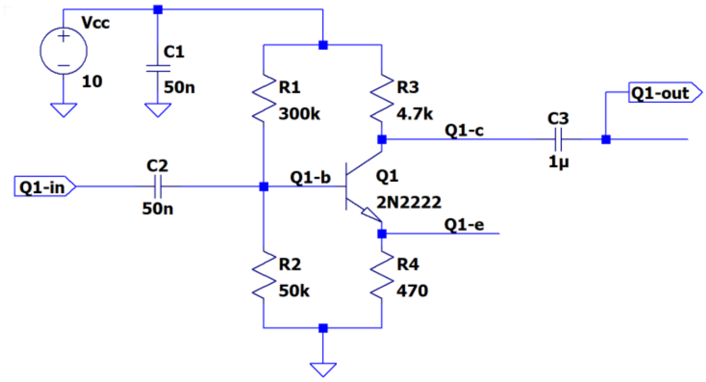
REPORT

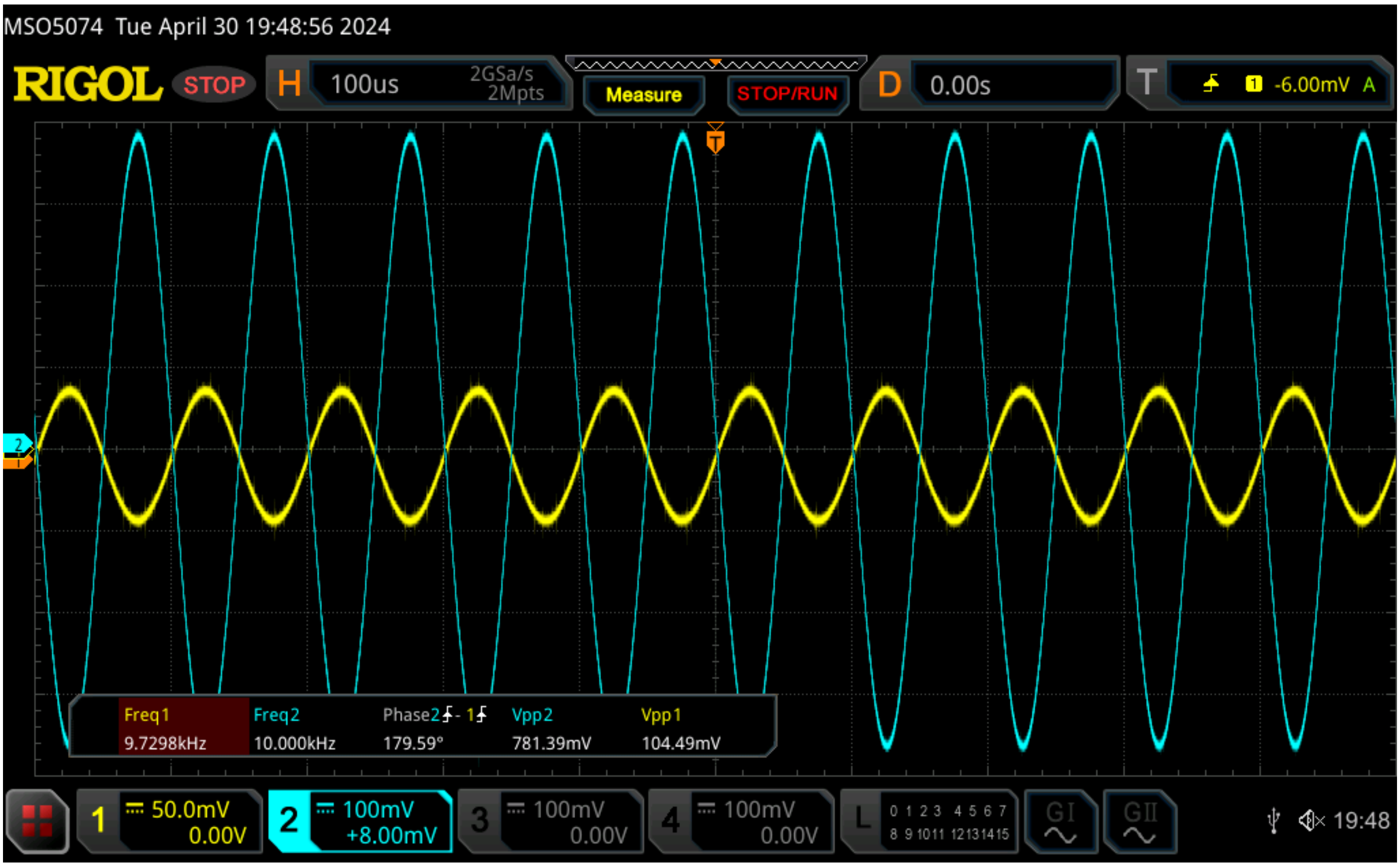
Experiment 1: Common Emitter Amplifier



2 DC bias point and other parameters (Note: NO SMALL SIGNAL INPUT)

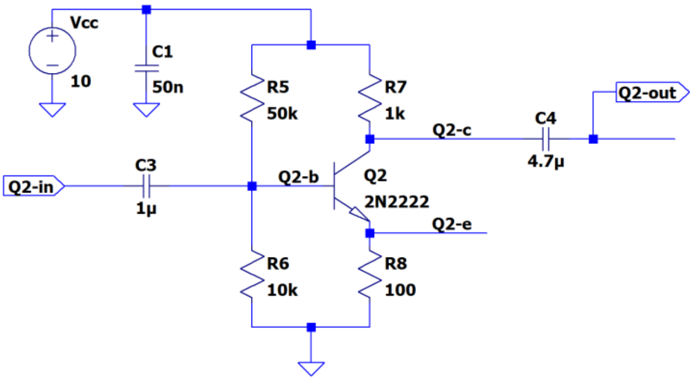
Vb (V)	Vc (V)	Ve (V)	Vbe (V)	Vce (V)	Ic (A)	Ib (A)	current gain (A/A)
1.12	**4.63**	0.51	**0.6**	**4.14**	**1mA**	**0.006mA**	**166.67**

3. Q1-in and Q1-out waveform



(Select one frequency in the middle band)

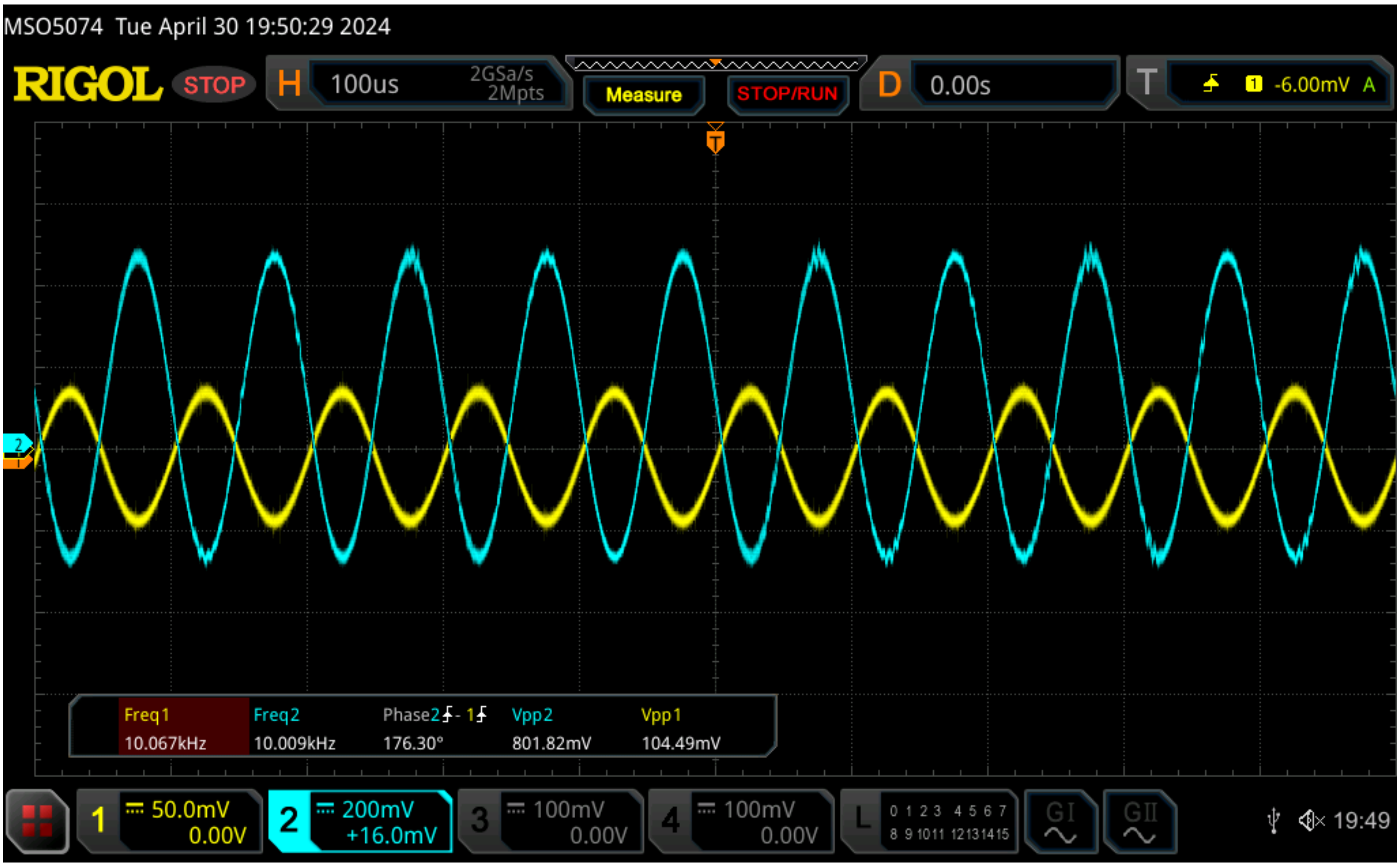
$f_{out,max}$ (Hz) (your choice)	vin (V)	vout (V)	voltage gain (V/V)	phase difference (out->in) (degree)
10k	**119.42mVpp**	**794.41mVpp**	**6.65**	**177.15**



6 DC bias point and other parameters (Note: NO SMALL SIGNAL INPUT)

Vb (V)	Vc (V)	Ve (V)	Vbe (V)	Vce (V)	Ic (A)	Ib (A)	current gain (A/A)
1.38	**3.93**	**0.68**	**0.7**	**3.25**	**6.5m**	**0.03m**	**216.67**

7. Q2-in and Q2-out waveform p9

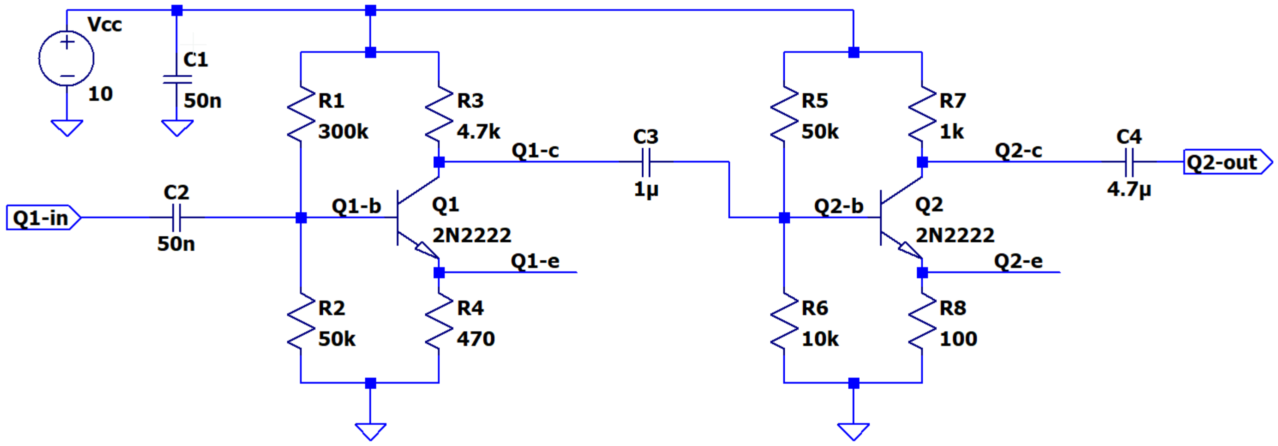


frequency = exp01-3 frequency

$f_{out,max}$ (Hz)	vin (V)	vout (V)	voltage gain	phase difference

			(V/V)	(out->in) (degree)
10k	**100.22mVpp**	**761.45mVpp**	**7.60**	**177.06**

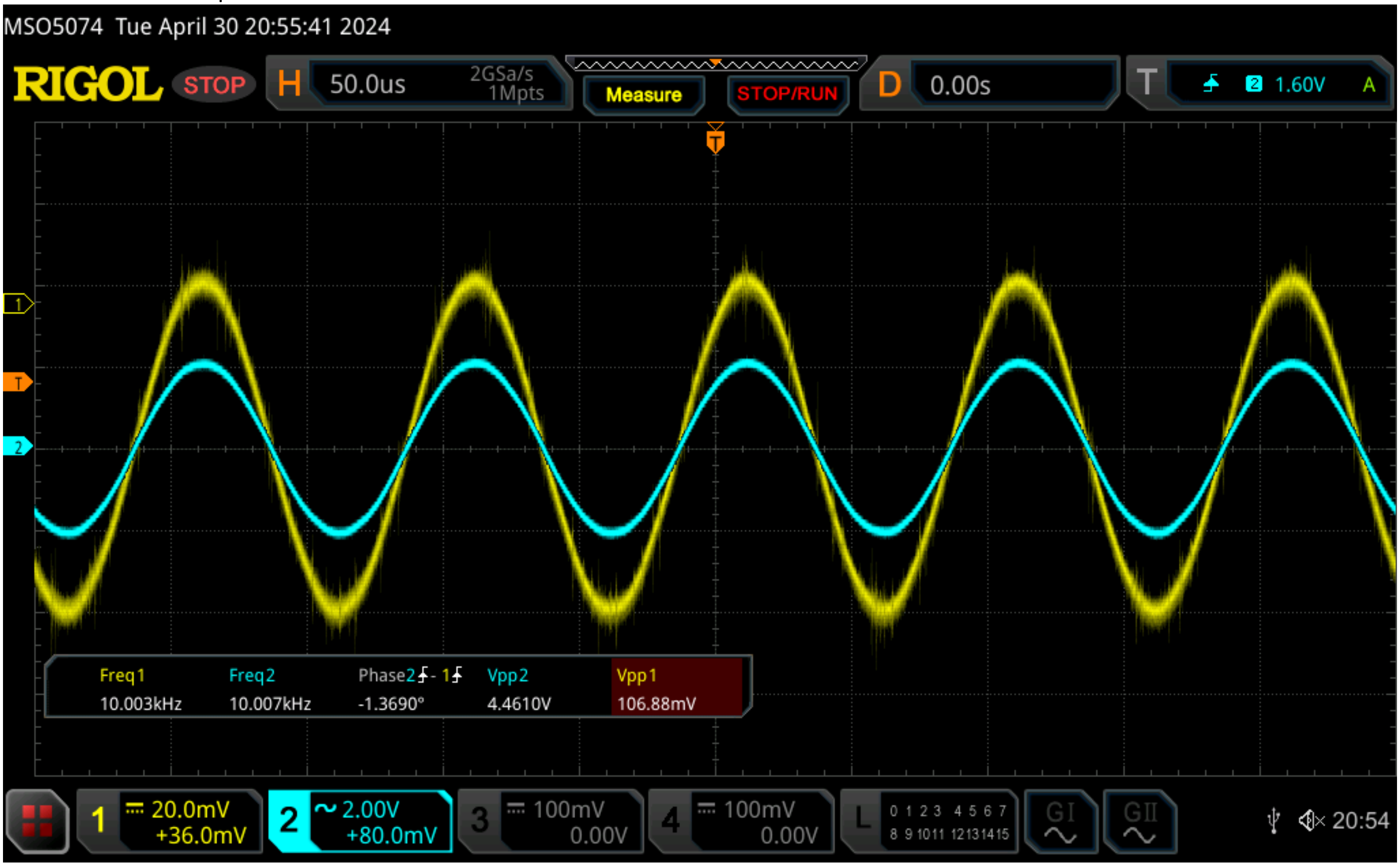
Experiment 2: Cascade Amplifier (CE + CE)



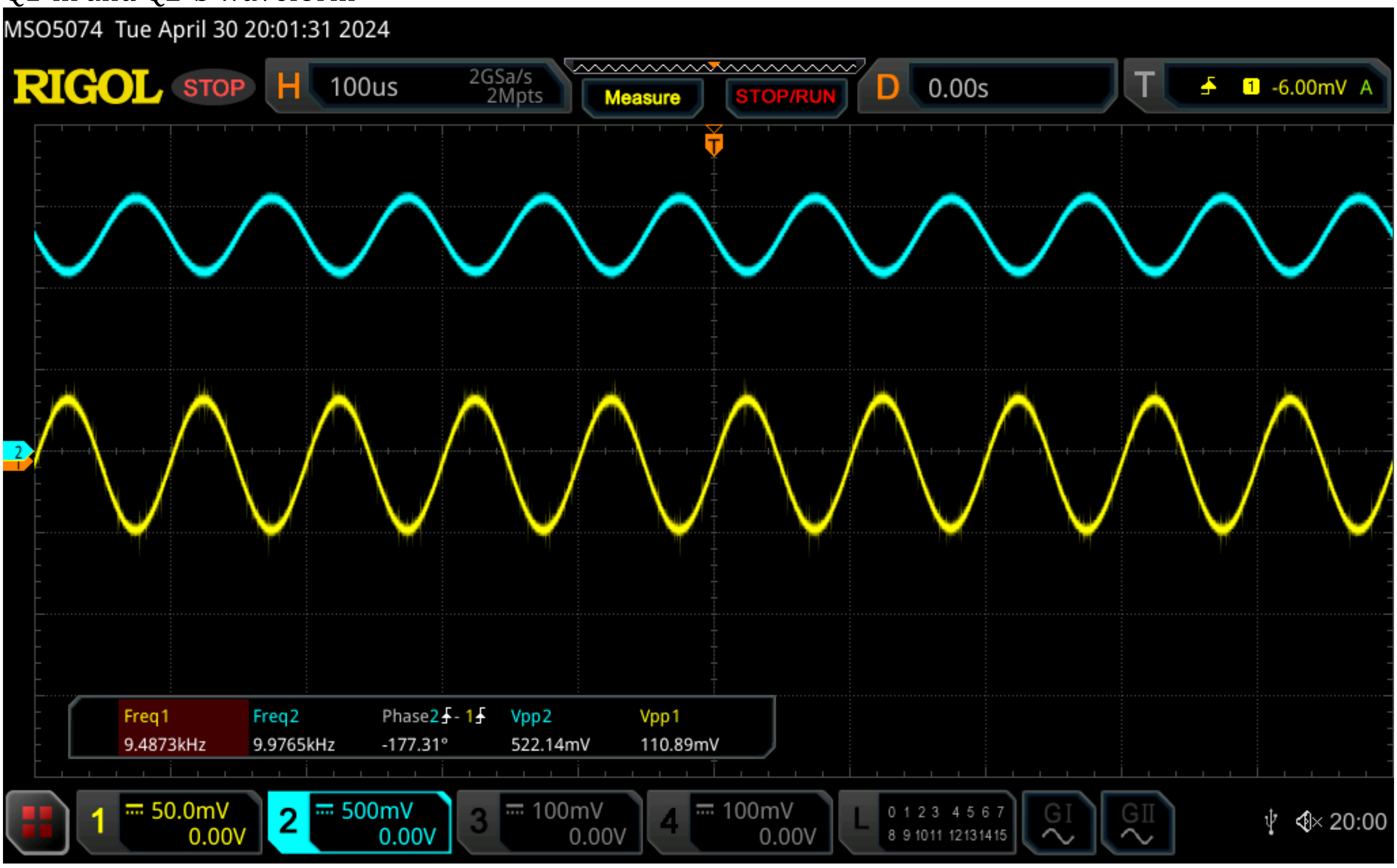
2 frequency = exp01-3 frequency 10,12,11

$f_{out,max}$ (Hz)	$V_{Q1\text{-}in}$ (V)	$V_{Q2\text{-}out}$ (V)	voltage gain (V/V)	phase difference (**Q2-out** -> **Q1-in**) (degree)
10k	**108.75mVpp**	**4.3134Vpp**	**39.66**	**-1.369**
	$V_{Q1\text{-}in}$ (V)	$V_{Q2\text{-}b}$ (V)	voltage gain (V/V)	phase difference (**Q2-b** -> **Q1-in**) (degree)
	110.89mVpp	**543.89mVpp**	**4.90**	**-176.36**
	$V_{Q1\text{-}c}$ (V)	$V_{Q2\text{-}out}$ (V)	voltage gain (V/V)	phase difference (**Q2-out** -> **Q1-c**) (degree)
	516.78mVpp	**4.3134Vpp**	**8.35**	**176.22**

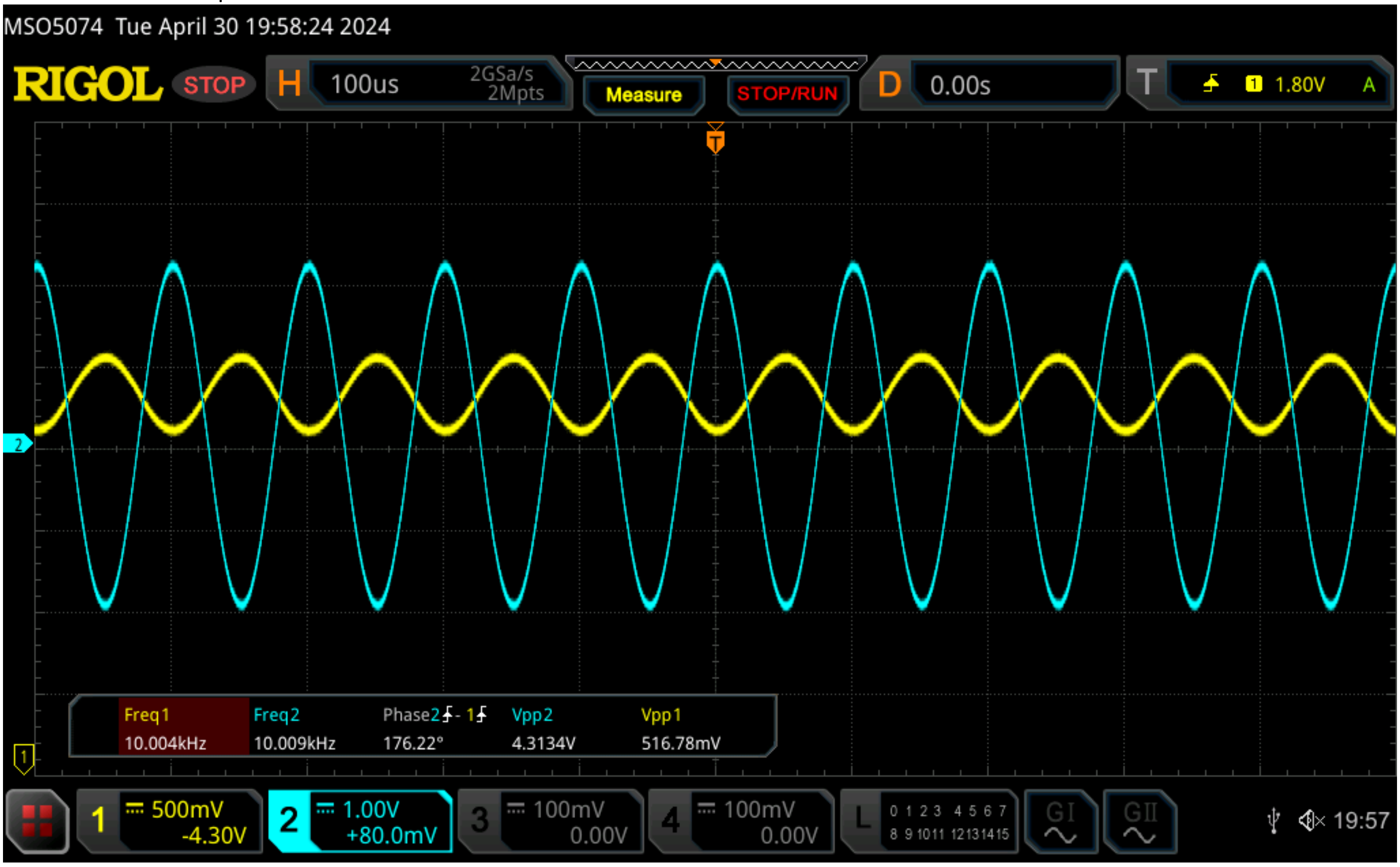
Q1-in and Q2-out waveform



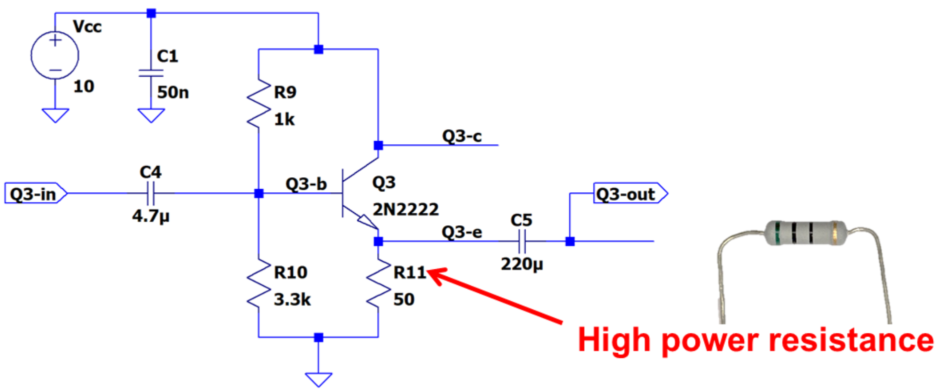
Q1-in and Q2-b waveform



Q1-c and Q2-out waveform



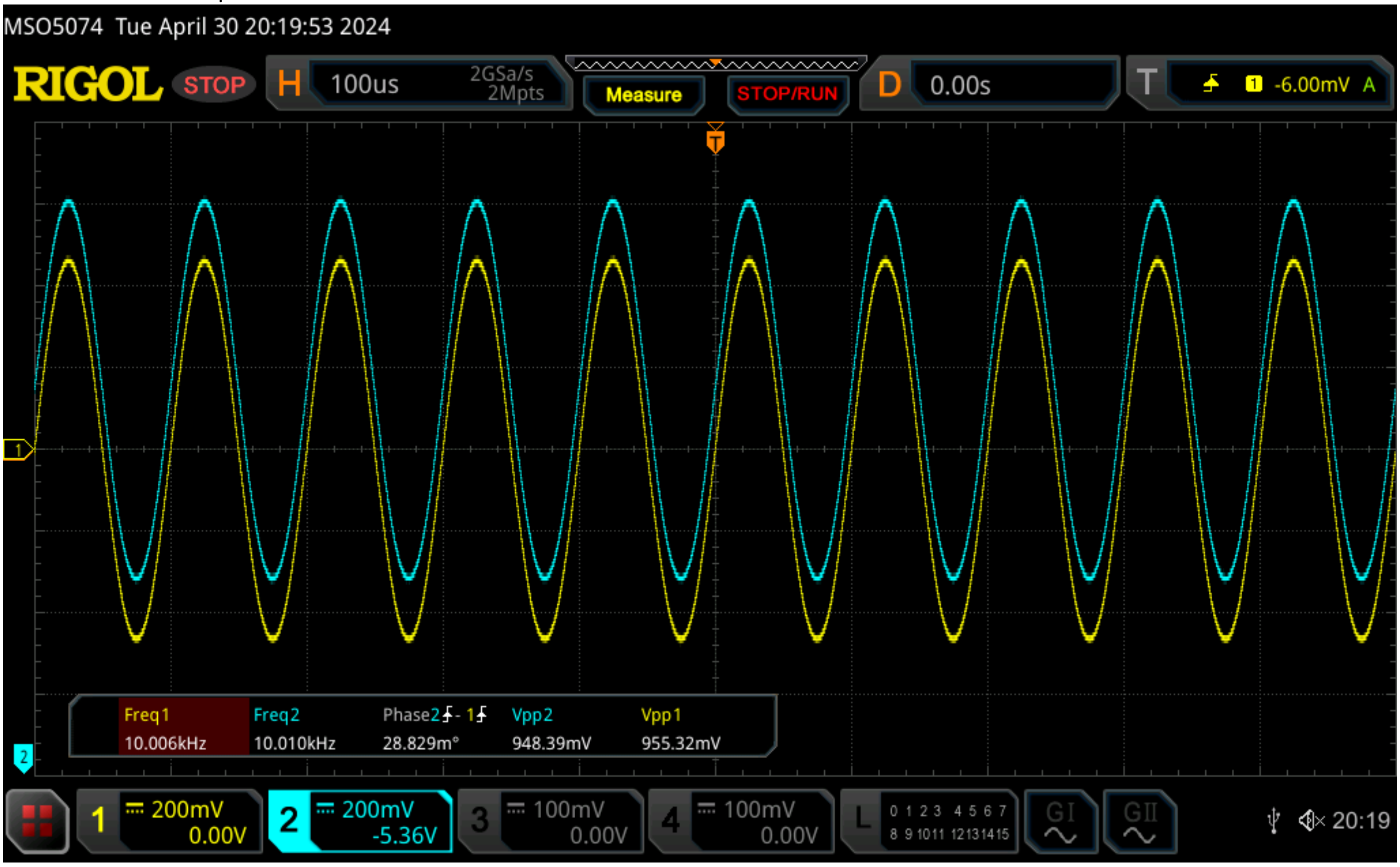
Experiment 3: Common Collector Amplifier



2 DC bias point and other parameters (Note: NO SMALL SIGNAL INPUT) 13

Vb (V)	Vc (V)	Ve (V)	Vbe (V)	Vce (V)	Ic (A)	Ib (A)	current gain (A/A)
7.1	**9.74**	**6.51**	**0.59**	**3.23**	**120.1m**	**0.5m**	**240.2**

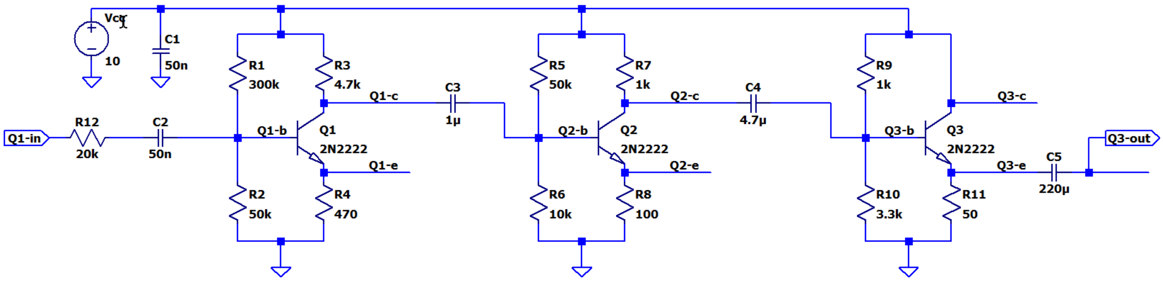
3. Q3-in and Q3-out waveform



frequency = exp01-3 frequency

$f_{out,max}$ (Hz)	vin (V)	vout (V)	voltage gain (V/V)	phase difference (out->in) (degree)
10k	**955.32mVpp**	**948.39mVpp**	**0.99**	**28.829m**

Experiment 4: Audio application(CE + CE + CC)



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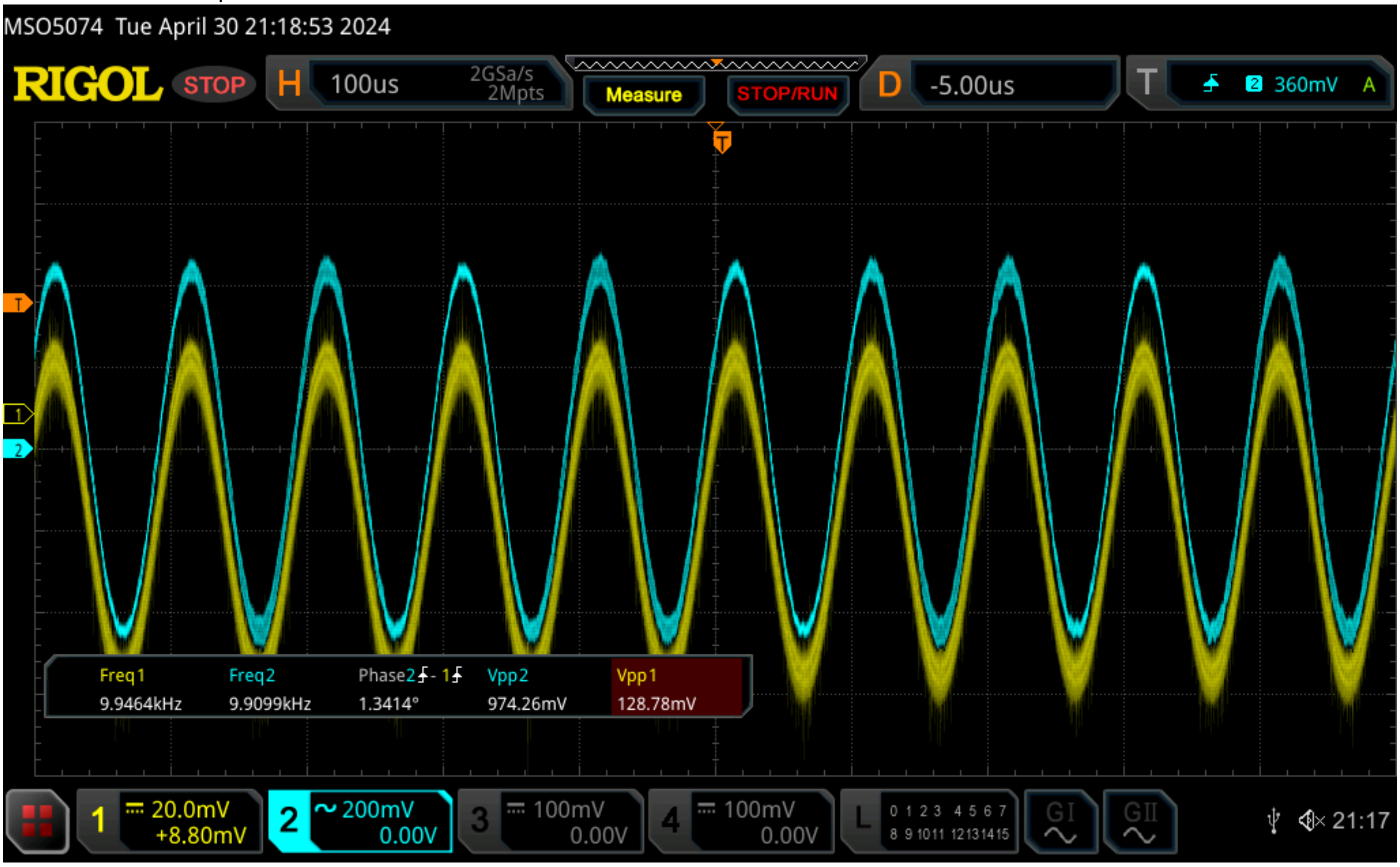
AC SWEEP waveform (node out2)

fL3dB (Hz)	fH3dB (Hz)	Bandwidth (Hz)	Vout,max (V)	fout,max (Hz)
120	**290k**	**289.88k**	**1.3105Vpp**	**10k**

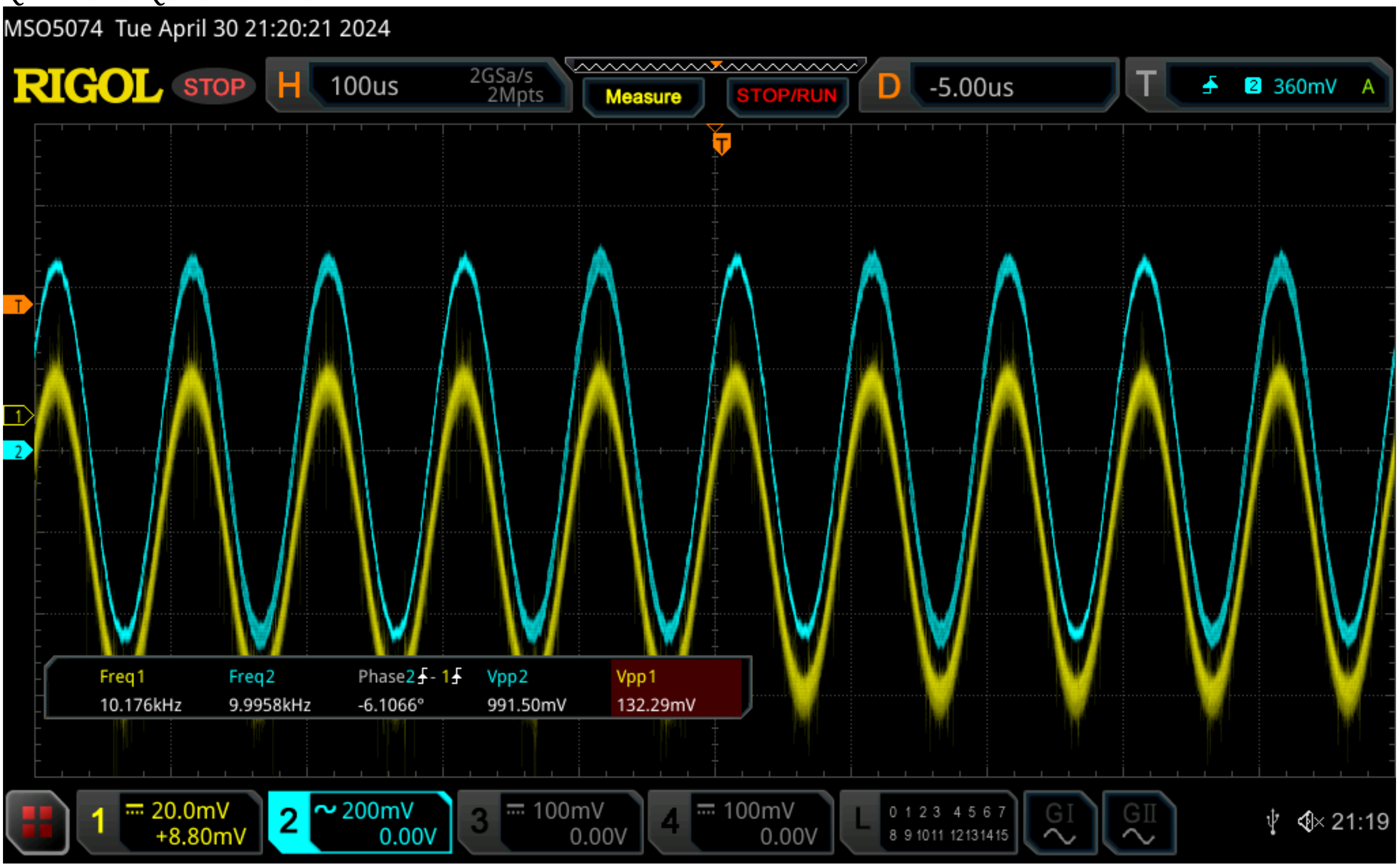
3. frequency = exp01-3 frequency

$f_{out,max}$ (Hz)	$V_{Q1\text{-in}}$ (V)	$V_{Q3\text{-out}}$ (V)	voltage gain (V/V)	phase difference (**Q3-out** -> **Q1-in**) (degree)
	128.78mVpp	**974.26mVpp**	**7.57**	**1.3414**
	$V_{Q1\text{-in}}$ (V)	$V_{Q3\text{-b}}$ (V)	voltage gain (V/V)	phase difference (**Q3-b** -> **Q1-in**) (degree)
10k	**132.29mVpp**	**991.50mVpp**	**7.49**	**-6.1066**
	$V_{Q2\text{-c}}$ (V)	$V_{Q3\text{-out}}$ (V)	voltage gain (V/V)	phase difference (**Q3-out** -> Q2-c) (degree)
	1.0335Vpp	**1.0087Vpp**	**0.976**	**0.32409**

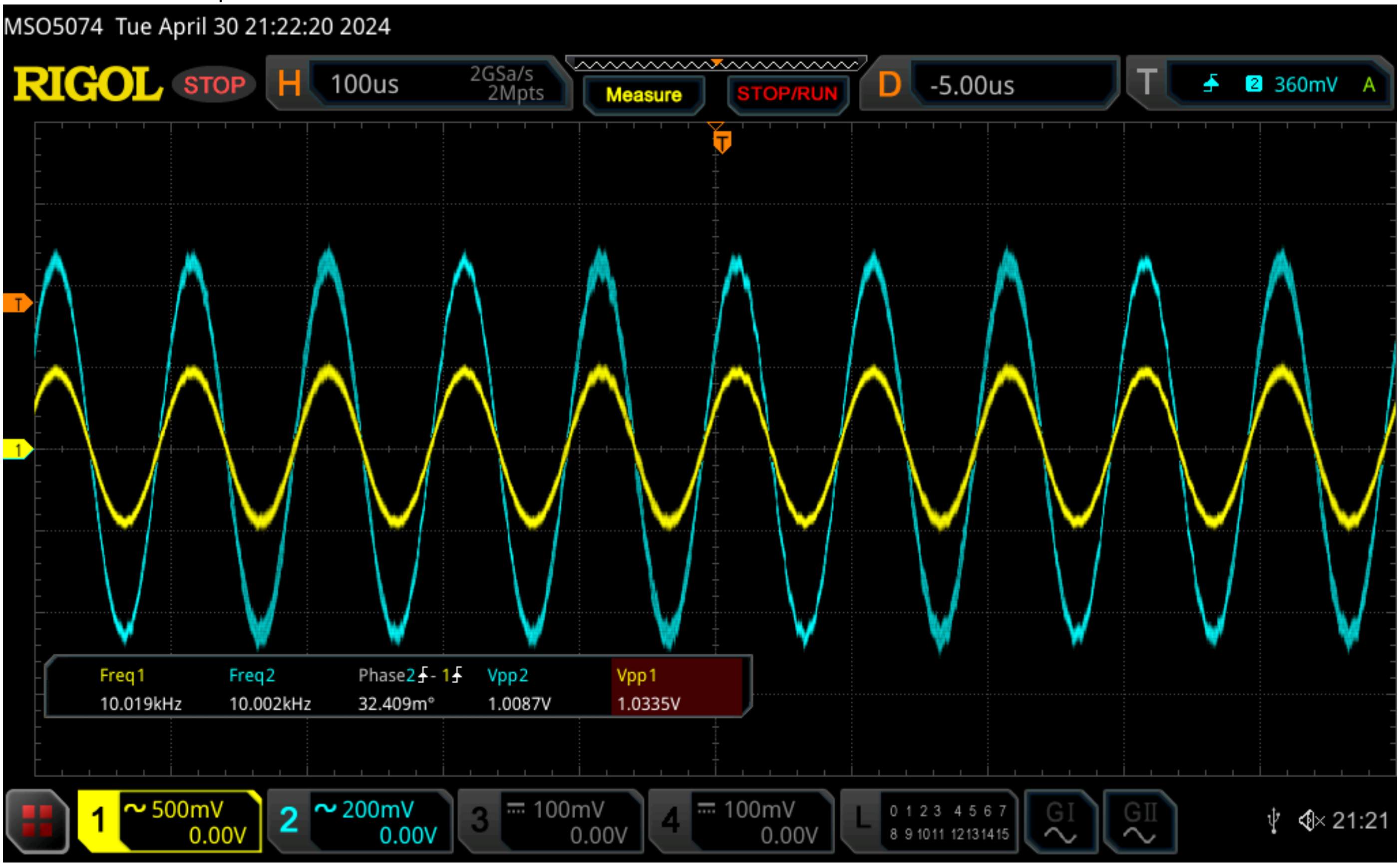
Q1-in and Q3-out waveform



Q1-in and Q3-b waveform



Q2-c and Q3-out waveform



4. Describe what you heard.

The frequency range of human voice covers a range of 100Hz to 17kHz. This is well within the bandwidth of the amplifier. Therefore, the voice coming out from the speaker was fairly clear.

This experiment explores the different configuration of transistor amplifiers.

The basic gain cell of IC amplifiers is the CE (BJT)or CS (MOSFET) amplifier. The maximum gain possible is defined as the intrinsic gain, A_0.

MOSFET:

$$A_0 = \frac{V_A}{\frac{V_{ov}}{2}}$$

The intrinsic gain of a MOSFET is inversely proportional to $\sqrt{I_D}$

BJT:

$$A_0 = \frac{V_A}{V_T}$$

The intrinsic gain of a BJT is independent of bias current and device dimensions.

The CB (BJT) or CG (MOSFET) amplifier is used as a current buffer. It has low input impedance and high output impedance. This allows it to provide a current gain of approximately 1.

The CC (BJT) (Emitter Follower) or CD (MOSFET) (Source Follower) amplifier is used as a voltage buffer. It has high input impedance and low output impedance. This allows it to provide a voltage gain of approximately 1.

I have compiled the input resistance, output resistance, and gain of MOSFET and BJT amplifiers in the following charts:

BJT Amplifier With r_o			
Type	R_i	R_o	A_v
CE	r_π	$r_o \| R_c$	$-g_m(R_c \| R_L \| r_o)$
CE with Re	$(\beta+1)(r_e+R_e)$	$R_e \| r_\pi + r_o + g_m r_o (R_e \| r_\pi)$	$-\frac{R_c}{R_e}$
CB	$r_\pi \| \frac{R_L + r_o}{1 + g_m r_o}$	$R_e \| r_\pi + r_o + g_m r_o (R_e \| r_\pi)$	$\frac{R_c}{R_e}$
(CC) Emitter Follower	$(\beta+1)(r_e+R_e)$	$\frac{1}{g_m} \| r_o \| R_e$	$\frac{(R_E \| r_o)}{(R_E \| r_o) + \frac{1}{g_m}}$

MOSFET Amplifier With r_o			
Type	R_i	R_o	A_v
CS	∞	$r_o \| R_D$	$-g_m(R_D \| R_L \| r_o)$
CS with Rs	∞	$R_s + r_o + g_m r_o R_s$	$\frac{-g_m r_o R_D}{R_D + R_s + r_o + g_m r_o R_s}$
CG	$\frac{R_L + r_o}{1 + g_m r_o}$	$R_s + r_o + g_m r_o R_s$	$(g_m + \frac{1}{r_o})(R_D \| R_L \| r_o)$
(CD) Source Follower	∞	$\frac{1}{g_m + \frac{1}{r_o}}$	$\frac{(R_L \| r_o)}{(R_L \| r_o) + \frac{1}{g_m}}$

References:

1. Fundamentals of Microelectronics (Behzad Razavi)
2. Microelectronic Circuits (Adel S. Sedra, Kenneth C. Smith)