ECSE 331: Electronics

Laboratory Report No. 5

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Design of a BJT Amplifier

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Abstract—**The purpose of laboratory experiment is to design a BJT amplifier using the 2N2222A npn transistor that we studied in Lab 4 using the NI Elvis-II test instrument. In the laboratory, an amplifier with a gain of 50 V/V was built. Then in the second part, its gain at various temperatures were measured and compared. Experimental results shows that as the temperature of the transistors increases, the gain also increases.**

Index Terms—**BJT, transistors, Amplifier**

I. Introduction

THE goal of this laboratory was to build, test, and explore the behavior of the BJT amplifier using the NI Elvis-II test instrument. The performance of the amplifier was tested under the required constrains of bandwidth and RMS level. The effect of temperature on the operation of the transistors was also tested and found.

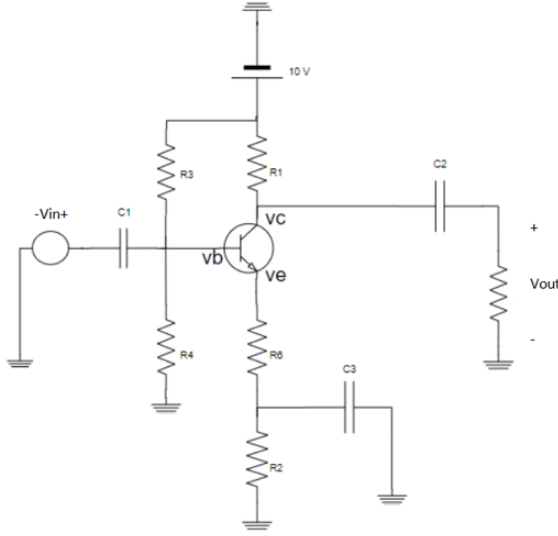## II. Experiments Procedures and Result

A. BJT Amplifier Circuit Design

Fig. 1. Design of BJT amplifier.

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The BJT amplifier design as shown in Fig. 1 was provided in the sample circuit, where R_1 to R_6 are $3\,\mathrm{k\Omega}$, $1.3\,\mathrm{k\Omega}$, $66.5\,\mathrm{k\Omega}$, $33\,\mathrm{k\Omega}$, $10\,\mathrm{k\Omega}$ and $0.024\,\mathrm{k\Omega}$ respectively, and all three capacitors are $47\,\mathrm{\mu F}$. Ideally, the gain should equal to $\frac{R_1||R_5}{R_6}$ if the capacitor was large enough; however, when we constructed the given circuit, the gain we found was only around 38 V/V. This was because the capacitor was not ideal. As a result, we wanted to increase the gain. There are three ways to increase the gain: to increase R_1, to increase R_5, or to decrease R_6. However, during the experiment, we found that if we were to increase R_1 slightly, the output signal we have would have a cutoff region on its sine wave. Therefore, we decided to increase R_5 to $1\,\mathrm{M\Omega}$ and decrease R_6 to $14\,\Omega$.

B. BJT Amplifier Performance Testing

After setting up the circuit as shown in Fig. 1 with the element we have mentioned in section II-A, we modified our input as $V_{pp} = 0.66\,\mathrm{V}$; $1\,\mathrm{kHz}$ sine wave; $0\,\mathrm{V}$ offset. The measured result from the two oscilloscope shows (in Fig. 2 (where black is the input signal, and grey line is the output signal) that this circuit has a voltage gain of 47.86 V/V, which is in the desired range.
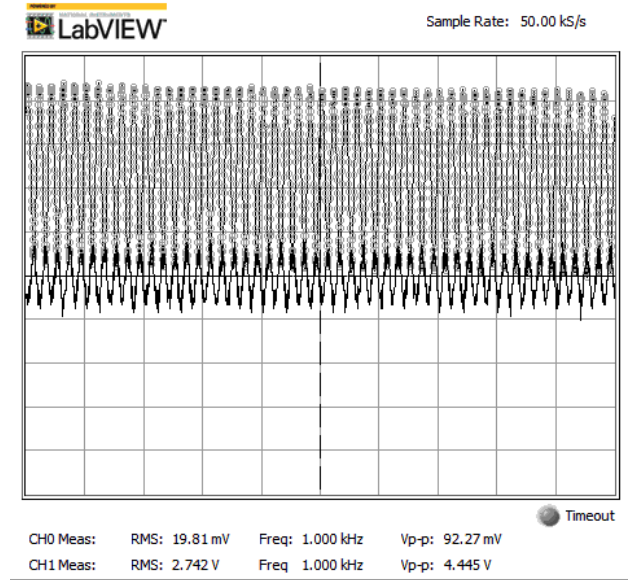

Fig. 2. Measured Output voltage and input voltage at room temperature ($27\,^\circ\mathrm{C}$) with input voltage at $1\,\mathrm{kHz}$

Next, without modifying any circuit elements, we changed our the frequency of our input voltage to 11 KHz. As shown in Fig. 3, the gain is obtained as 55 V/V, which is acceptably desirable.
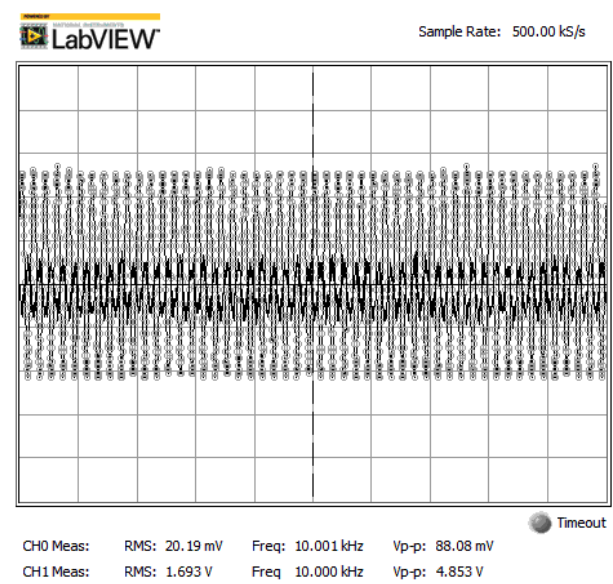

Fig. 3. Measured Output voltage and input voltage at room temperature (27 °C) with input voltage at 11 kHz

Finally, the frequency and of the input was inverted back to 1 kHz but added with 1 V offset. The measured gain under such circumstane is 45 V/V as shown below in Fig. 4.
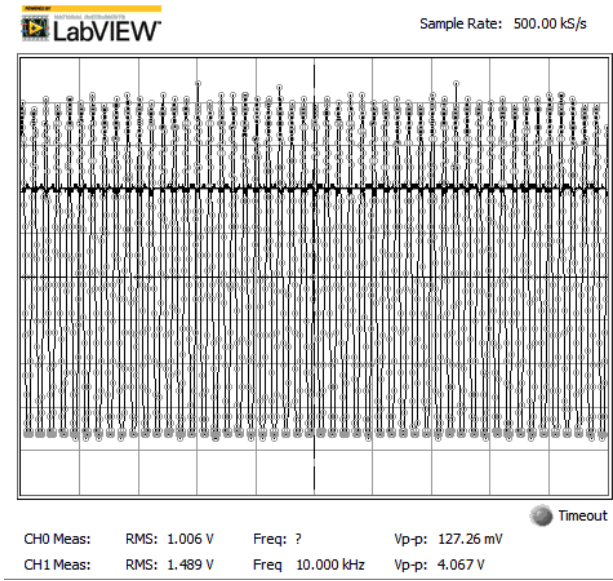

Fig. 4. Measured Output voltage and input voltage at room temperature (27 °C) with input voltage at 11 kHz

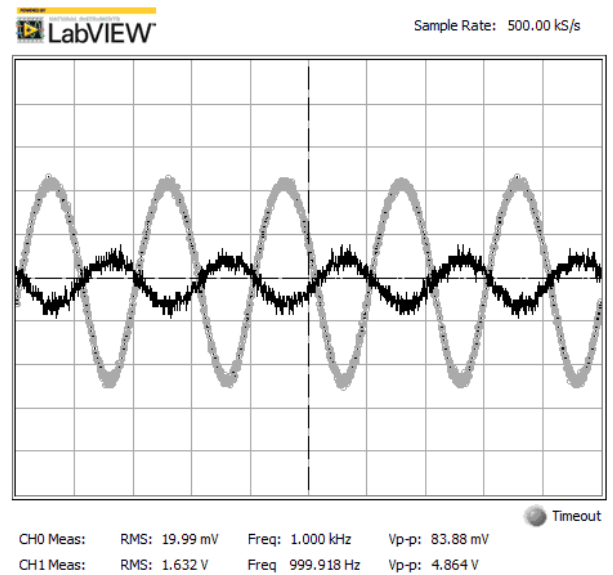## C. Temperature Effects of BJT Amplifier

Fig. 5. V_{in} and V_{out} of the circuit at room temperature (27 °C).

As seen in Fig. 5, the gain of the BJT amplifier at at room temperature (27 °C) is

$$
\begin{aligned}
G &= \frac{V_{out}}{V_{in}} \\
&= \frac{4.864\,\text{V}}{83.88\,\text{mV}} \\
&= 58.0\text{V}/\text{V}
\end{aligned}
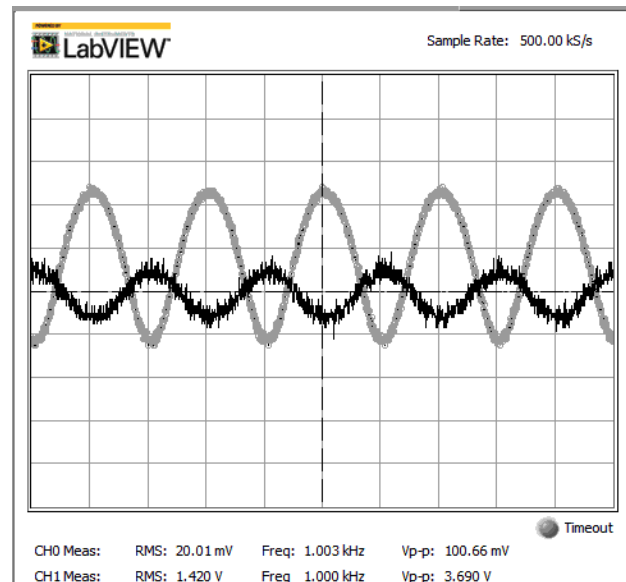$$

When the temperature is increased to 63 °C, as seen in Fig.

Fig. 6. V_{in} and V_{out} of the circuit at 63 °C.

6, we have the gain

$$G = \frac{V_{out}}{V_{in}}$$
$$= \frac{3.690\,\text{V}}{100.66\,\text{mV}}$$
$$= 36.9\text{V/V}$$

Thus, it is observed that the gain of the BJT amplifier decreases as its temperature increases. Similarly, we conducted similar operations to observe its temperature characteristics when the circuit is brought down from room temperature. Similarly, as given in Fig. 7, we could calculate that the gain
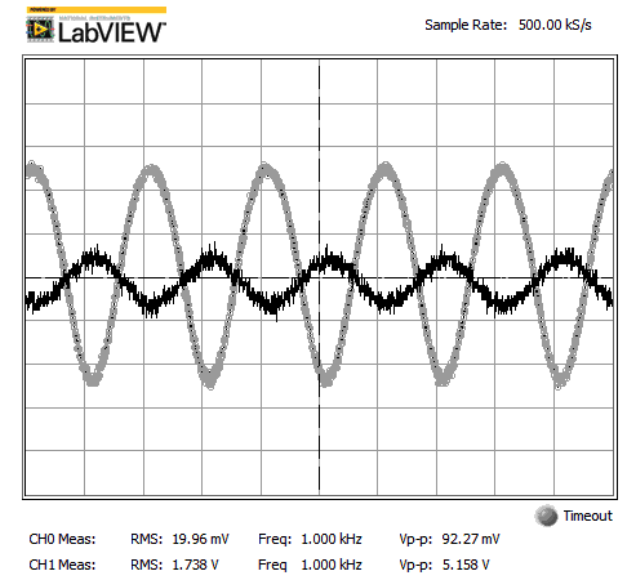

Fig. 7. BJT amplifier at $-10\,^{\circ}\text{C}$.

of the amplifier at $-10\,^{\circ}\text{C}$ is 55.64 V/V. It can be observed that the gain has a small decrease as the temperature is brought down, which is surprisingly not pertaining with the theory.

III. CONCLUSION

To conclude, this lab was very helpful for using a BJT transistor. We built an amplifier that produced a gain of around 55 V/Vfor a frequency range of over $100\,\text{kHz}$. The behavior of the amplifier was tested at various temperatures, the gain was found using the Bode plot at room temperature ($27\,^{\circ}\text{C}$), $-10\,^{\circ}\text{C}$ and $63\,^{\circ}\text{C}$. The differences in the gain were very small, but overall satisfying. Our gain increased slightly as we decreased the temperature of the BJT. This could have been due to the fact that, at lower temperature, there are less mobile charge carriers.