EE 360 Circuits & Electronics Lab. #5

Common Emitter Amplifier

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ABSTRACT

By using the basic concept of the NPN transistor, it did confirm that the transistor could amplifier input signal to the output signal. In order to do so, the voltage between corrector and emitter and corrector current were figured out paper example and experimentally. Moreover, the voltage gain of one particular circuit, which was used the NPN transistor, was also figured out from desk calculation and experimentally. Knowing the mathematical calculations of this experimental circuit, the experiment was set up building the circuits using the one NPN transistor, five different resisters, two capacitors, and the wave generator. Finally, the voltages between corrector and emitter and the voltage gain data sets were compared between mathematical calculations and real measurements.

OBJECTIVE

The purpose of the laboratory was to confirm that the operating point of the circuit as shown Fig 1 and voltage gain could be calculate by using the theory of the transistor and to become familiar with the use of the transistor's amplifier circuit, and to construct a electric circuit in order to examine the operating point of the particular transistor (2N2222A) and voltage gain of entire circuit. Conclusively, the results from the pre-lab calculations and the experimental results were compared.

PROCEDURE

The first step of this lab was the pre-lab section had to be done. First, the objective of the pre-lab was to calculate the operating point of the 2N2222A transistor in this experience, which entire circuit is shown in Fig 1.

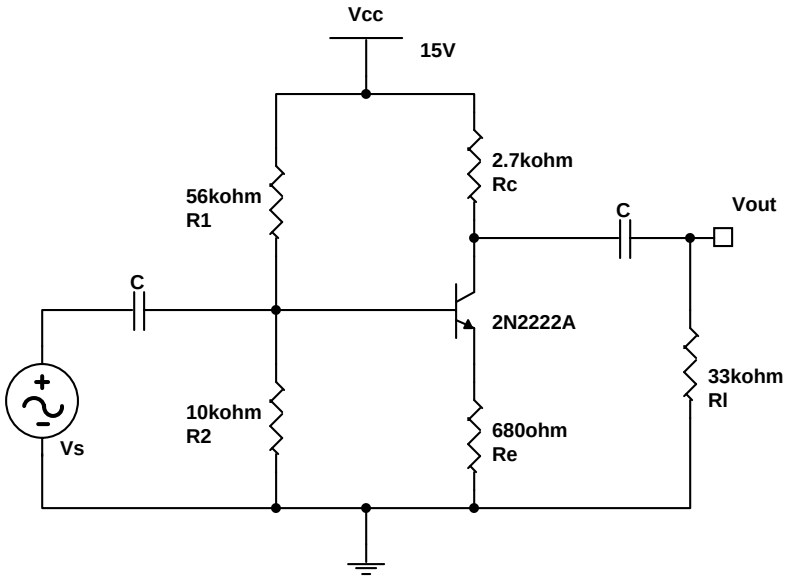

Fig 1. Experimental circuit.

The pre-lab calculations above were done by the basic theory of the transistor and Ohm's law. In order to proceed the calculation, the experimental circuit was examined carefully and determined that the experimental circuit was constructed with DC and AC parts. The DC part could be said the middle part of the Fig 1; in the other words, the circuit was divided by two capacitors; left side of C and right side of C. Therefore, at the beginning, in order to apply the transistor's theory, the circuit was determined only middle part of the circuit. Fig 2 indicates the way it was.

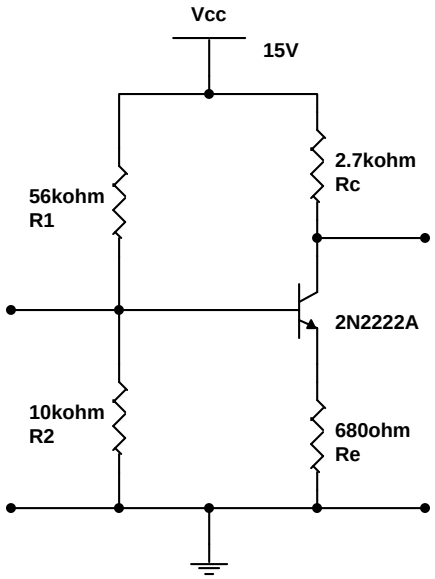

Fig 2. Experimental circuit without AC parts.

In order to calculate the operating point of the transistor, the base current should be figured out, very fast. Following calculations were performed.

R1 and R2 were parallel each other.

$$R_B = R_1 // R_2 = 56K // 10K = \frac{56K \times 10K}{56K + 10K} = 8.48K\Omega$$

Voltage (Vcc) was divided by the parallel resistors (R_B = R1 //R2).

$$V_{BB} = V_{CC} \cdot \frac{R_1 // R_2}{R_1} = V_{CC} \cdot \frac{R_2}{R_1 + R_2} = 15 \times \frac{10K}{56K + 10K} = 2.27V$$

Then, the base current was calculated by V_{BB}, h_{ie} (given value = 2K), β (given value = 150), and summation of the emitor resistors (this time was only 680Ω).

$$I_B = \frac{V_{BB}}{h_{ie} + \beta \cdot \overline{R}_E} = \frac{2.27}{2K + 150 \times 680} = 2.18 \times 10^{-5} A = 0.0218mA$$

Supplementary, the circuit was re-drawn by following way. Fig 3 is indicating the most basic shape of the circuit around the transistor 2N2222A.

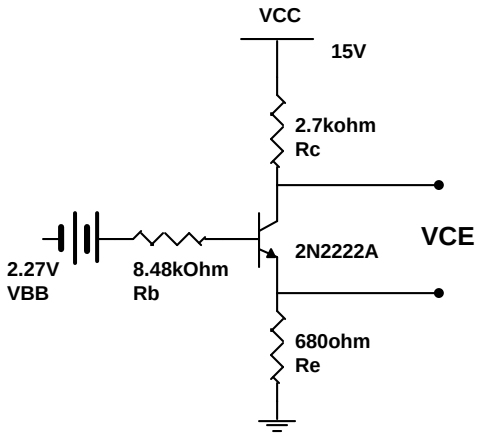

Fig 3. Simplest circuit around the transistor. (virtual circuit)

Then, the corrector current, I_C, and voltage across the corrector and emitter, V_{CE}, were figured out by following way, which were based on the theory of the transistor.

$$I_C = \beta \cdot I_B = 150 \times 0.0218mA = 3.27mA$$

$$V_{CE} = V_{CC} - I_C \cdot R_C = 15V - (3.27mA)(2.7K\Omega) = 6.17V$$

Finally, the operating point (saturation point) was figured out by those data such as Vcc = 15V, Ic = 3.27mA, and V_{CE} = 6.17V. Then, following diagram (Fig 4) was assumed by using those calculated data sets.

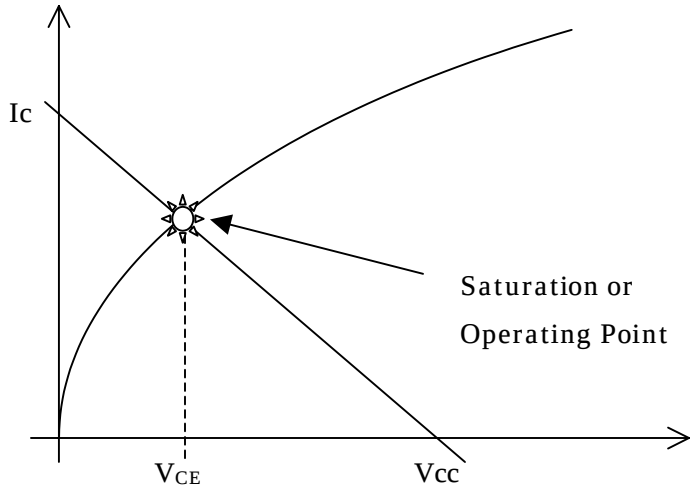

Fig 4. Assumed diagram, the relationship of the operating point. (not exact)

Next, the voltage gain of this circuit was figured out by following way. The experimental circuit (Fig 1) could be drawn differently (Fig 5).

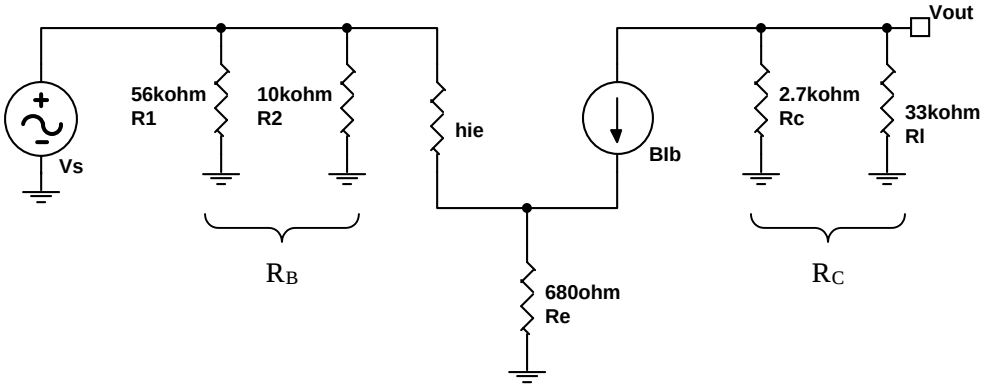

Fig 5. The other expression of the experimental circuit.

The sum of the corrector resisters was calculated by following way.

$$\overline{R}_C = R_C \,//\, R_L = \frac{2.7K \times 33K}{2.7K + 33K} = 2.5K\Omega$$

The voltage gain of this experiment was calculated by following way.

$$Av = -\frac{\overline{R}_C}{\frac{h_{ie}}{\beta} + R_E} = -\frac{2.5K}{\frac{2K}{150} + 0.68K} = -3.60V/V$$

Knowing those calculated values, the real experiment was performed. The experimental circuit was constructed on the protoboard by using 2N2222A transistor and 56K, 10K, 2.7K, and 680 resisters, which was a part of DC circuit. After examined that the DC circuit worked properly, the capacitors and some kind of input source was added into the DC circuit. Then, the voltage between corrector and emitter and the current of corrector were measured and compared. Moreover, the input AC voltage source and output one were used to figure out the real voltage gain value.

RESULTS

	Pre-lab values	Experimental values	Error %
V_{CE}	**6.17V**	**7.04V**	**14.1**
I_C	**3.27mA**	**2.20mA**	**32.7**
V_{input}	**------**	**1.16V**	**-----**
V_{output}	**------**	**3.92V**	**-----**
Voltage Gain, Av	**-3.60V/V**	**3.38V/V**	**6.1**

DISCUSSION

In examining the results and comparing the values, the experimental results did not slightly meet the expected values to a reasonable amount. The voltage between corrector and emitter was 6.17V in pre-lab section, and 7.04V was measured value. These error percentage was 14.1%. The error percentage was little big number, but it was assumed that the number was still acceptable number of 2N2222A transistor. Because of the characteristics of the transistor, it could be affected by many situations such as temperature, life-expired transistor, and so on. In addition, the voltage gain of this circuit in pre-lab section was –3.60V/V, and the 3.38V/V was experimental number. Between these, the error percentage was 6.1%, which was calculated by absolute pre-lab number. Even though the sign (+) or (-) was significant aspect of the scientific world, this experience did not focus on that because it was assumed that the sign could change input phase condition.

CONCLUSION

Overall, in observing the results and the error calculated in the discussion section, the laboratory was a success where the experimental values met the theoretical values calculated from the pre-lab section. The laboratory showed how the NPN transistor basics came in act with the circuit and how it affected the voltage gain in the circuit.