Experiment #13 Frequency response of BJTs

Objective.

To study and analyze the frequency response of BJTs.

Equipment

IT-2012 Trainer
DMM
Dc supply
Oscilloscope with probes
Function generator with probes

Theory

The frequency response of an amplifier is the change in gain or phase shift over a specified range of input signal frequencies.

There are two kinds of frequency response.

1. Low frequency response
2. High frequency response

13.1 Low frequency response

The voltage gain and phase shift of capacitively coupled amplifier are affected when the signal frequency of below a critical value at low frequencies, the reactance of coupling capacitor and bypass capacitors becomes significant resulting in reduction in voltage gain and increase in phase shift. This response is given by Input RC circuit output RC circuit and bypass RC circuit for the circuit shown in figure 13.1. The lower critical frequency due to input RC circuit is

$$f_c = \frac{1}{2\pi(R_S + R_{in})C_1} \qquad (13.1)$$

Where,

$$\theta = \tan^{-1}\frac{X_{C1}}{R_{in}} \qquad (13.2)$$

Where $R_{in} = R_1 \parallel R_2 \parallel \beta r_e{}'$ and C1 is input coupling capacitor.

The lower critical frequency due to output RC circuit is`

$$f_c = \frac{1}{2\pi(R_C+R_L)C_3} \qquad (13.3)$$

$$\theta = \tan^{-1}\frac{X_{c3}}{R_C+R_L} \qquad (13.4)$$

Where Re is collector resistance and C3 is output coupling capacitor.

The lower frequency response due to bypass RC circuit is

$$f_c = \frac{1}{2\pi[(r_{e'}{}^{R_{th}}/_{\beta_{ac}}) \| R_E]C_2} \qquad (13.5)$$

Where $R_{th=}R_1 \parallel R_2 \parallel R_s$ and C2 is bypass capacitor.

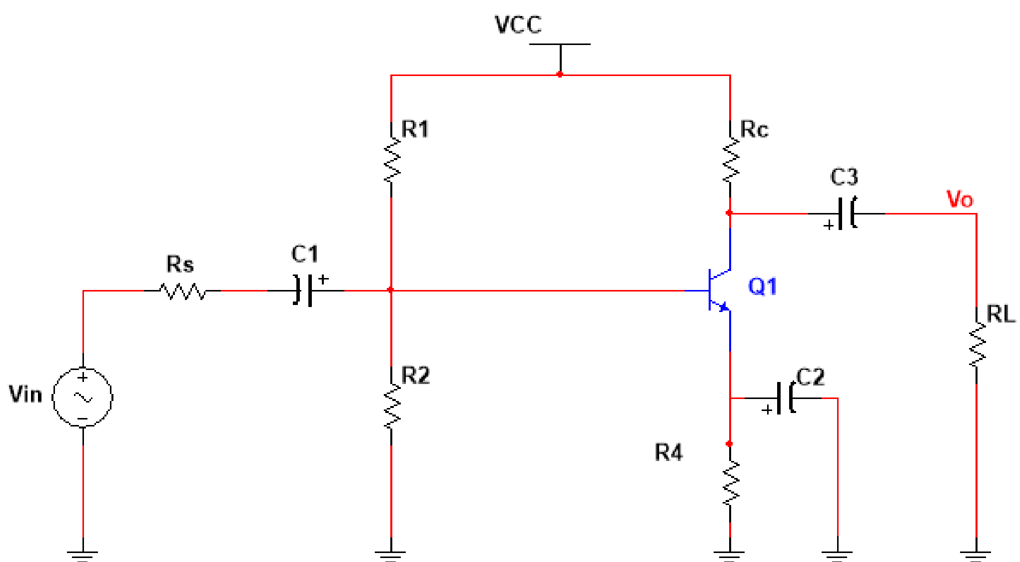

Figure 13.1: Common Emitter Amplifier

13.2 High frequency response

The voltage gain and phase shift of BJT amplifier is affected when signal frequency is above fc. At high frequencies the transistors internal capacitors begin to have significant effect on gain. The effect of these internal capacitors is negligible at lower frequencies.

Miller's theorem

By applying Miller's theorem to Inverting amplifier and using mid-range gain we have a circuit that can be analyzed for high frequency response.

Miller input capacitance

$$C_{in(miller)} = C_{bc}(A_v + 1) \qquad (13.6)$$

Miller output capacitance

$$C_{out(miller)} = C_{bc}\frac{A_v+1}{A_v} \qquad (13.7)$$

The upper critical frequency due to Input RC circuit is

$$f_{cu} = \frac{1}{2\pi(R_s \| R_1 \| R_2 \| \beta_{ac} r_e')C_{in(tot)}} \qquad (13.8)$$

$$\theta = \tan^{-1}\frac{R_s \| R_1 \| R_2 \| \beta_{ac} r_e')}{X_{c(tot)}} \qquad (13.9)$$

The upper critical frequency due to output RC circuit is given as

$$f_{cu} = \frac{1}{2\pi(RC)C_{out(miller)}} \qquad (13.10)$$

$$\theta = \tan^{-1}\frac{R_C \| R_L}{X_{out(miller)}} \qquad (13.11)$$

Where$R_C = R_C \parallel R_L$, and θ is the phase shift.

Circuit Diagram

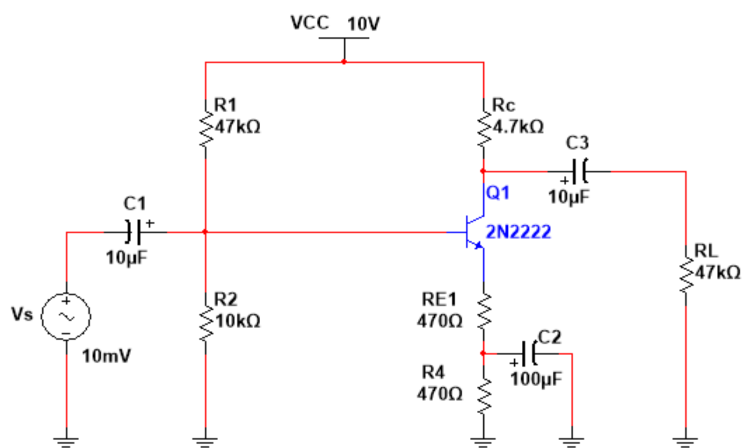

Figure 13.2: Frequency Response of Common Emitter Amplifier

Procedure

1. Collect the components required for the experiment.
2. Insert 2N2222 transistor in the breadboard and construct circuit according to given circuit diagram.

3. Perform DC and AC analysis as done in experiment#1.
4. Calculate the lower cutoff and higher cutoff frequencies.
5. Apply AC signal of different frequencies and find the gain.
6. Record the values in the table.
7. Observe the effect of frequencies on the gain.

Observations

f(Hz)												
A_V												

Lab Task

1. Analyse the frequency response of given BJT amplifier and Draw Bode plot for the Figure 13.3.
2. Calculate lower and upper critical frequency.

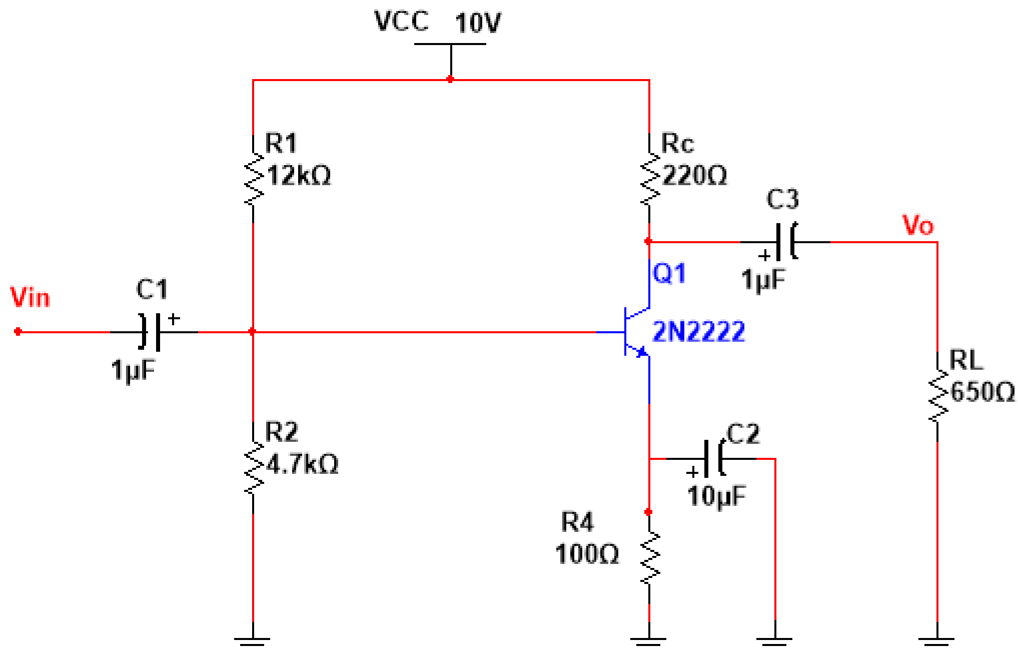

Figure 13.3: Frequency Response of Common Emitter Amplifier

Conclusion

____

____

____