Fall 2019

California State University of Northridge
Department of Electrical & Computer Engineering

Experiment 6
Design of Common Emitter Amplifiers

ECE 340L
October 15, 2019

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Introduction:

The purpose of this experiment is to implement and verify the design of a common emitter amplifier. The design was completed by making a few assumptions, which is that the current running through the collector is 1mA and a collector voltage of 10v. The design is used to verify theoretical equations developed by analyzing the circuit such as the resistance as seen from the input and output of the circuit, as well as the gain of the output over the input.

Equipment:

Type	Model
Oscilloscope	Agilent Technologies DSO1002A
Digital Multimeter	Tektronix CDM250
Function Generator	Agilent 3322OA
Power supply	Hewlett Packard E363OA
Curve Tracer	Tektronix 370A

Parts used:

QTY	Component	Value	Type
1	Resistor	1 kΩ	Carbon +/- 5%
1	Resistor	220 kΩ	Carbon +/- 5%
1	Resistor	10 kΩ	Carbon +/- 5%
1	Resistor	18 kΩ	Carbon +/- 5%
1	Capacitor	10 µF	Polypropylene film +/- 5%
1	Transistor	Q2N2222A	Silicon

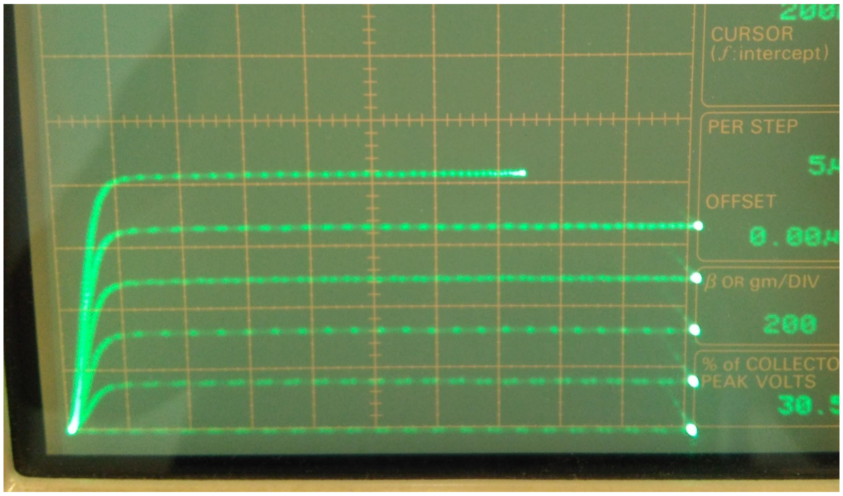
Software:

Pspice
Microsoft Word
Microsoft Excel

Procedure & Results:

The transistor Q2N2222A was placed in a curve tracer. The current across it's collector was plotted against its collector to emitter voltage in Graph 1.

Graph 1



The I_{CQ} was found to be 4.2 mA and the I_{BQ} was found to be 25 μA. Using the following Equation the Beta at DC was found to be 168.

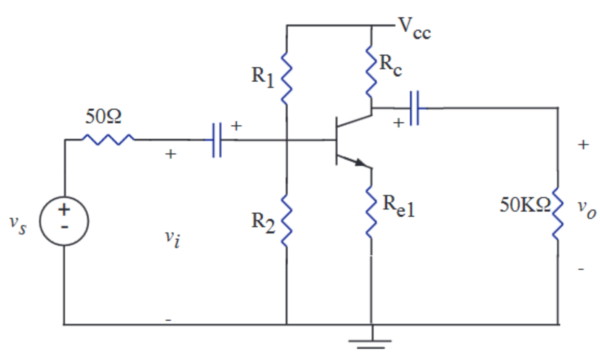
$$\beta_{DC} = \frac{I_{CQ}}{I_{BQ}} = 168$$

Then the Beta at AC was found to be 180 using the delta equations using another value of I_C = 3.3 mA and I_B = 5 μA.

$$\beta_{DC} = \frac{\Delta I_C}{\Delta I_B} = \frac{(4.2-3.2)\ mA}{5\ \mu A} = 180$$

The circuit in Figure 2 was constructed using values in the design. The nominal values of resistance were R_1 = 216 kΩ , R_2 = 19.7 kΩ, R_{e1} = 0.98 kΩ, and R_C = 9.7 kΩ.

Figure 2



Voltages and currents were measured across the transistor to determine if the transistor was in the active region before continuing. The results were placed in Table 1.

Table 1

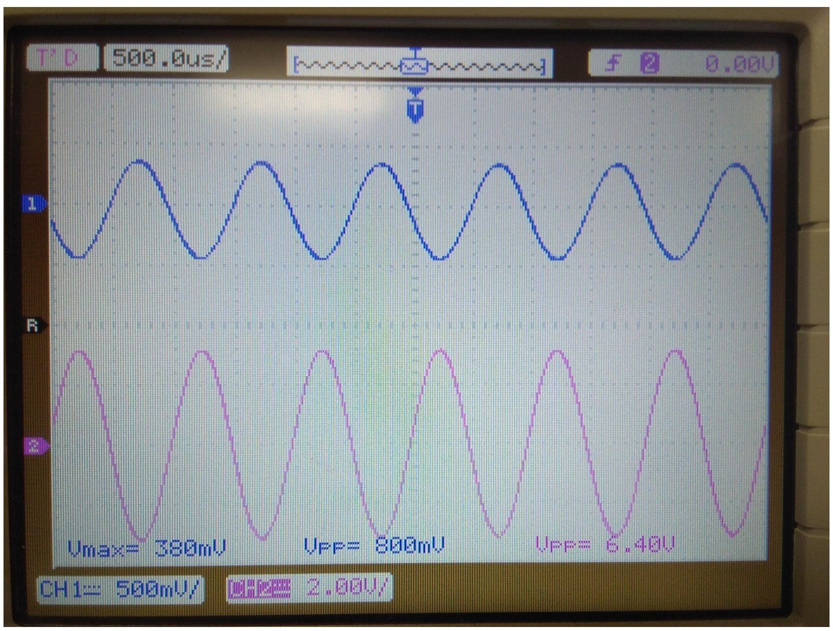
	V be (v)	V ce (v)	V e (v)	I c (mA)	V c (v)	V b (v)
calculated	0.7	8	1	1	10	1.7
Measured	0.613	9.64	0.95	0.97	10.58	1.56
% error	12%	21%	5%	3%	6%	8%

The calculated results when compared to the measured results do have some accuracy with some significant percent error. This percent error is explained by the nominal values of resistances used as opposed to the theoretical values. Differences in V_{BE} and V_{CE} were assumptions made through the specifications and are unique to this transistor.

After the transistor was determined to be active, the function generator was applied to the input at the base. The voltage at the output was measured using an oscilloscope to be 6.40 V_{pp}.
The gain was calculated using the following equation. The oscilloscope was plotted in Graph 2.

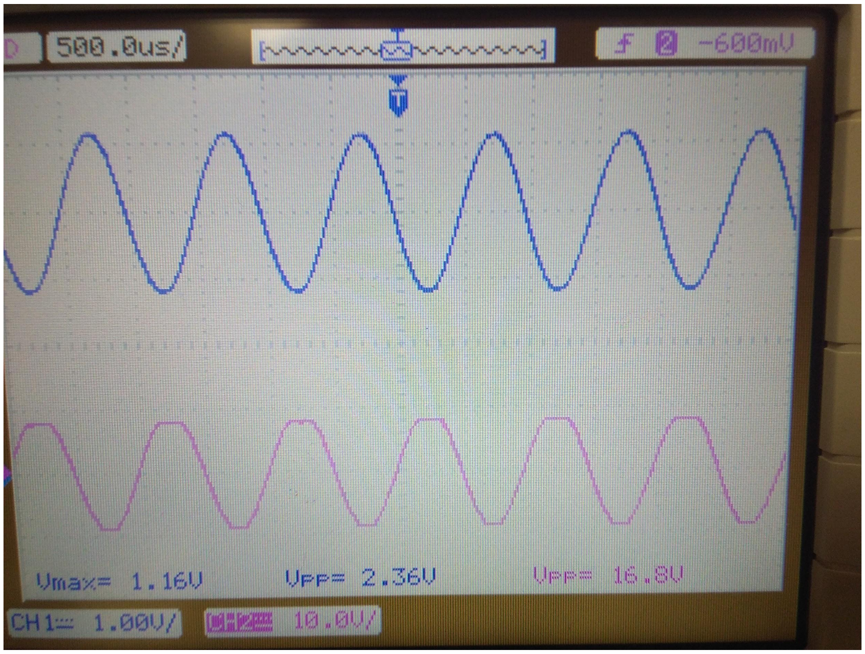
$$A_V = \frac{-6.40\ V_{pp}}{400\ mV_{pp}} = -16.0$$

Graph 2



After the gain was found, the input signal was increased in steps until the output experienced some distortion. Distortion occurred at a value of 1.20 V_{PP} with an output of 16.8 V_{pp}. The oscilloscope display showing the distortion was plotted in Graph 3.

Graph 3

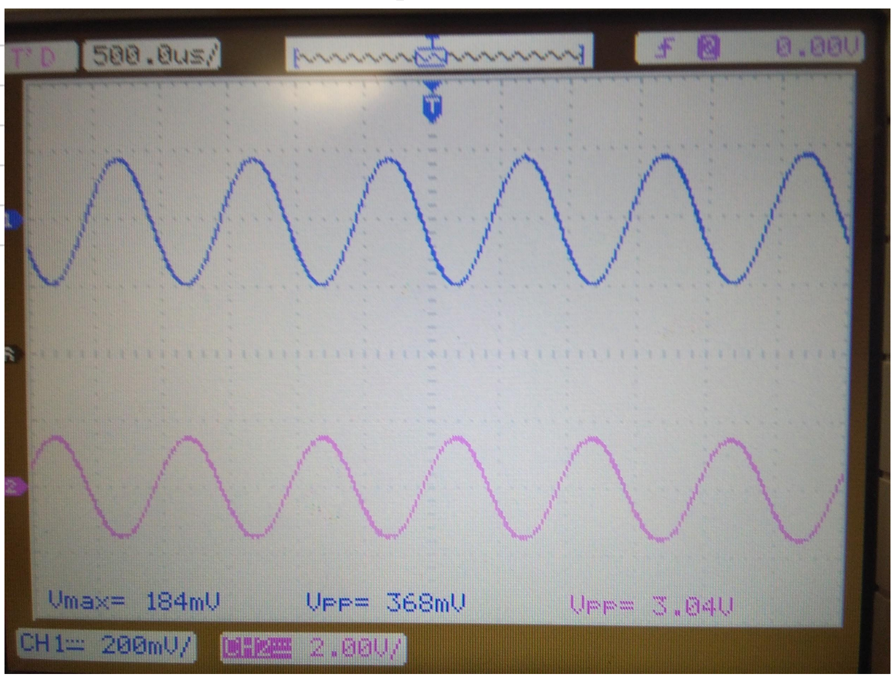


The input signal was returned to 400 mV_{PP}. A resistor value of R_S was placed at the input of the base. The value of R_S was incremented until the output was half the Voltage without R_S. The results are shown in Table 2 and the oscilloscope in Graph 4 shows the final result of 18kΩ.

Table 2

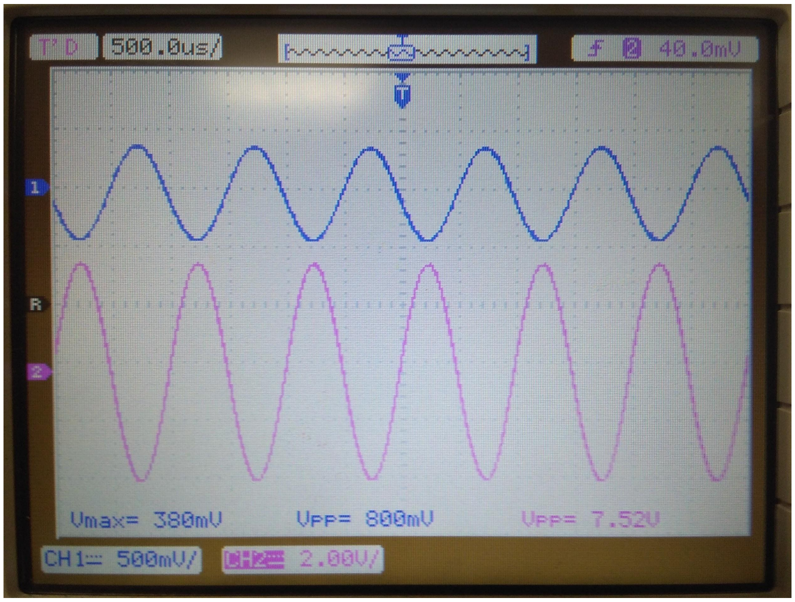
R s (ohm)	Output (V pp)
0kΩ	6.32
5kΩ	4.88
10kΩ	4
18kΩ	3.04

Graph 4



The load resistance was removed from the output and the output voltage was recorded and plotted in Graph 5.

Graph 5

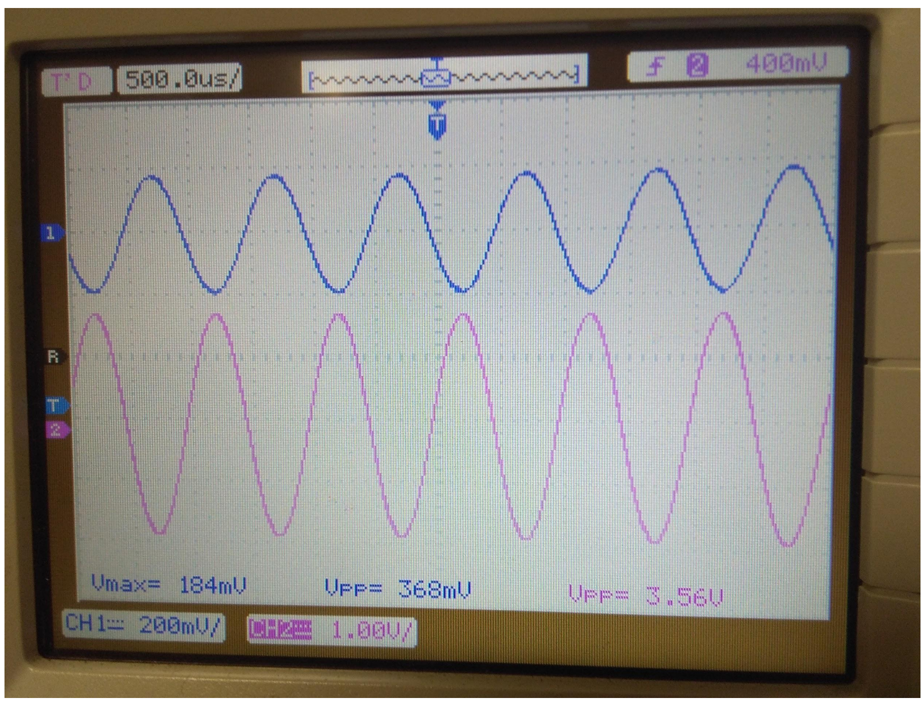


The R_S value was decremented until the output voltage was halved. The results are shown in Table 3 and the final result was graphed in Graph 6. Again around 18 kΩ shows the input impedance.

Table 3

R s (ohm)	Output (V pp)
50kΩ	1.92
33kΩ	2.48
22kΩ	3.24
18kΩ	3.6
10kΩ	4.72
0	7.52

Graph 6



The circuit in Figure 6.2 was then constructed with new specifications. The new resistance values were R_1 = 102 kΩ, R_2 = 8 kΩ, R_{e1} = 300 Ω, and R_C = 10kΩ.
More assumptions that were made is that I_C = 0.5 mA and V_{CC} would be 12 V.
The input was given a DC input. Voltages were measured across the transistor and shown in Table 4.

Table 4

	V be (v)	V ce (v)	V e (v)	I c (mA)	V c (v)	V b (v)
calculated	0.65	7.85	0.15	0.5	7	0.8
Measured	0.613	8.1	0.16	0.48	7.21	0.773
% error	6%	3%	7%	4%	3%	3%

A 400 mV_{PP} was applied to the input of the circuit. The output recorded a 9.47 V_{pp}.

$$A_V = \frac{-9.46\ V_{pp}}{400\ mV_{pp}} = -23.66$$

Conclusion

The experiment was a success in verifying the equations for impedance of the transistor and the gain seen at the output. Beta values ranging from 168 to 180 were found using the curve tracer. This fits within the 100 - 300 range for all transistors. The design of the common emitter amplifier was effectively set in the active region and had a gain of 16 which was over the design specification of 10. By using the maximum power transfer theorem, the input impedance of the design was correctly identified.