

Electronics engineering report examples

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Lab Report: Common Emitter Amplifier

Acronyms and Abbreviations

AC Alternate Current

BJT bipolar-junction-transistor

DC Direct Current

mA milliAmps

PNP Positive-Negative-Positive

Q point Quiescent Point

RF Radio Frequencies

Lab Report: Common Emitter Amplifier

Introduction

A laboratory was conducted to evaluate the characteristics of a common emitter amplifier. The configuration is a bipolar-junction-transistor (BJT). Transistors allow current to flow from positive to negative states or from negative to positive states. A transistor board was supplied for the experiment. Five activities were done during the lab: a DC analysis, An AC analysis gain at midband (with bypass capacitor in circuit), AC analysis gain at midband (with no bypass capacitor in circuit), measurement of the frequency response of the amplifier, and measurement of distortion. Capacitance refers to the capability of a material to store an electrical charge; the energy is stored in a capacitor. Distortion is the amount of non-linearity measured between the input and the output signals.

Characteristics of a Transistor

Silicon is a common material for transistors because it has the same performance capabilities as solid state item. The number of free electrons available determines the conductivity of a material. Impurities such as gallium added to the silicon create an electron deficiency; in other words a hole is created which increases the conductivity. After a controlled addition of holes is added to a material the material is called a semi-conductor. An n-type semi-conductor uses free electrons for conduction whereas a p-type semi-conductor uses electron deficiency. (See fig. 1)

Figure 1 A bipolar junction transistor

(Source: Google images)

The configurations for a bipolar junction transistor essentially falls into three categories (a) the common emitter configurations, (b) the common base configuration, and (c) common collector configuration. The input and output signal are both generated from one terminal in all three categories. The simple schematics below display the three categories (without depicting the power supplies and bias circuits). (See fig. 2) When the emitter terminal is used by both the input signal and the output signal the BJT configuration is the same as for a Positive-Negative-Positive (PNP) type transistor. (See fig. 2a) This should be used when the desired effect is to gain high voltage, gain high current, medium output impedance, and medium input impedance.

Figure 2 (a) the common emitter configurations, (b) the common base configuration, and (c) common collector configuration

(Source: Google Images)

common base configuration on the other hand is useful for Radio

Frequencies (RF). High voltage gain is a feature but the current gain is at unity or less, with low input impedance and high output impedance. (See fig. 2b) The common collector configuration is the emitter follower. The emitter voltage gain is close to unity; at the base the input signal is applied followed almost immediately by the emitter. Notice that the polarities are reversed in Figures 1b and 2c compared to Figure 2a.

The DC current gain is equal to

DC Current Gain = I_C/I_B

when

I_C = output current, and

I_B = input current.

So the DC current gain is the ratio between the two currents which exist in an NPN type transistor; the current between the emitter and the collector, I_C , and the biasing current, I_B , acts as a control passing current into the base terminal of the transistor. The ratio is designated as β (beta) and when β is large the size of the amplification of the transistor is enough for practical purposes. The current gain $I_C/I_E = \alpha$ (alpha). The electrons which diffuse across the junction control α so the value for α is a function of the transistor. Alpha is approximately unity. I.e, the emitter current is equal to the amount of the base current (which is very small) added to the collector unit (which is very large). (See fig. 3)

Figure 3 NPN transistor connection

A graph of the output characteristics curves is useful because the DC load line can be drawn and the value for the Q point (operating point) can be identified. The slope of each output curve is the output conductance. Each

line has a portion that is close to horizontal which demonstrates that changing V_{ce} (the collector emitter voltage) has close to a zero effect on the collector current along this portion of the graph. If V_{ce} has little to no effect on V_{cc} then it can be assumed that transistor output is in series with a large value resistor. A graph with only the output characteristics has V_{cc} (as voltage) for the x-axis and I_{ce} (as mA) for the y-axis. A Class A Amplifier operates halfway between two regions: the cut-off and the saturation so the base terminal remains biased the Base emitter junction has a forward bias. The purpose is to permit the transistor amplifier to reproduce the AC positive and negative halves, and overlay the AC input signal on the DC biasing voltage. Ohms law can be used to gain the necessary information from the graphs.

The equation for the Collector Current is

$$I_C = (V_{cc} - V_{CE})/R_L$$

when

R_L = the load resistor

V_{cc} = supply voltage, and

V_{ce} = Voltage drop between collector and emitter terminals.

Therefore in words the equation is when V_{ce} is equal to zero 0 (at saturation, A); I_C equals V_{cc}/R_L graphed on the same axes as when I_C is equal to zero (to the cut-off, B) then V_{cc} minus V_{ce} creates the dynamic load line. (See fig. 4)

The output curves represent the characteristics of transistors with the same Beta value. I_c = output collector current, V_{ce} = values of different base currents, I_b (if present). The Q point, Quiescent Point, is the graphed when V_{ce} is set at its initial value to allow the variance of the output up and down

when AC input signals are being amplified. (See fig. 4)

Figure 4 Output characteristics curves of bipolar transistor (Class A Amplifier)

Experimental Results

The DC analysis results showed that the measured data was consistent with the theoretical values. (See table 10)

AC analysis gain at midband (with bypass capacitor in circuit) experimental results were 138 volts and for the theory the reported value is 127-165 volts. There is a phase shift between V_{in} and V_{out} , this is a common emitter amplifier and the output voltage is $-V_R$ therefore the output is 180° out of phase in ideal conditions. Also the capacitor causes a partial phase shift between V_{in} and V_{out} .

AC analysis gain at midband (with no bypass capacitor in circuit) demonstrated a gain of -4.4 and by comparing the experimental and theoretical values there was a discrepancy. The experimental value was equal to -3.6. The theoretical value was equal to -4.4.

The frequency response of the amplifier; the frequency was set from 20 Hz to 1110 kHz. The response increases linearly reaching a maximum at 5 kHz, and then reached a plateau of about 50 kHz and then demonstrated a linear decrease.

Distortion was measured with the oscilloscope connected to the input channel of the amplifier and channel 2 was connected to the output. The signal generator voltage was increased until the output of the amplifier began to distort. I think the main cause of distortion was from the transistor.

References

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