Report of Lab 4: BJT Responses Using OrCAD

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1 Lab 1st Circuit

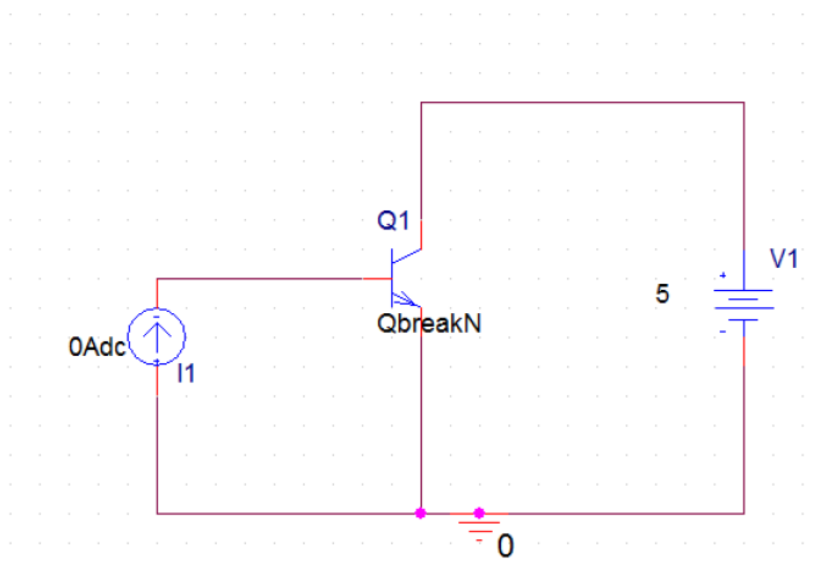


Figure 1: 1st Circuit Schematic

1.1 I_s Change

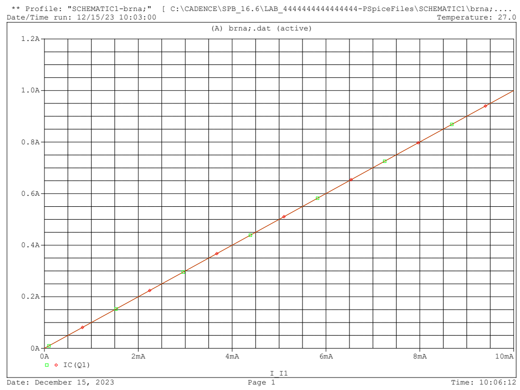
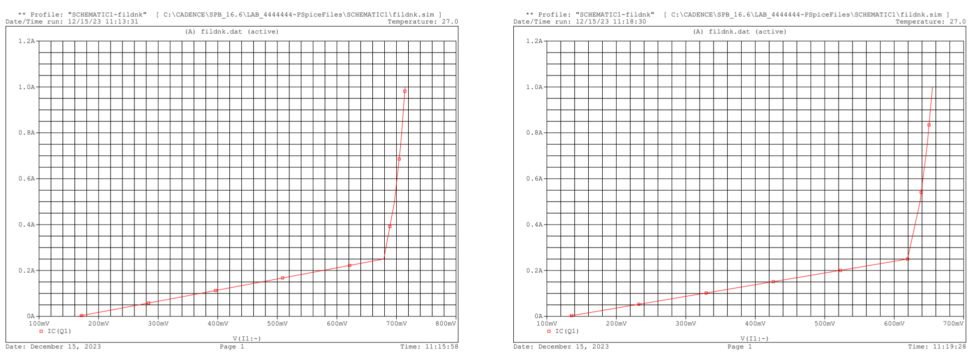


Figure 2: $I_{s1} = 1pA, \quad I_{s2} = 10pA$

1.1.1 Discussion

The reason the curves look similar is because the collector current I_C is linked to the input (base) current I_B through β. It is expressed as $I_C = \beta I_B$. Interestingly, this connection doesn't depend on I_S, and the slope of the curve shows us the value of β.



(a) $I_{s1} = 1pA$

(b) $I_{s2} = 10pA$

Figure 3: Plot $V(I_1)$ on X-axis

1.1.2 Discussion

When we increase the parameter I_S, there's a noticeable drop in the on-voltage. This is shown by the relationship:

$$V_{BE} = V_T \ln\left(\frac{I_C}{I_S} + 1\right), \quad I_C = \beta I_B$$

The slope of the curve is described by:

$$I_C = I_S\, e^{\frac{V_{BE}}{V_T}}, \quad \frac{\mathrm{d}I_C}{\mathrm{d}V_{BE}} = I_S\, e^{\frac{V_{BE}}{V_T}} \frac{1}{V_T}$$

Here, the term $\frac{I_C}{V_T}$, which we call g_m, represents the transconductance.

1.2 β and I_s Change

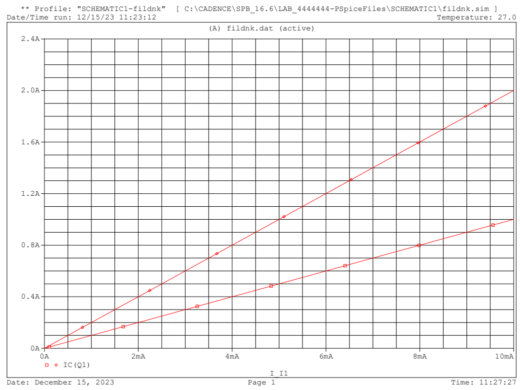
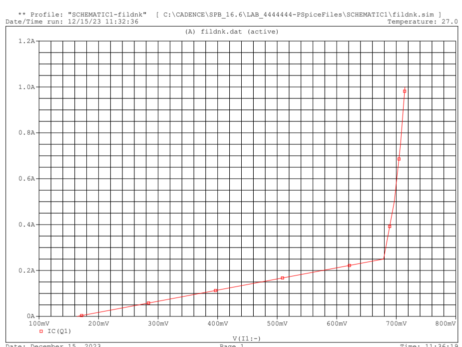


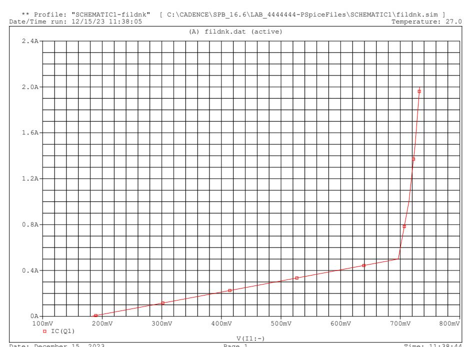
Figure 4: $\beta = 100, \quad \beta = 200$

1.2.1 Discussion

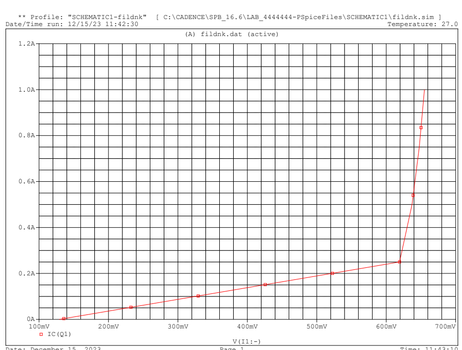
The reason the two graphs are different is because the collector current I_C relies on the parameter β, as we discussed in the equation $I_C = \beta I_B$. When we raise the value of the current gain β, it leads to a proportional rise in both collector current and slope.



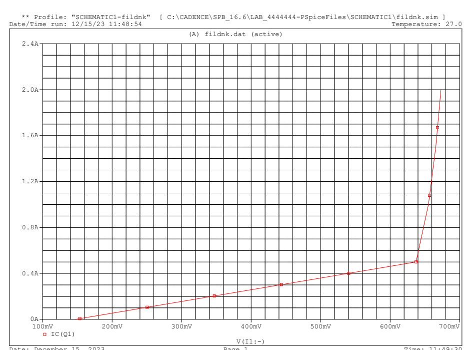
(a) $I_{s1} = 1pA, \quad \beta = 100,$



(b) $I_{s2} = 1pA, \quad \beta = 200$



(c) $I_{s2} = 10pA, \quad \beta = 100$



(d) $I_{s2} = 10pA, \quad \beta = 200$

Figure 5: Plot $V(I_1)$ on X-axis

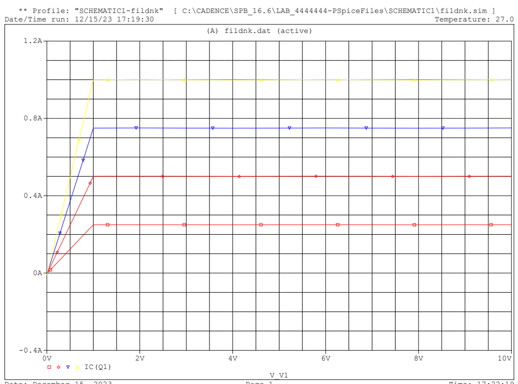
1.2.2 Discussion

Looking at this simulation helps us understand how the parameters I_S and β affect the on-voltage (V_{on}). When we increase the current gain β, V_{on} also increases proportionally. This is shown by the equation:

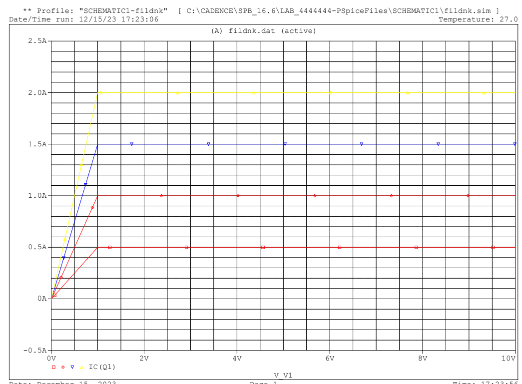
$$V_{BE} = V_T \ln\left(\frac{\beta I_B}{I_S} + 1\right)$$

On the other hand, if we raise the value of I_S, V_{on} decreases following the same relationship.

1.3 β Change



(a) $\beta = 100$



(b) $\beta = 200$

Figure 6: I and V Change Plots

1.3.1 Discussion

When we increase the parameter β, there's a clear rise in the saturation current I_C for each base current I_B. This is explained by the equation:

$$I_C = \beta I_B$$

2 Lab 2^{nd} Circuit

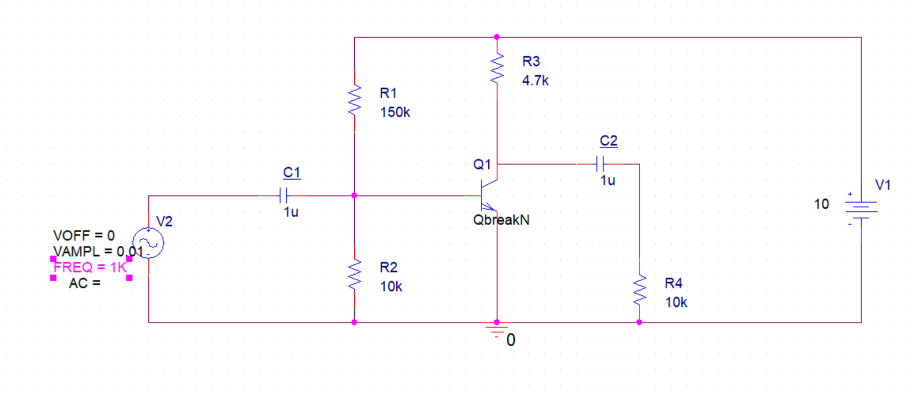
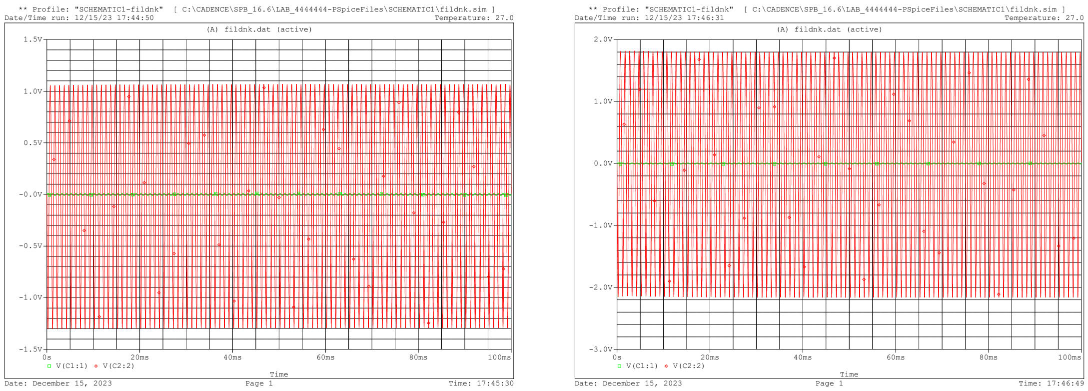


Figure 7: 2^{nd} Circuit Schematic

2.1 V_i vs V_o



(a) $\beta = 100$

(b) $\beta = 200$

Figure 8: Plot V_i and V_o

2.1.1 Discussion

Increasing the parameter β is linked to a noticeable increase in the output voltage relative to the input voltage. This relationship is measured by the voltage gain (A_v), defined as:

$$A_v = -\beta \frac{R_L}{r_e}$$

2.2 Gain due to the change in V_A

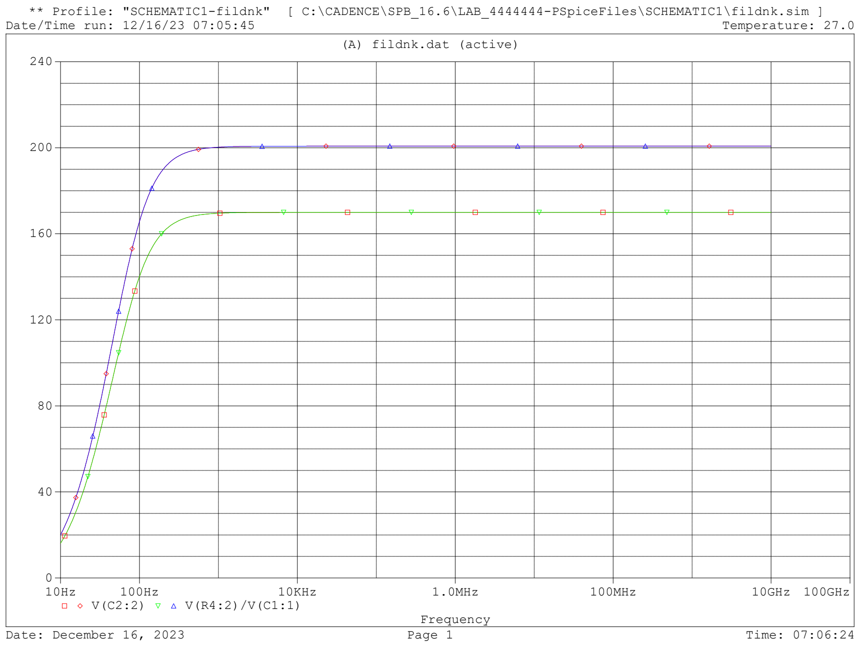


Figure 9

2.2.1 Discussion

Taking into account the impact of the Early voltage brings in the effect of the output resistance, defined as:

$$r_o = \frac{V_A}{I_C}$$

As a result, the voltage gain A_v follows the relationship:

$$A_v = -\frac{R_B \mid\mid r_o}{r_e}$$

Increasing the Early voltage raises the voltage gain A_v, and as the frequency increases, capacitor impedance decreases according to:

$$X_C = \frac{1}{C}$$

This leads to a rise in output voltage and, consequently, an increase in voltage gain.

2.3 Filter using BJT

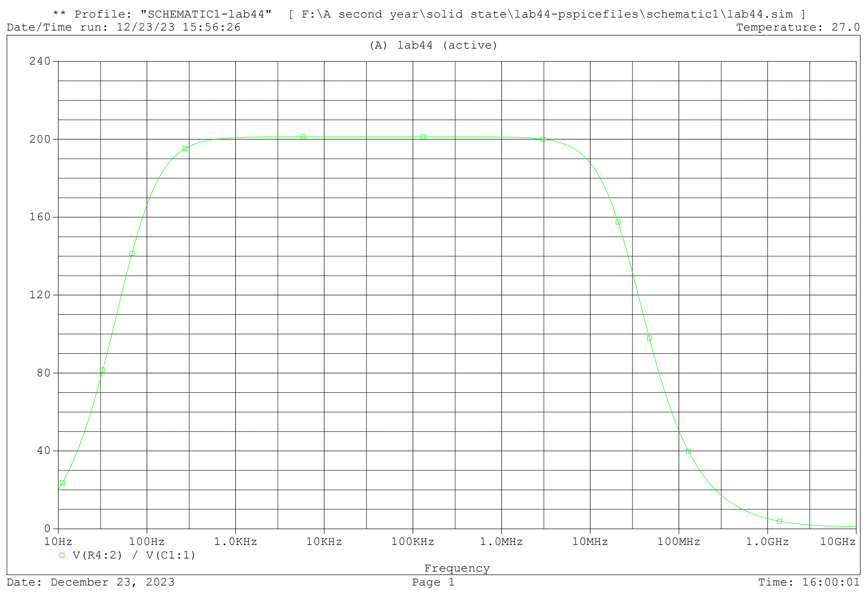


Figure 10

2.3.1 Discussion

Attaining the highest voltage gain at low frequencies takes more time due to the influence of additional junction voltage and parasitic capacitance.

The amplifier circuit reaches its maximum voltage gain at medium frequencies, where effects of capacitance, like coupling capacitors short circuiting, become minimal.

As the cut-off frequencies of the RC circuits, formed by the junction capacitance, come into play, the voltage gain begins to decrease at high frequencies.

By utilizing the effects of junction capacitance, this circuit serves a dual purpose: amplifying the input voltage and functioning as a band-pass filter.