EEO352 Lab 8
Bipolar Junction Transistors (BJTs)

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Copy of Original Assignment

EEO 352 Fall 2023 - Assignment 8 – Bipolar Junction Transistors (BJTs)

Please document each step with snapshots of the built circuit, plots, pictures and your observations. Please include this page.

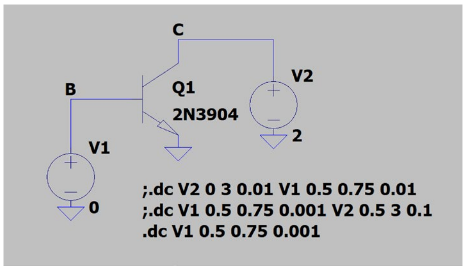

Fig.1

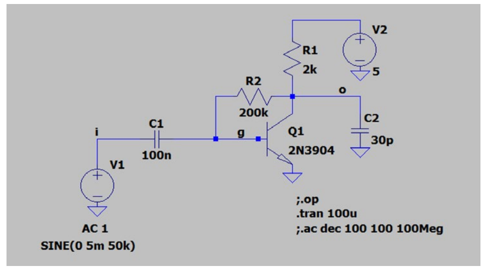

Fig.2

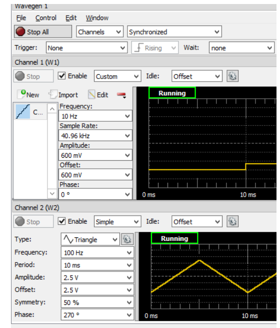

Fig.3

1) Using the npn BJT 2N3904 (pick from npn) as in Fig1 simulate and plot the following (**25pts**):

a) Collector current Ic vs Vce (range 0V to 3V) with parametric Vbe (0.5V to 0.75V, 10mV steps)

b) Collector current Ic vs Vbe (range 0.5V to 0.75V) with parametric Vce (0.5V to 3V in 100mV steps)

c) Collector current Ic vs Vbe (range 0.5V to 0.75V) at Vce=2V, and extrapolate the Vbe at Ic=1mA

d) Derivative (d(.)) of the collector current Ic vs Vbe (range 0.5V to 0.75V) at Vce=2V, and extrapolate the transconductance at Ic=1mA

e) Current gain Ic/Ib vs Vbe (range 0.5V to 0.75V) at Vce=2V, and extrapolate the gain at Ic=1mA

2) Using the npn BJT 2N3904, one 2kΩ resistor at the collector, and one 200kΩ to bias the base, build the amplifier in Fig.2 and simulate and plot the following (**25pts**):

a) Response to 50kHz 5mV sinusoidal signal (plot in separate panes) and extrapolate the gain

b) Frequency response, extrapolating the gain and -3dB bandwidth without and with a 30pF load

3) Using the npn BJT 2N3904, one 100Ω resistor at the collector and one 10kΩ resistor at the base (between the base and the applied voltage), build and plot (**75pts**):

a) Collector current Ic vs Vce (range 0V to 3V) with parametric Vbe (see example in Fig.3)

b) Collector current Ic vs Vbe (range 0.5 to 0.75V) for Vce>2V, and extract the Vbe and the gm at Ic=1mA

c) Gain Ic/Ib vs Collector current Ic (setting as in (b)) and extract the gain at Ic=1mA

Hint1: for (b) use W1 Triangle Amp=0.3V, Off=0.9V at the 10kΩ

Hint2: for (c) use connect C2 across the 10kΩ and add Math Ic/Ib

4) Build and measure the amplifier in Fig.2 and plot the following (**75pts**):

a) Response to 50kHz 5mV sinusoidal signal and extract the gain

b) Frequency response, extracting the gain and the -3dB bandwidth

Hint1: for (b) use the minimum signal amplitude

Summary

In this lab we ...

1 Simulate and Measure Circuit 1

a)

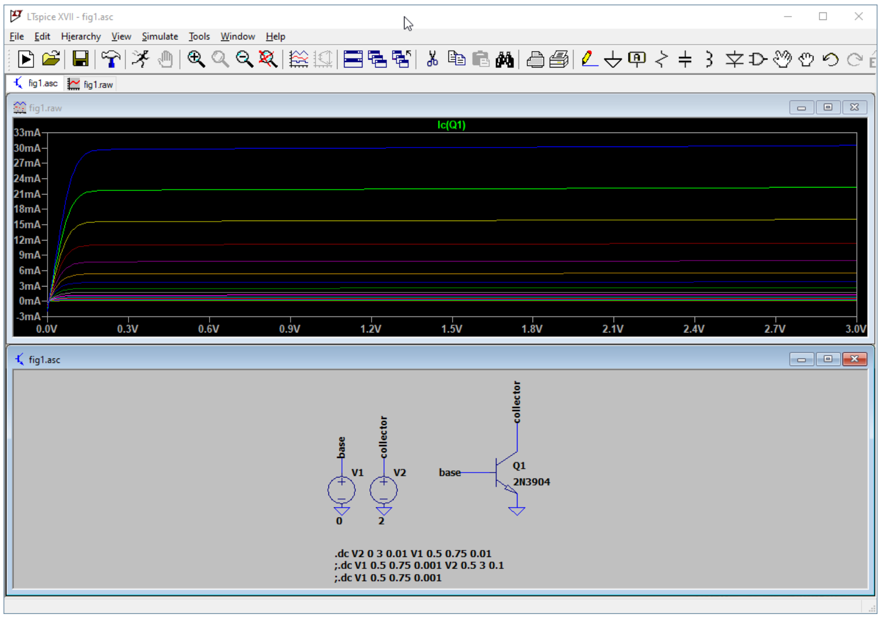

Figure 1: Collector current Ic vs Vce (range 0V to 3V) with parametric Vbe (0.5V to 0.75V, 10mV steps)

b)

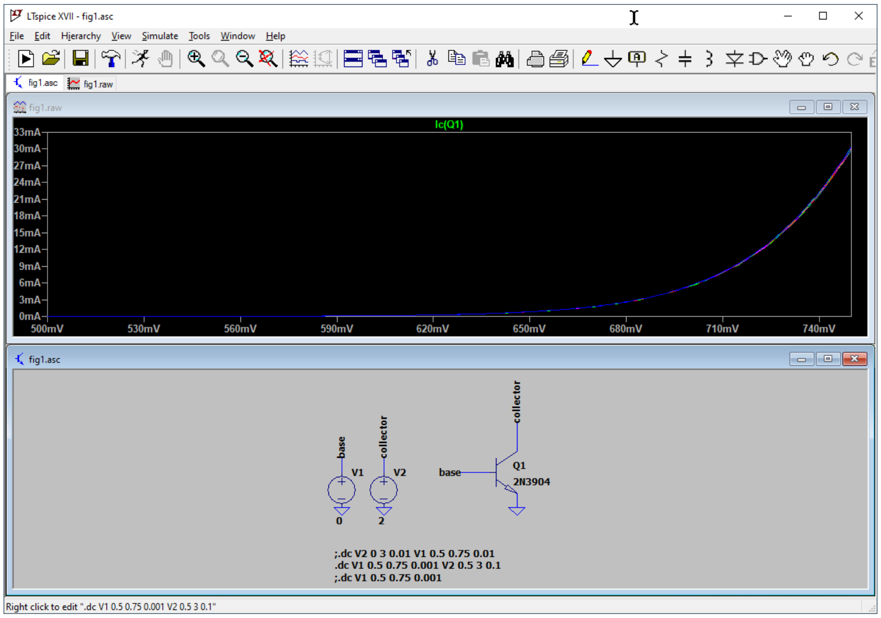

Figure 2: Collector current Ic vs Vbe (range 0.5V to 0.75V) with parametric Vce (0.5V to 3V in 100mV steps)

c)

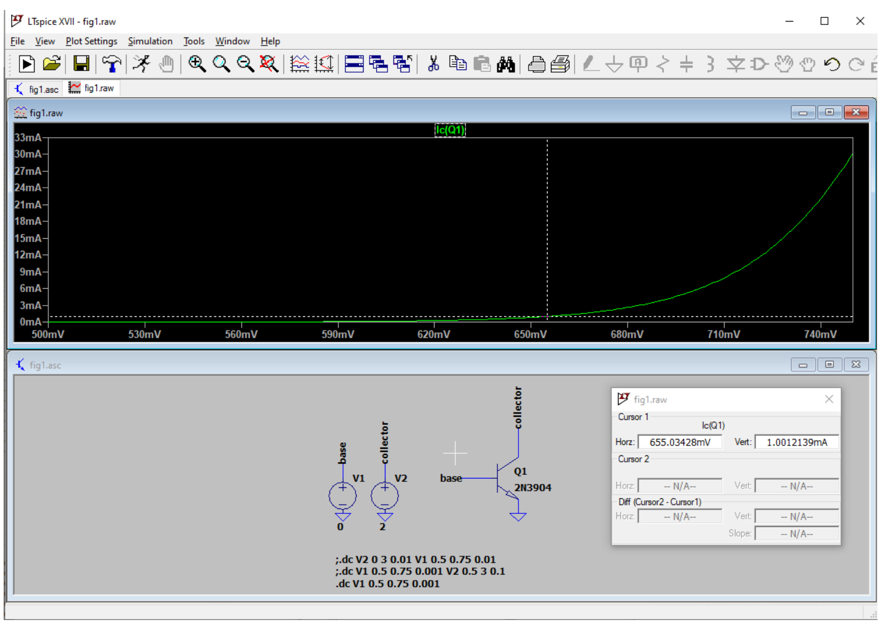

Figure 3: Collector current Ic vs Vbe (range 0.5V to 0.75V) at Vce=2V, and extrapolate the Vbe at Ic=1mA

V_{be} is $\approx 655\,\mathrm{mV}$ @ $I_c = 1\,\mathrm{mA}$

d)

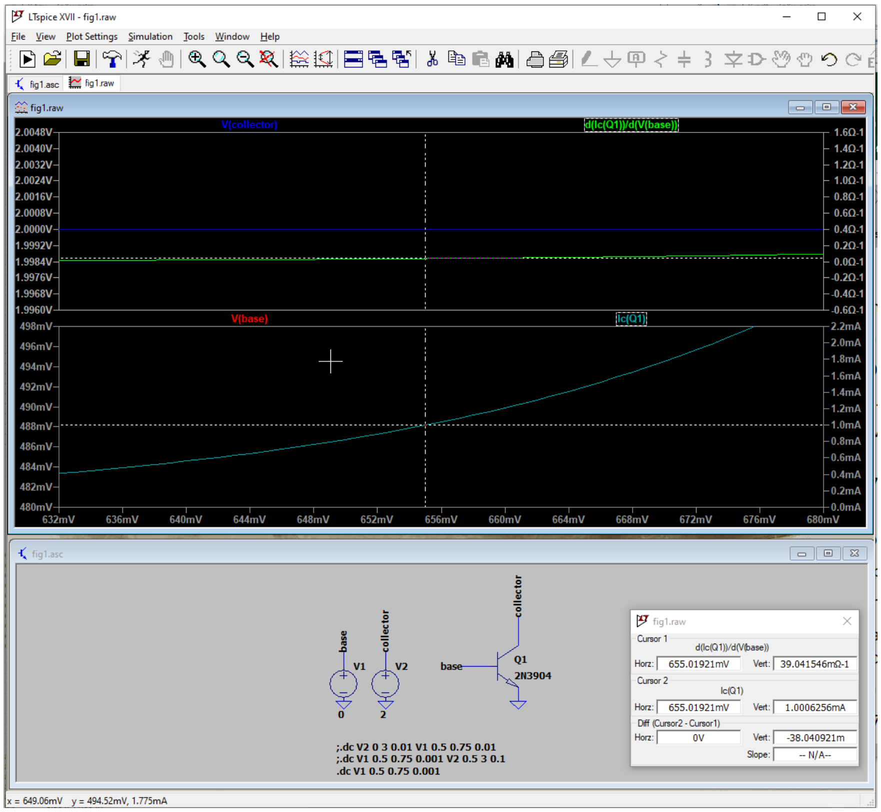

Figure 4: Derivative (d(.)) of the collector current Ic vs Vbe (range 0.5V to 0.75V) at Vce=2V, and extrapolate the transconductance at Ic=1mA

The transconductance g_m is found to be $39.042\,\mathrm{m}\Omega$ @ $I_c = 1\,\mathrm{mA}$

e)

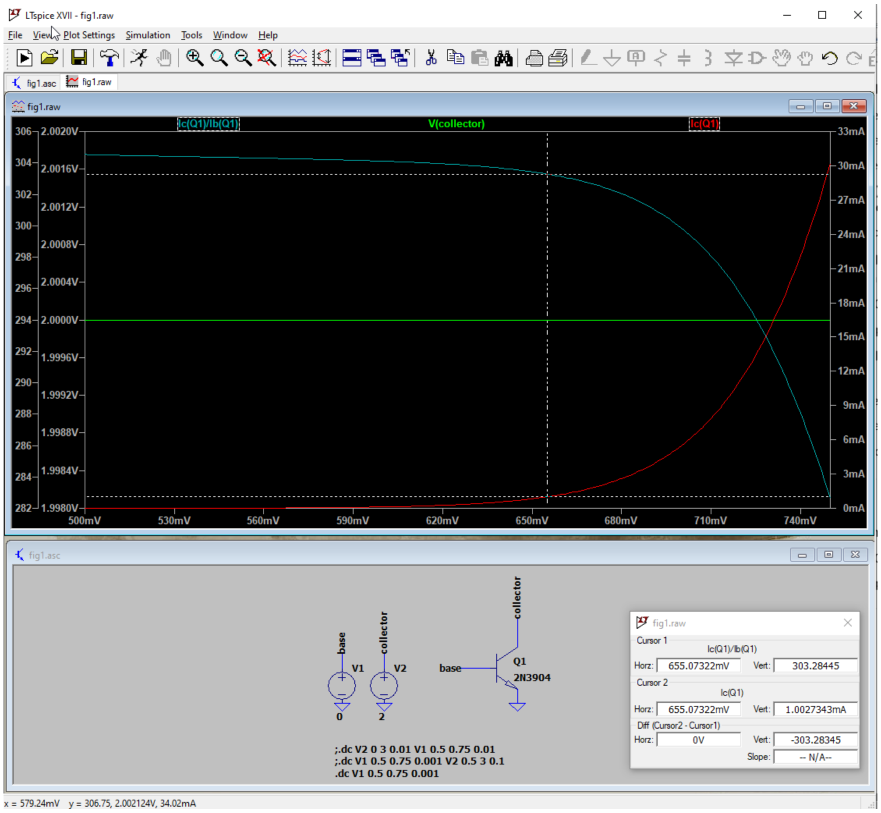

Figure 5: Current gain Ic/Ib vs Vbe (range 0.5V to 0.75V) at Vce=2V, and extrapolate the gain at Ic=1mA

The gain is ≈ 303.3

2 Simulate and Measure Circuit 2

a)

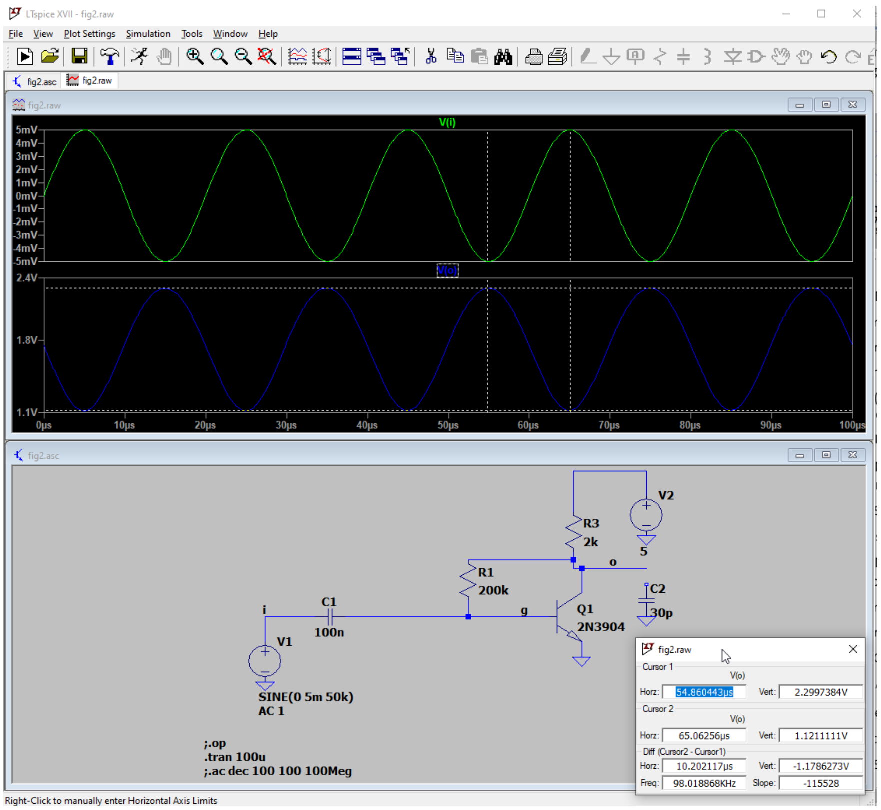

Figure 6: Response to 50kHz 5mV sinusoidal signal (plot in separate panes) and extrapolate the gain

The input amplitude is 5 mV pp and output amplitude is 1.179 V pp, centered about 1.77 V, therefore the gain is ≈ 236.

b)

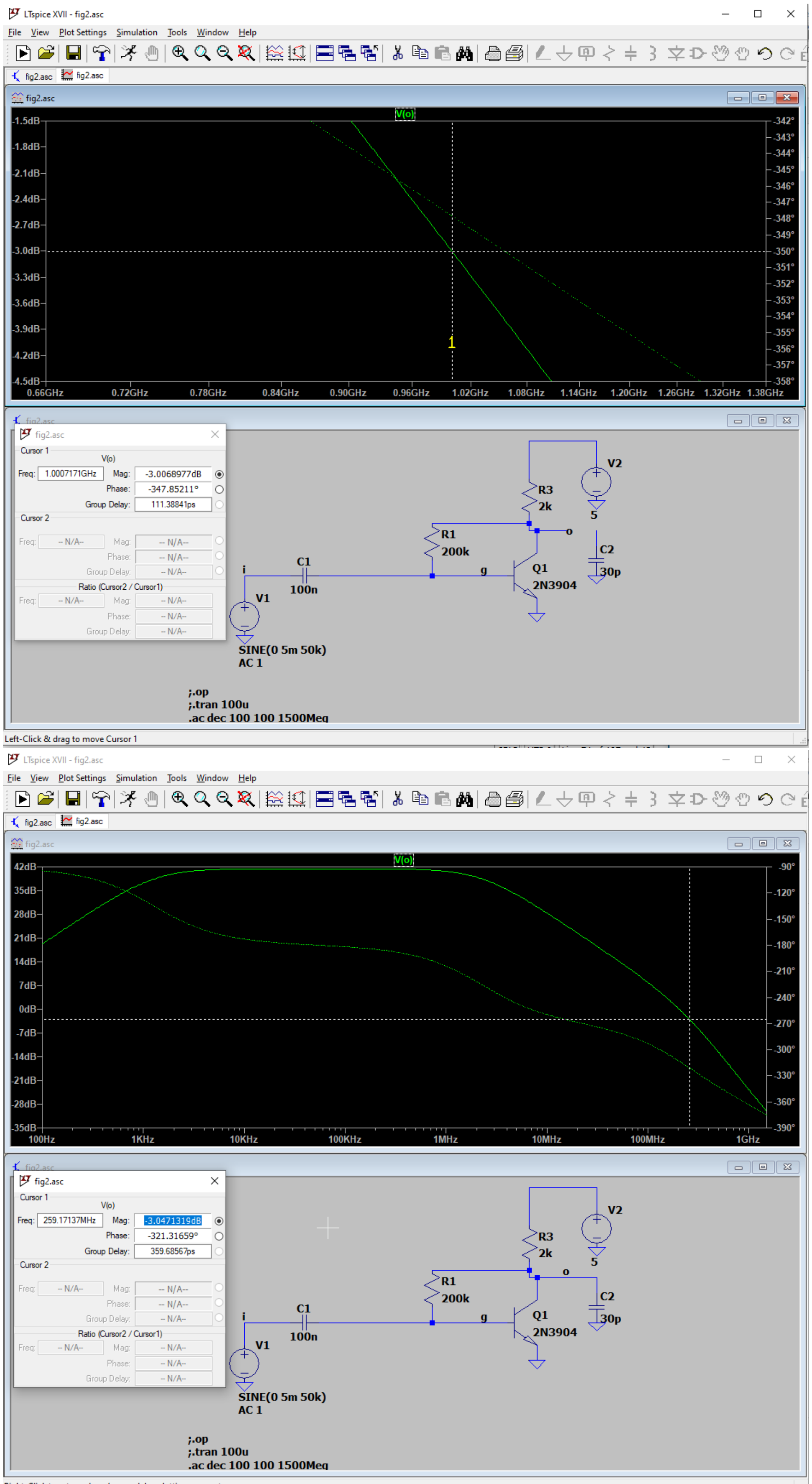

Figure 7: Frequency response, extrapolating the gain and -3dB bandwidth without and with a 30pF load

Without the 30 pF output capacitance, the −3 dB point is found at 1.0 GHz
With the 30 pF output capacitance, the −3 dB point is found at 259.2 MHz

3 Build and Measure Circuit 1

a)

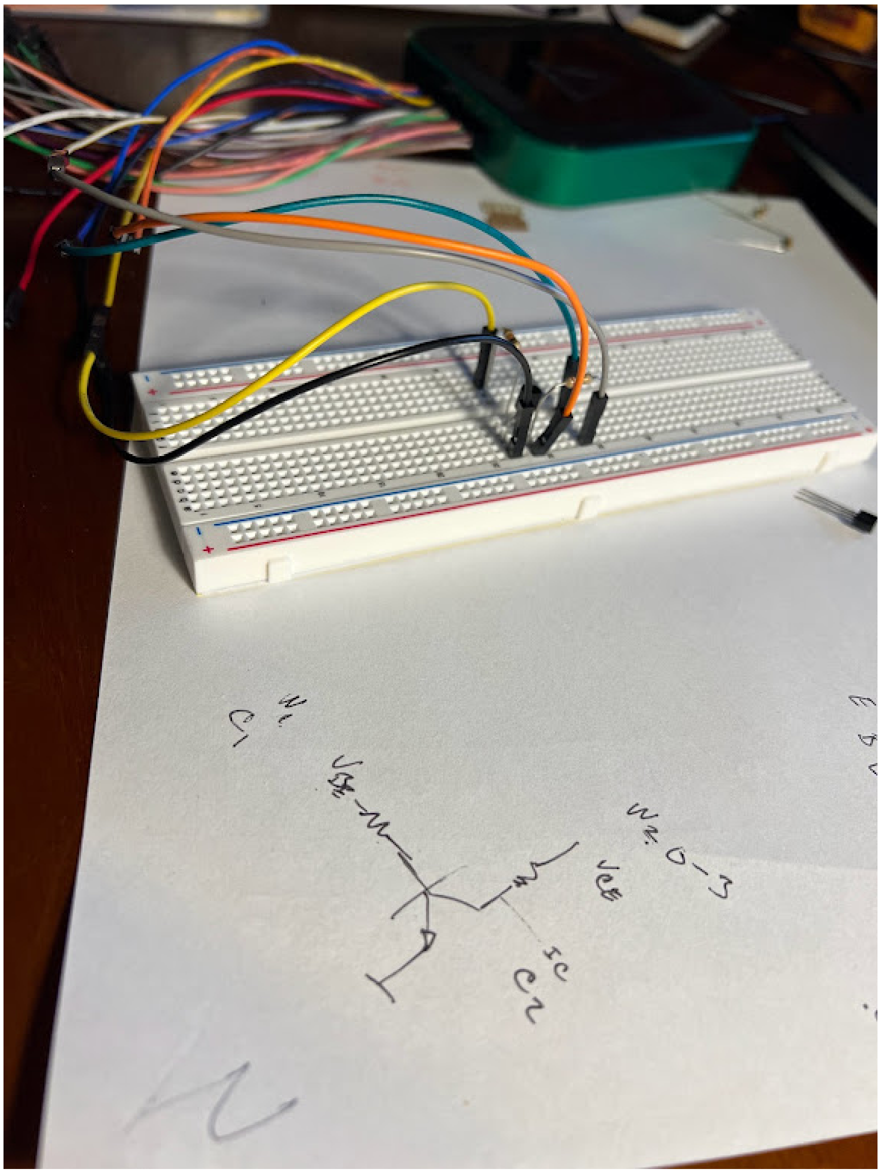

Figure 8: Test Setup

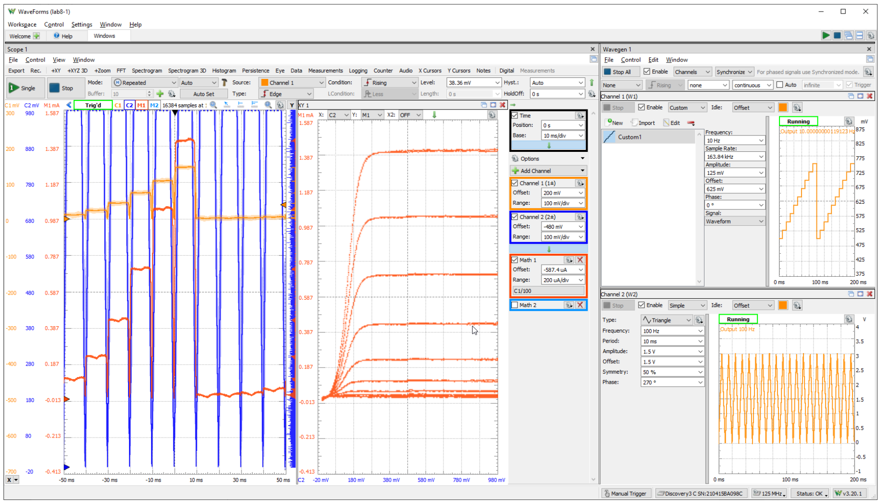

Figure 9: Collector current Ic vs Vce (range 0V to 3V) with parametric Vbe (see example in Fig.3)

b)

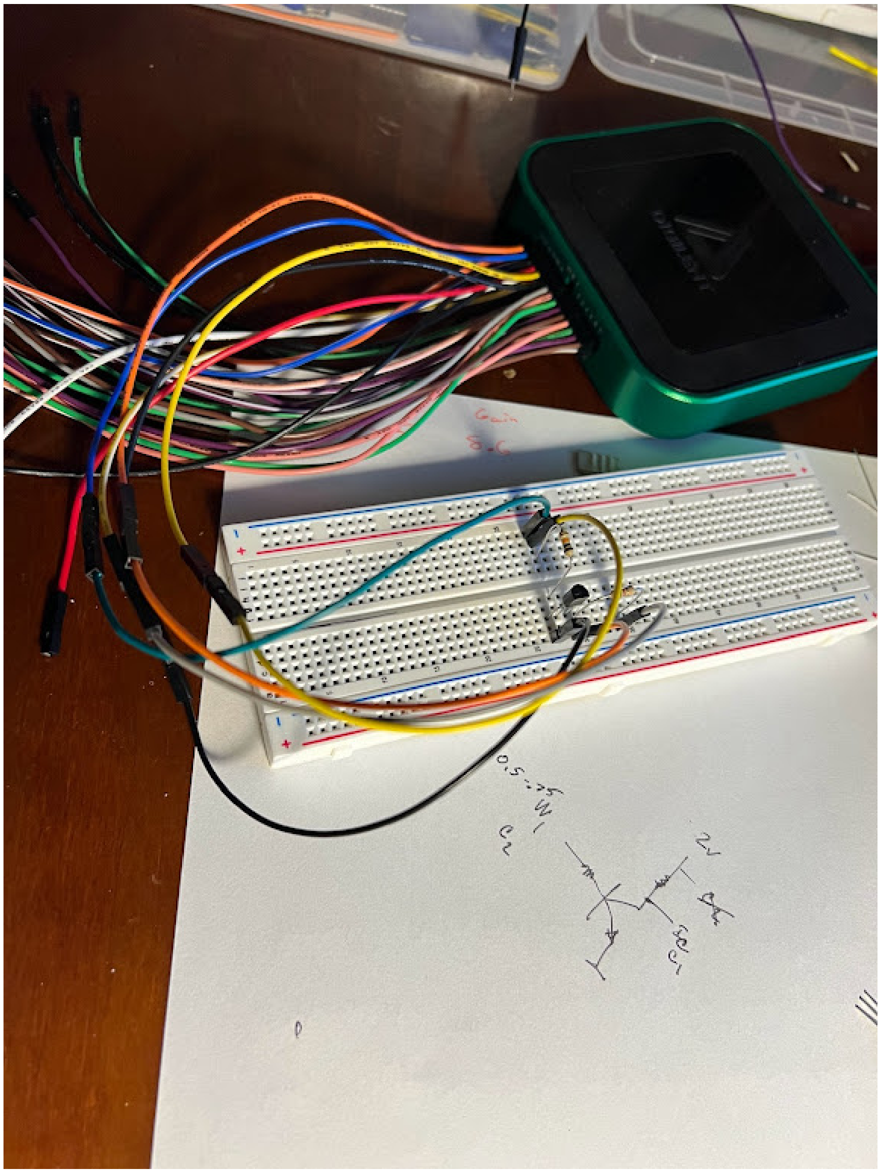

Figure 10: Test Setup

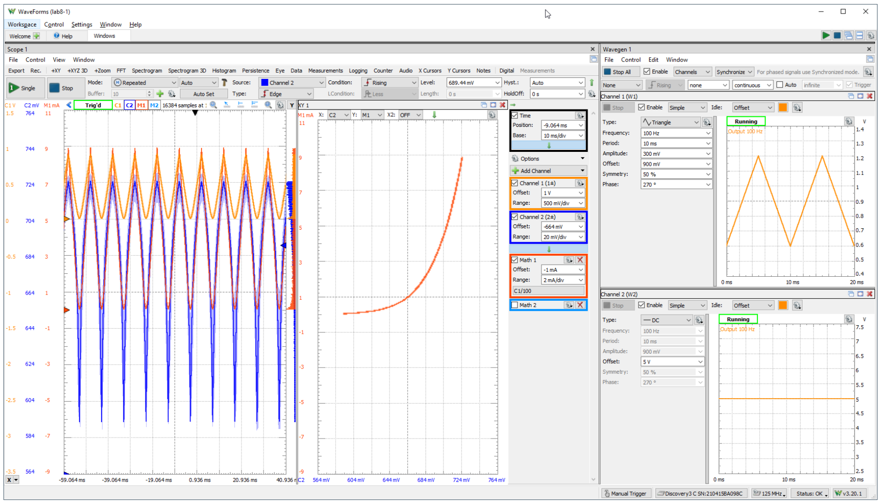

Figure 11: Collector current Ic vs Vbe (range 0.5 to 0.75V) for Vce¿2V, and extract the Vbe and the gm at Ic=1mA

V_{be} is $\approx 664\,\mathrm{mV}$ @ $I_c = 1\,\mathrm{mA}$

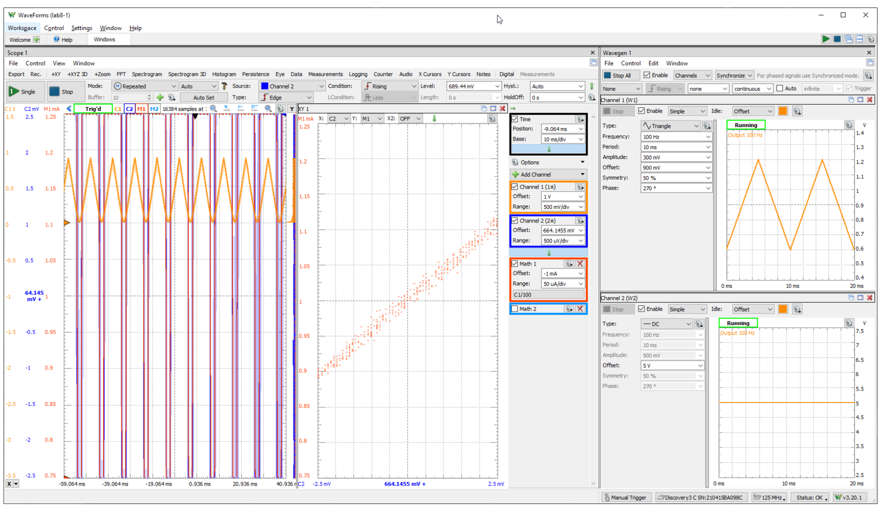

Figure 12: Zooming in to calculate $gm = \Delta V/\Delta I$

At $I_c = 1\,\mathrm{mA}$, $gm \approx 25\,\mathrm{m}\Omega$

c)

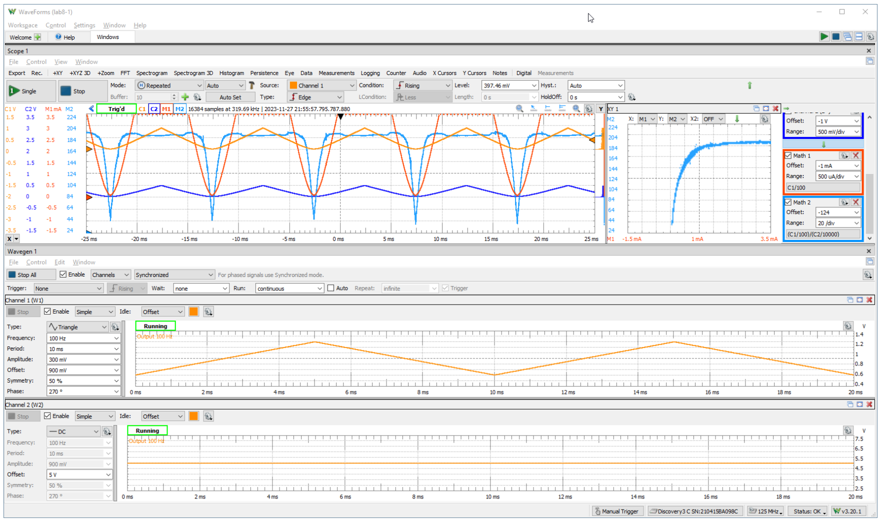

Figure 13: Gain Ic/Ib vs Collector current Ic (setting as in (b)) and extract the gain at Ic=1mA

The gain is found to be ≈ 180

4 Build and Measure Circuit 2

a)

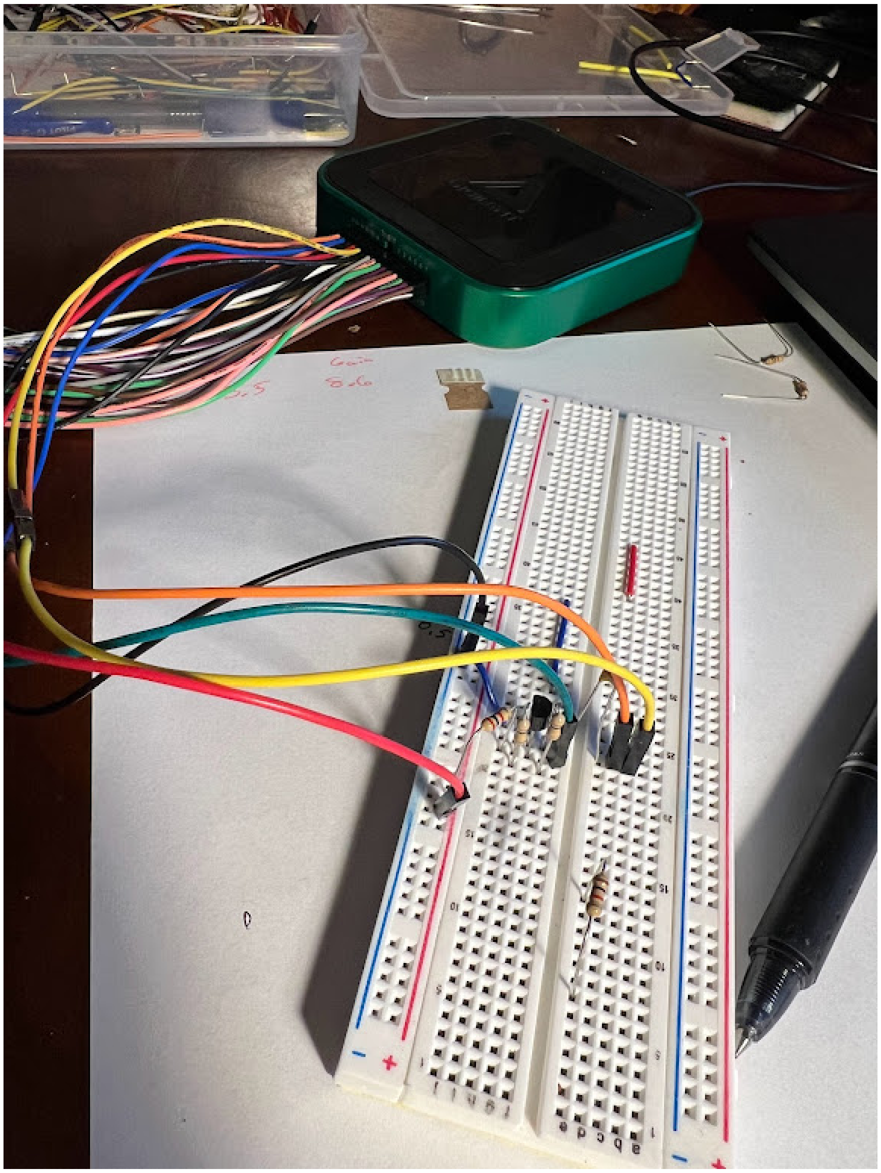

Figure 14: Test Setup

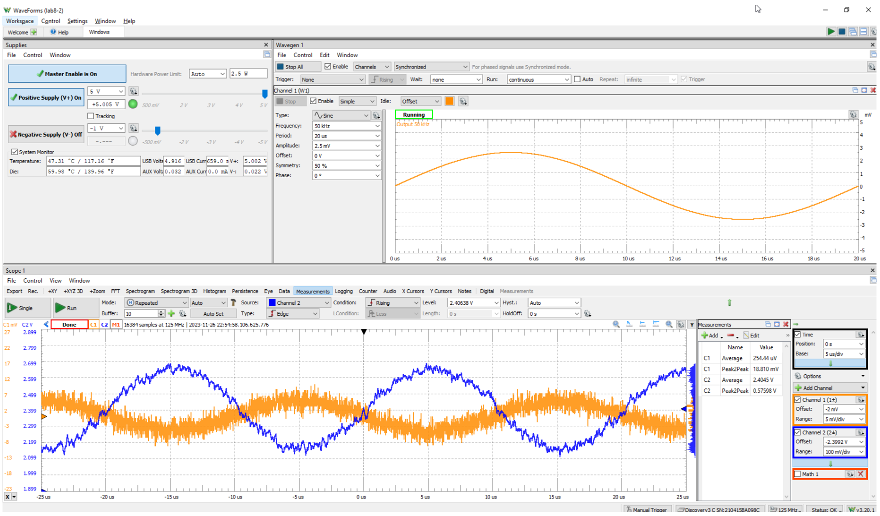

Figure 15: Response to 50kHz 5mV sinusoidal signal and extract the gain

The input amplitude is 5 mV pp and output amplitude is 0.57 V pp, centered about 2.4 V, therefore the gain is 114.

b)

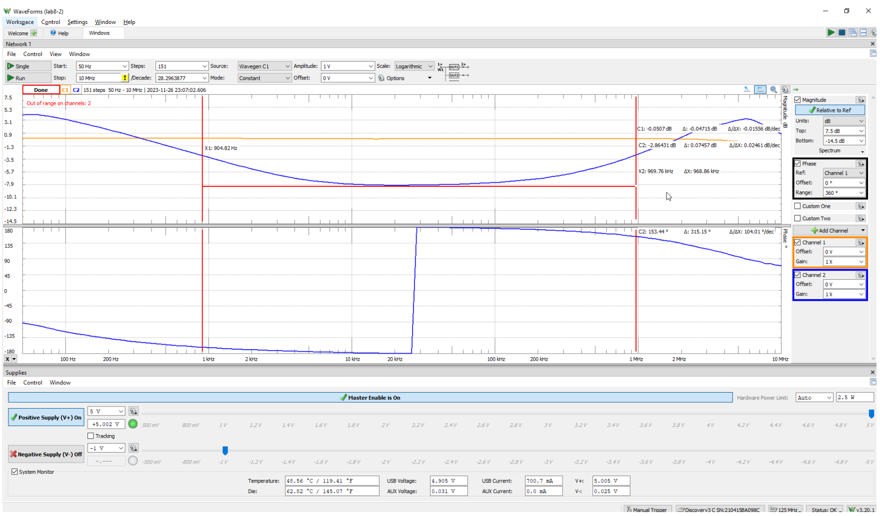

Figure 16: Frequency response, extracting the gain and the -3dB bandwidth

Using the Digilent Waveforms Network Analyzer it appears there is a -3 dB point at about 900 Hz and another at at about 900 kHz. At the time of writing, I am not sure what this means, but will continue to research to understand.