Macau University of Science and Technology
CE102
Analog Circuit

Emitter Follower Report

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Objective

To understand and verify the features of an Emitter Follower circuit

To learn the methods to measure the parameters of an amplifier

Device Required

Digital Multi-Meter (DMM)

Resistors (1k, 2k, 4.3k, 56k)

Capacitors 10μ x 2

NPN BJT 2N3904

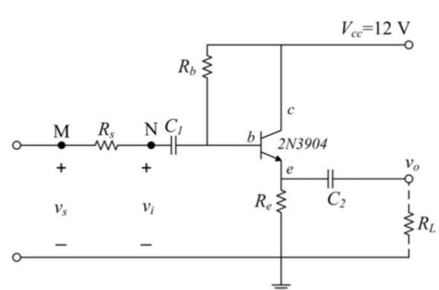
SS1798 DC Power Supply

Breadboard

EE1651 Function Generator

Tektronix TDS210 Digital Oscilloscope

Circuit Explanation



The common collector BJT amplifier, also called Emitter Follower, is one of the three basic BJT amplifier configurations. The name originates from its nearly unity voltage gain. The experimental circuit used in the lab is shown below. The parametersofthecircuitare: R_s =4.3KΩ, R_b =56KΩ, R_e =1.0KΩ, C1 =C2 = 10μF. The BJT used is 2N3904, a general purpose NPN BJT, whose datasheet can be found from $http://www.fairchildsemi.com/ds/2N/2N3904.pdf$.

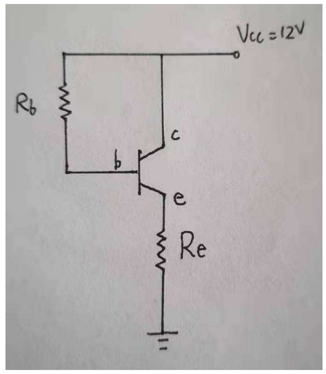
Prelab Questions

1. Find β of the BJT 2N3904 from its datasheet.

for β we recoganized is called DC current gain h_{FE}, and we found some data of β on the datasheet.

ON CHARACTERISTICS				
DC Current Gain (Note 2)		h_{FE}		
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3903		20	–
	2N3904		40	–
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3903		35	–
	2N3904		70	–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3903		50	150
	2N3904		100	300
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3903		30	–
	2N3904		60	–
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3903		15	–
	2N3904		30	–

2. Do DC analysis of the circuit and find Q point.



we assume β is 100, write KVL form V_{cc} to ground

V_{cc}-$i_b R_b$-0.7-$(1+\beta)i_b R_e$=0

Solve i_b=0.072mA

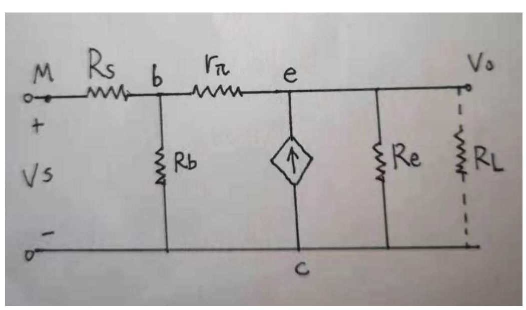
I_e=βi_b=7.2mA

i_c=βi_b=7.2mA, so we takes β=100

V_{cc}-V_{CEQ}-$(1+\beta)i_b R_e$=0

V_{CEQ}=9.728V

3. Do ac analysis of the circuit and find A_v, R_i, R_0.



V_0=$(1+\beta)i_b R_e$

V_0=7.272V

V_i=$i_b r_\pi$+$i_e R_e$=7.226V

$V_s = \left(\frac{i_b r_\pi+(1+\beta)i_b R_e}{R_b} + i_b\right) R_s + i_b r_\pi + (1+\beta) i_b R_e$

V_s=8.167V

A_v=$\frac{V_0}{V_s}$=0.89

R_i=$\frac{V_i}{\left(\frac{i_b r_\pi+(1+\beta)i_b R_e}{R_b}+i_b\right)}$=35.95k$\Omega$

R_0=R_e=1kΩ

Procedures

Circuit Set up

Without applying the dc power, connect the circuit on the breadboard. Carefully check all connection to make sure there is no short-circuit in your setup. As much as possible, make sure that the devices are not too tightly connected

When getting BJT CN3904, note that the cut side of the cylinder faces you, 'ebc' from left to right.

Measurement of DC operational point

Turn on the +12V DC supply, Note that when you see a value, press the onoff button and then continue. Use the functional generator to generate a 1kHz, 2 V (peak-to-peak) sinusoidal signal and apply it to point M. Using the two channels of the oscilloscope to monitor V_i and V_0. Check if the output voltage V_0 is correct. Then remove the ac input signal from point M. Using the DMM to measure the dc voltages of the three terminals of the BJT and fill Table. Those values show where the location of Q-point is.

the experimental record data are in below.

At Prelab part, my theory caculation is I_e is 7.2 mA, and real tested data as shown is

Table 2.1: DC operational point

R_e (kΩ)	V_B (V)	V_C (V)	V_E (V)	V_{CE} (V)	$I_E = \frac{V_E}{R_e}$ (mA)
1	9.604	8.930	3.059	3.059	8.93

8.93 mA, it has a little error. Introduces some errors into the overall experiment, possibly due to errors in the bias voltage, as well as errors in the accuracy of the measurement instrument itself.Taken together, this may be a signal resistance and op amp bias problem, or an op amp supply voltage problem, or an op amp input/output range, or an output driving capability problem.

Measurement of Amplifier Voltage Gain

Connect a 1 kΩ resistor as the load RL and apply a 1 kHz ac signal to point M. Using the two channels of the oscilloscope to monitor V_i and V_0. Adjust the amplitude of input signal at different values and check the amplitude of output V_0.

the experimental record data are in below.

Table 2.2: Voltage Gain of a BJT Amplifier

$v_{i,peak-to-peak}$ (V)	$v_{o,peak-to-peak}$ (V)	$A_v = \frac{v_o}{v_i}$
1 V	2	2
1.6 V	3	1.875
2.4 V	4.48	1.866
3 V	5.52	1.84

and my theory caculation is

V_0=$(1+\beta)i_bR_e$

V_0=7.226V

V_i=i_br_π+$i_e(R_e\|R_L)$=3.613V

$\frac{V_0}{V_i}$=2

Introduces some errors into the overall experiment, possibly due to errors in the bias voltage, as well as errors in the accuracy of the measurement instrument itself

Measurement of Input Resistance

Apply a 1 kHz, 1 V (peak-to-peak) ac signal to point M. Using the two channels of the oscilloscope to monitor V_i and V_0 and make sure the output is not distorted. Using the DMM in ac voltage mode to measure the potential of point M and N (i.e. the rms voltages of V_s and V_i). Please also measure the actual value of R_s and fill in the table. The input resistance can be calculated with the equation in Table 2.3.

the experimental record data are in below.
as shown before, theory calcuulation is R_i=$\frac{V_i}{\left(\frac{i_br_\pi+(1+\beta)i_bR_e}{R_b}+i_b\right)}$=35.95kΩ

Table 2.3: Measurement of Input Resistance

R_s (kΩ)	v_s (V)	v_i (V)	$R_i = R_s/(\frac{v_s}{v_i} - 1)$ (kΩ)
4.3	0.685	0.626	47.77

Introduces some errors into the overall experiment, possibly due to errors in the bias voltage, as well as errors in the accuracy of the measurement instrument itself.

Measurement of Output Resistance

Apply a 1 kHz AC signal to point M. Using Channel 1 of the oscilloscope to monitor V_i at point N. Adjust the Function Generator to get V_i,peak to peak = 2V . Without load, using Channel 2 to measure no-load output voltage V_0,rms; with R_L = 2 kΩ, using Channel 2 to measure load output voltage V_L,rms. Please also measure the actual value of R_L and fill in the table. The input resistance can be calculated with the equation in Table 2.4

the experimental record data are in below.

Table 2.4: Measurement of Output Resistance

R_L (kΩ)	$v_{o,rms}$ (V) at no-load	$v_{L,rms}$ (V) at $R_L = 2$ kΩ	$R_o = (\frac{v_{o,rms}}{v_{L,rms}} - 1)R_L$ (kΩ)
2.0	1.296	1.281	0.0234

Observation of the Maximum Swing

Apply a 1 kHz ac signal to point M. Using the two channels of the oscilloscope to monitor vi and vo. Adjust the Function Generator to increase the amplitude of input ac signal vi until the output voltage vo is distorted.

Aftter the experiment, the maximum input amplitude is 3.52V nearly

summary

For the same measurement point on the circuit, or any other measurement, the measured value and the theoretical value will produce a deviation, this deviation is related to the accuracy of the measurement equipment, that is, there is an inherent error. In the circuit, the deviation of the output signal from the theoretical value to the measured value is mainly determined by the non-linear characteristics of the transistor and the frequency response capability.