AE_Lecture5_PartA_Low FrequencyAnalysisofCE_Amplifier*

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Abstract

AE_Lecture5_PartA describes the short Circuit Time Constant Method of determining the lower -3dB frequency of RC coupled CE Amplifier.

AnalogElectronics_Lecture5_PartA_Low Frequency Analysis of CE Amplifier(Final)

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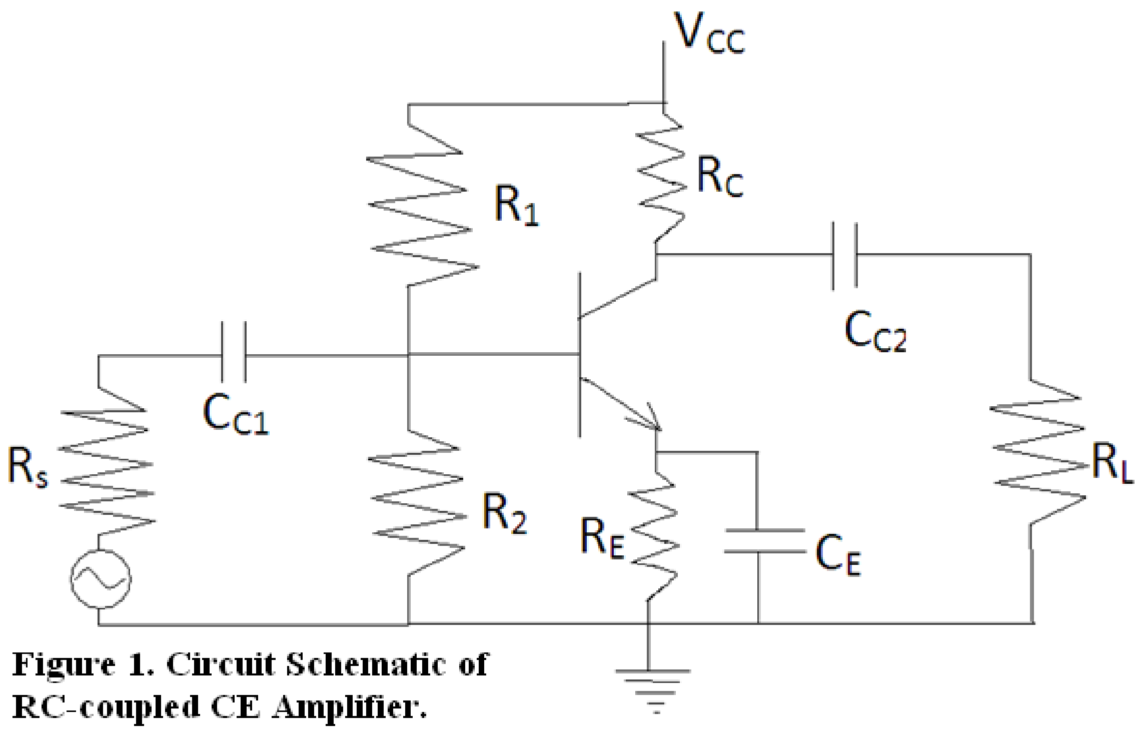

Figure 1. Circuit Schematic of RC-coupled CE Amplifier.

Figure 1

Figure 1. RC-coupled CE Amplifier.

Lower -3dB frequency of CE Amplifier is determined by Short Circuit Time Constant Method.

Coupling Capacitors and Emitter By-pass capacitor are responsible for lower -3dB frequency(f_L).

We consider the time constant associated with each capacitor with the remaining capacitors shorted. Suppose the time constants associated with C_{C1}, C_{C2} and C_E are τ_{1S} , τ_{2S} and τ_{3S} . Then the overall time constant associated with the amplifier due to combined effect of C_{C1}, C_{C2} and C_E is τ_L where:

$$\frac{1}{\tau L} \triangleq \frac{1}{\tau 1s} + \frac{1}{\tau 2s} + \frac{1}{\tau 3s} = 2\pi f_L = \omega_L$$

Figure 2

Here Time Constant associated with each capacitor is τ = RC where R is the equivalent resistance seen by each Capacitor.

$$R_s = 5k\Omega, R_B = R_1||R_2 = 10k\Omega, R_C = 2k\Omega$$

$$r_x = 100\Omega, r_\pi = 0.4k\Omega, g_m = \frac{I_C}{V_T} = 100mmho$$

Figure 3

$$I_C = 2.5mA, R_E = 0.4k\Omega, \beta_{fo} = 40$$

Figure 4

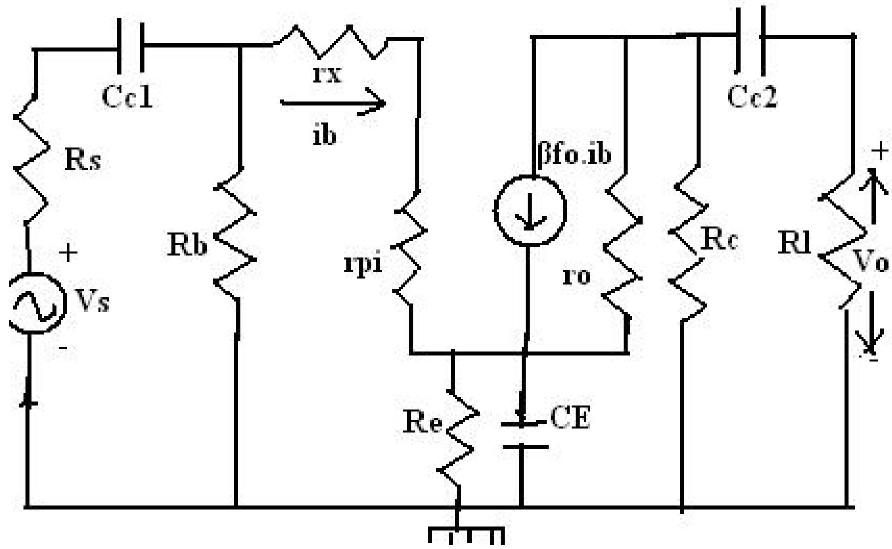

Figure 2. The incremental model of RC-coupled CE Amplifier. Battery Vcc has been shorted and BJT has been replaced by Hybrid-pi Model.

Figure 5

Figure 2. Low Frequency Incremental model

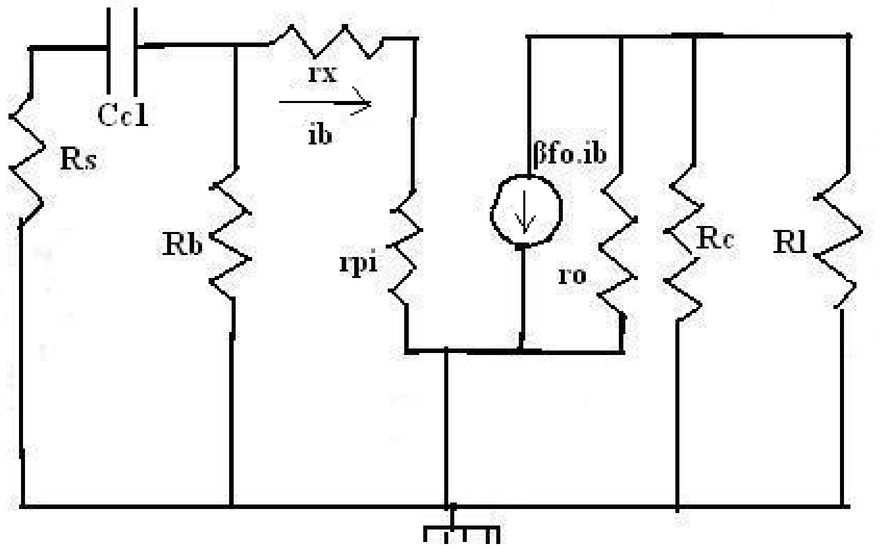

Figure 3. Calculation of Short Circuit Resistance as seen by Cc1.

Figure 6

Figure 3. Low frequency Incremental Model with C_E and Cc2 shorted. Equivalent resistance seen by Cc1 is $R_S + (R_B||(r_x+r_\pi))$

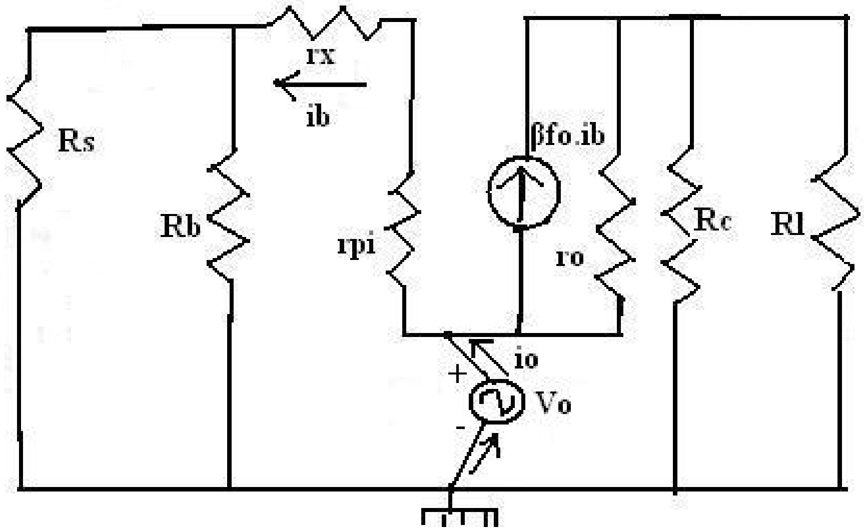

Figure 4. Equivalent circuit for measuring the short circuit resistance as seen by Ce

Figure 7

Figure 4. Incremental Model with Cc1 and Cc2 shorted. Ce sees the equivalent Resistance $R_{2s}= v_o/i_o$
In Figure 4 , a voltage source v_o is connected in place of C_E .
Current drawn from the source is : $i_o= i_b + \beta_{fo}.\ i_b$
where $i_b = v_o/(r_\pi + r_x + R_B||R_S)$ therefore $i_o = i_b(1 + \beta_{fo}) = (1 + \beta_{fo}).v_o/(r_\pi + r_x + R_B||R_S)$;
Therefore $v_o/\ i_o = (r_\pi + r_x + R_B||R_S)/\ (1 + \beta_{fo}) = R_{2s}$;

$$R_{1s} = R_s + R_B||(r_x + r_\pi) = 5.48k\Omega$$

$$R_{2s} = R_E||\left[\frac{r_x + r_\pi + R_S||R_B}{\beta_{fo} + 1}\right] = 0.0758k\Omega$$

$$C_{C1} and C_E \ are\ both\ present. C_{C2} = \infty$$

Overall -3dB frequency will be:

$$\omega_l = \frac{1}{\tau_L} = \frac{1}{\tau_{1s}} + \frac{1}{\tau_{2s}}$$

For equal poles:-

$$1.15\omega_l = \frac{1}{\tau_{1s}} + \frac{1}{\tau_{2s}}$$

Figure 8

If $f_l = 30Hz; \omega_l = 188.5\frac{rad}{sec} = 0.1885(msec)^{-1}$

$$\therefore 0.217(msec)^{-1} = \frac{1}{5.48C_C} + \frac{1}{0.0758C_E}$$

$$C_C = 1.68\mu F, C_E = 122\mu F$$

From first principles:

(i.e. detailed circuit analysis)

$$A_V(j\omega) = \frac{-A_{vo}(j\omega)(j\omega + \omega_z)}{(j\omega + \omega_{p1})(j\omega + \omega_{p2})}$$

At $\omega \gg \omega_{p1}, \omega_{p2}, \omega_z,$

Figure 9

$$A_V(j\omega) = \frac{-A_{vo}(j\omega)(j\omega)}{(j\omega)(j\omega)} = -A_{vo}$$

Figure 10

By detailed analysis,

$$\frac{1}{\tau L} \triangleq \frac{1}{\tau 1s} + \frac{1}{\tau 2s} + \frac{1}{\tau 3s} = 2\pi f_L = \omega_L$$

Figure 11

Here there are two poles corresponding to two capacitors C_{C1} and C_E . The second coupling capacitor is considered to be infinity. The highest pole decides lower -3dB frequency. So 0.188Krads/sec decides the lower -3dB frequency which comes out to be 30Hz.