EE}) \times \beta r_e$

βr_e:

r_e — base-emitter internal resistance

$[r_e = 25mV / I_E]$ or $\dfrac{26mV}{I_E}$

$\rightarrow r_e = \dfrac{25mV}{10.1mA}$

$r_e = \underline{2.4752\Omega}$

$Z_{IN} = 247.52 \times (R_{B11} \parallel R_{B12} \parallel R_E)$

$\rightarrow Z_{IN} = \underline{27.1708k\Omega}$

$\underline{C_{IN1}} = \dfrac{1}{2\pi(30mHz)(27.1708k\Omega)}$

$= 0.1953nF = \underline{C_{IN2}}$

$C_{OUT} = \dfrac{1}{2\pi f_{3dB} Z_{OUT}}$

And $Z_{OUT} = R_C = \underline{720\Omega}$

$C_{OUT} = \dfrac{1}{2\pi f_{3dB} R_C}$

$C_{OUT} = \underline{7.37pF}$

These values can then be taken to Proteus and simulated, and then

~~further~~ Built on a breadboard — and then on a PCB.

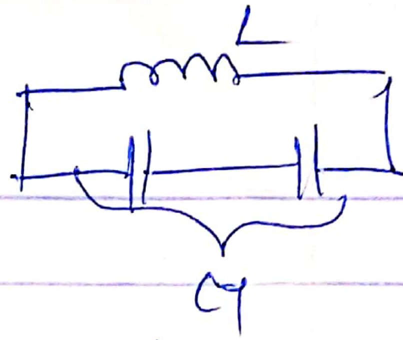
(xv) The estimated frequency response is simply the amplifier frequency response (or Bode plot) diagram.

(xvi) Simply comment on the efficiency of the class A amplifier (Eff = 50%)

(xvii) A oscillator is an amplifier with a feedback loop.

→ Take the Colpitts oscillator feedback path and connect it to the input of the 2nd stage.

(xviii) $C_T = 12nF$
$f = 90MHz$. Calc. L.



Colpitts LC tank

$$f = \frac{1}{2\pi\sqrt{LC_T}}$$

$$\rightarrow 2\pi f = \frac{1}{\sqrt{LC_T}}$$

$$\left(\frac{1}{2\pi f}\right)^2 = LC_T$$

$$\text{or } L = \frac{1}{C_T}\left(\frac{1}{2\pi f}\right)^2$$

$$\underline{L = 0.2606nH}$$

(xix) A response having an exponential plot upwards and downwards.

(xx) The frequency will fit very perfectly. b/c ...?

<u>Next Class</u>: The remaining questions will be treated