Experiments #5

Frequency Response of JFET

1) Objectives:

To study the frequency response and bandwidth of the common source JFET amplifiers and know we can design an amplifier with specification cutoff frequencies.

2) Introduction:

As we studied in the previous experiment the frequency is a graphical representation that describe the relationship between the voltage gain and varying frequency.

And we studied also the response of the amplifier systems to sinusoidal input signal have the same frequency but different amplitude and phase.

The figure shown below describe the general frequency response of an amplifier systems.

![Frequency Response Curve of an Amplifier](image)

Figure 5.1: Frequency response of amplifier

Now, we will not repeat the same words but we will direct discuss the AC-analysis of JFET amplifier.
3) AC-analysis:

In this analysis we will study the effect of capacitors in different level of frequencies as:

- Low frequency response.
- High frequency response.

In the figure 5.2 shown the JFET amplifier circuit diagram and describe the location of low cutoff frequency \( (C_G, C_D, C_S) \)

![Figure 5.2: The effective capacitors in low cutoff frequency response](image)

In the figure 5.3 shown the JFET amplifier circuit diagram and describe the location of virtual capacitors which appear in high frequency and have small value in \( pF \).

![Figure 5.3: The effective capacitors in high cutoff frequency response](image)
1- The Low cutoff frequency of JFET amplifier:

In the low frequency region the effective capacitors are \((C_G, C_D, C_S)\) which start as open circuit and goes to be short circuit at low cutoff frequency \(f_L\) which can be determine by the following expression

\[
f_L = \text{MAX}(f_{LCG}, f_{LCD}, f_{LCS})
\]

Where the low cutoff frequency \(f_{LCG}\) is determined by \(C_G\) is given by the relation:

\[
f_{LG} = \frac{1}{2\pi(R_{sig} + R_i)C_G}
\]

Where: \(R_i = R_G\)

And the low cutoff frequency \(f_{LCD}\) is determined by \(C_D\) is given by the relation:

\[
f_{LD} = \frac{1}{2\pi(R_o + R_L)C_D}
\]

Where: \(R_o = R_D\)

And the low cutoff frequency \(f_{LCS}\) is determined by \(C_S\) is given by the relation:

\[
f_{LS} = \frac{1}{2\pi R_{eq}C_S}
\]

Where: \(R_{eq} = R_S/(\frac{1}{g_m})\)

2- The high cutoff frequency of JFET amplitude:

In this region will be appear the effect of virtual capacitors which called parasitic effect \((C_{wi}, C_{wo}, C_{ds}, C_{gd}, C_{gs})\), and its value in Nano-farad.

These capacitors at very high frequency will be short circuit and it reactance equal zero, and the voltage gain goes to zero.

In this region all practical capacitors are short circuit also.
For the input circuit the high cutoff frequency is determined by the relation:

$$f_{Hi} = \frac{1}{2\pi R_{thi} * C_i}$$

**Where:**

$$R_{thi} = R_{slg} / / R_G \quad & \quad C_i = C_{wi} + C_{gs} + C_{mi} \quad & \quad C_{mi} = (1 - Av)C_{gd}$$

For the output circuit the high cutoff frequency is determined by the relation:

$$f_{Ho} = \frac{1}{2\pi R_{tho} * C_o}$$

**Where:**

$$R_{tho} = R_D / / R_L / / r_d \quad & \quad C_o = C_{wo} + C_{ds} + C_{mo} \quad & \quad C_{mi} = (1 - Av)C_{gd}$$

4) Lab work:

![Circuit Diagram](image)

Figure 5.4: The simple circuit diagram of common source JFET amplifier
Procedure:

1- Connect the circuit in figure 5.4
2- Adjust the DC power supply at 20V.
3- Adjust the function generator to sinusoidal of amplitude \( V_p = 1V \) at frequency \( 1KHz \).
4- Measure the output voltage \( v_o \).
5- Calculate the value of \( v'_o = 0.707v_o \).
6- Decrease the frequency until the output voltage value match the calculated value of \( v'_o \) to find \( f_L \).
7- Increase the frequency until the output voltage value match the calculated value of \( v'_o \) to find \( f_H \).
8- Now, calculate the bandwidth (BW) which equal \( BW = f_H - f_L \)
9- Varying the frequency according to table and measure the input and output RMS value.
10- After that plot the relationship between voltage gain and frequency.

<table>
<thead>
<tr>
<th>Frequency Hz</th>
<th>Vin (RMS)</th>
<th>Vo (RMS)</th>
<th>( Av = \frac{Vo}{Vi} )</th>
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<tr>
<td>5M</td>
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</tbody>
</table>

Exercises:

- Calculate the cutoff frequencies using equations mathematically
- Repeat all steps using Orcad