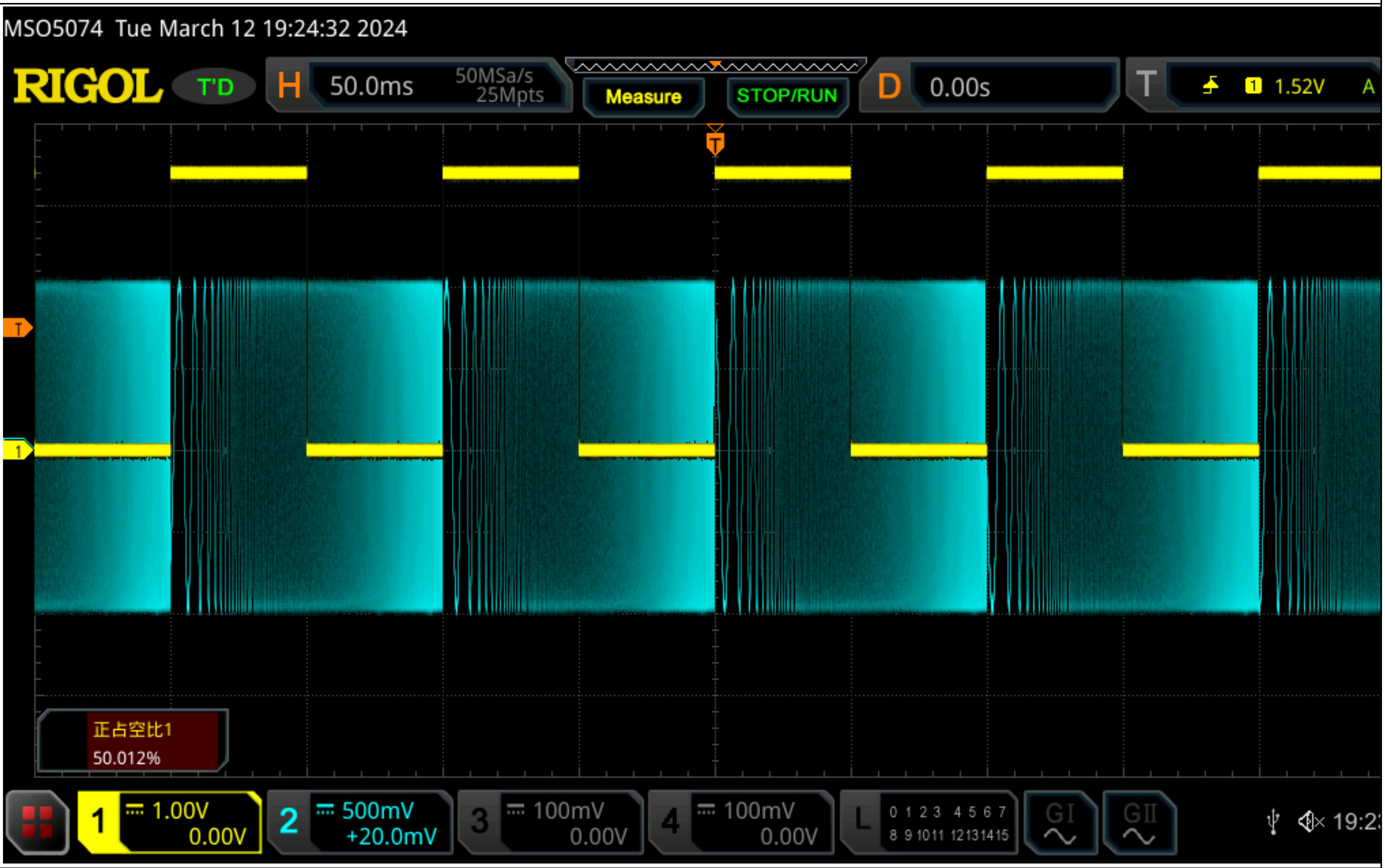
REPORT

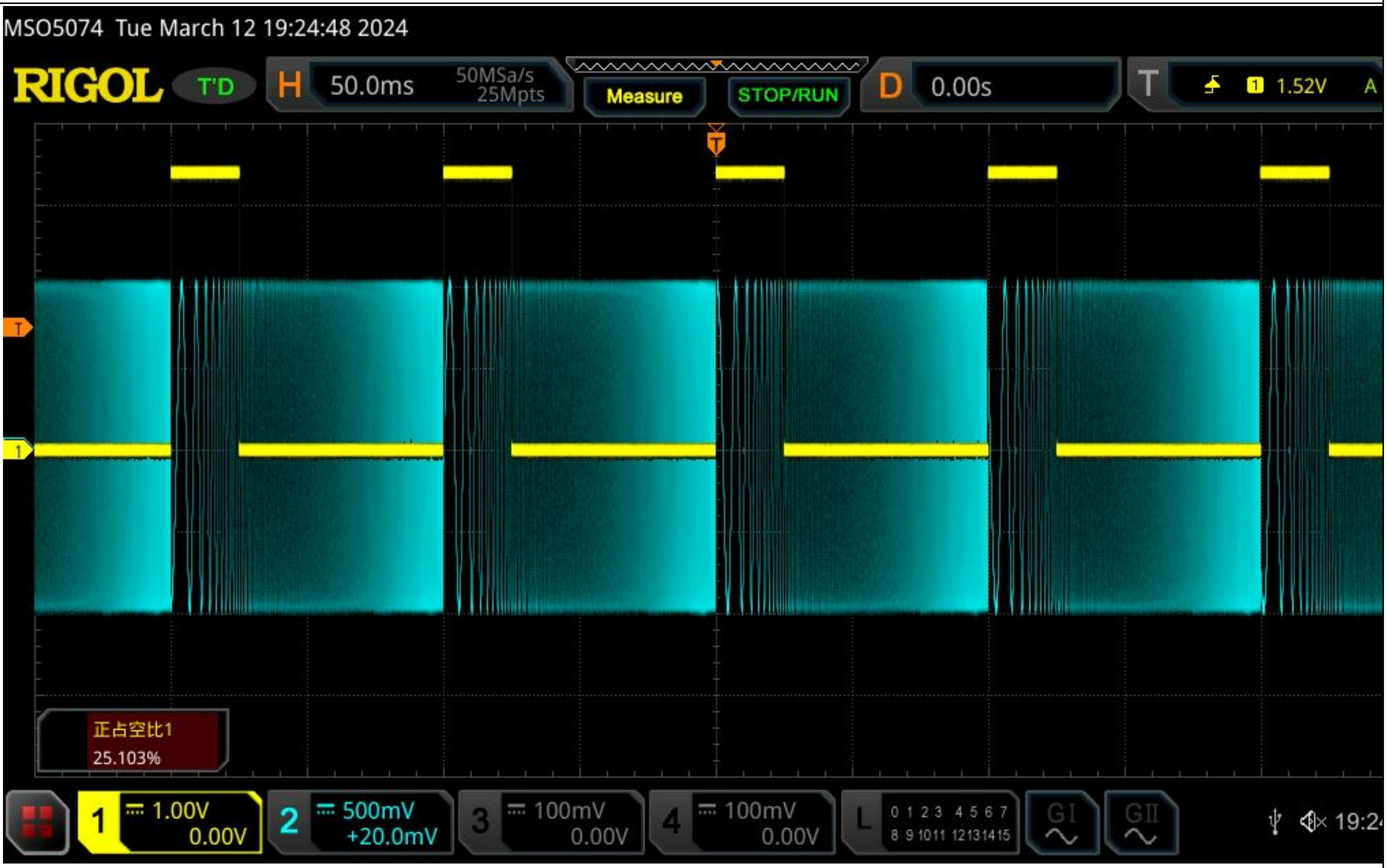
Experiment 0: Basic AC Sweep Configuration

1.

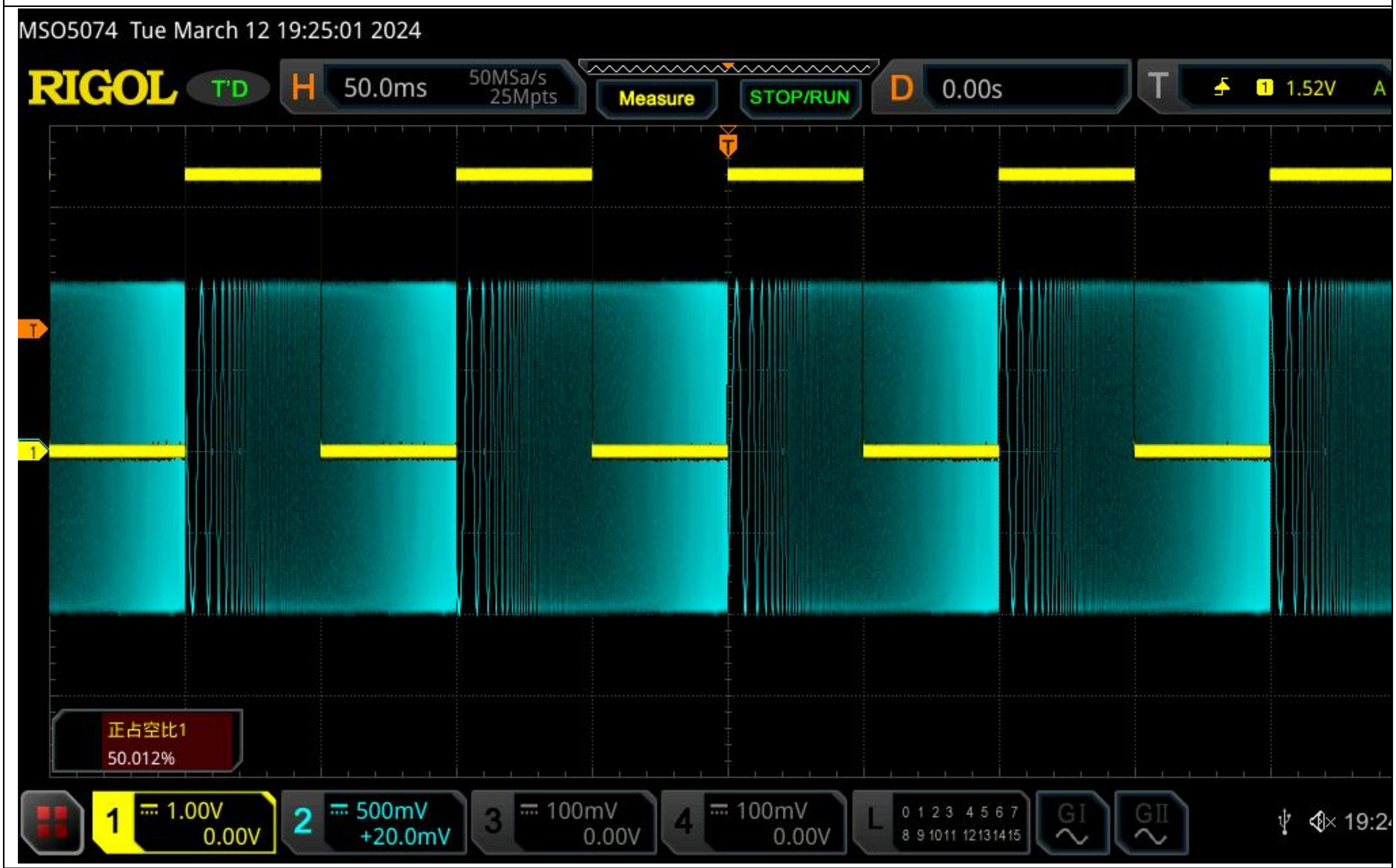
CH1(SYNC) and CH2(output) waveform
marker= off


2.

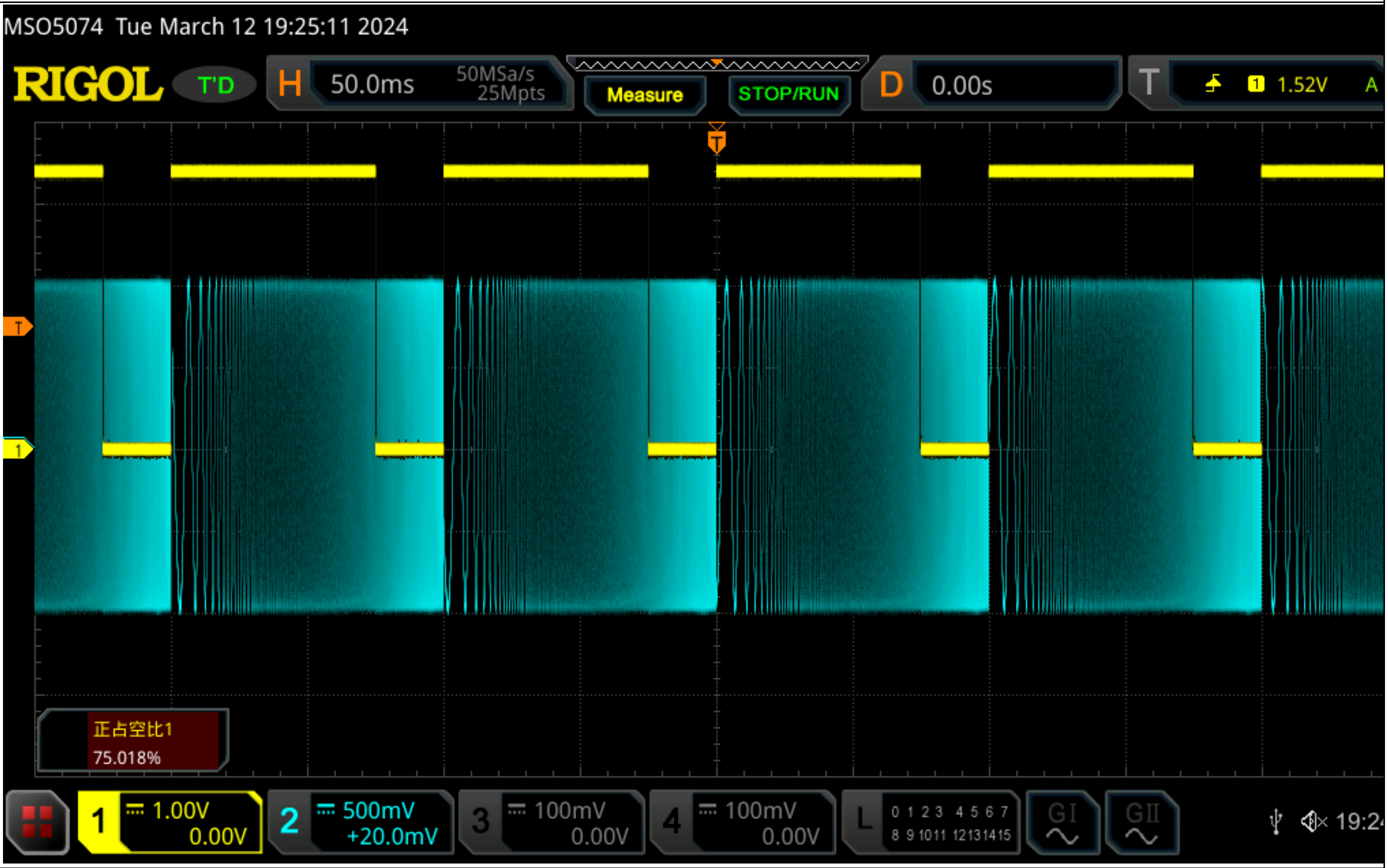
CH1(SYNC) and CH2(output) waveform
marker = 1k Hz



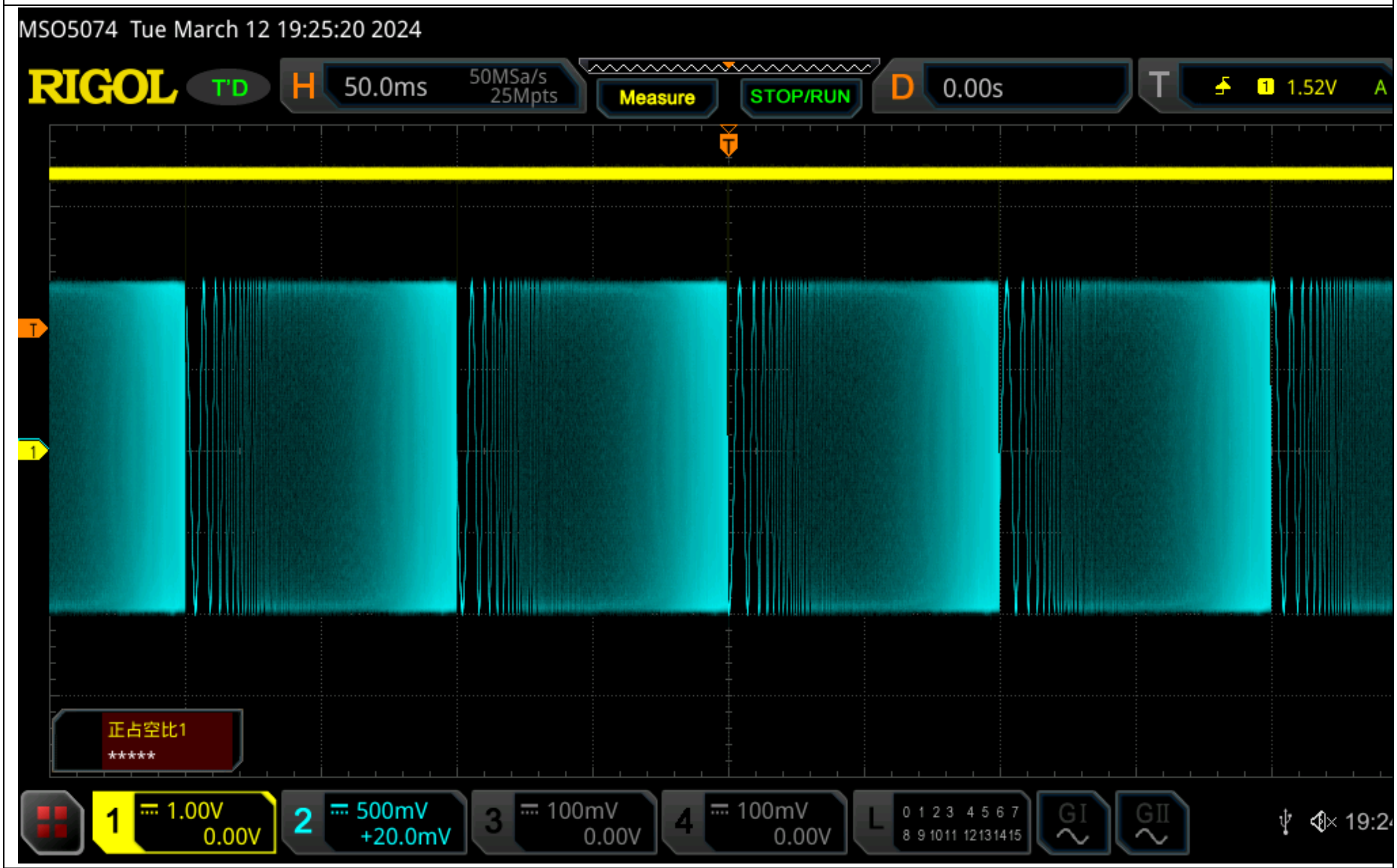
marker = 10k Hz



marker = 100k Hz



marker = 1M Hz



Question:

What did you find?

I found that the duty cycle of the marker increased alongside the marker frequency.

What is the main purpose of the marker frequency?

The marker is used to locate the 3dB frequency. We must match it with the waveform at 0.707 of its max amplitude.

What is the meaning of the "fish" waveform?

The "fish" is composed of sine waves of different frequency from1 Hz to 100k Hz. The lowest frequency is on the left and the highest frequency is on the right. The leftmost waves represent the maximum gain provided by the filter. The higher frequency waves to the right are attenuated by the filter. That's why the right side of the "fish" starts shrinking.

How do we find the 3dB frequency?

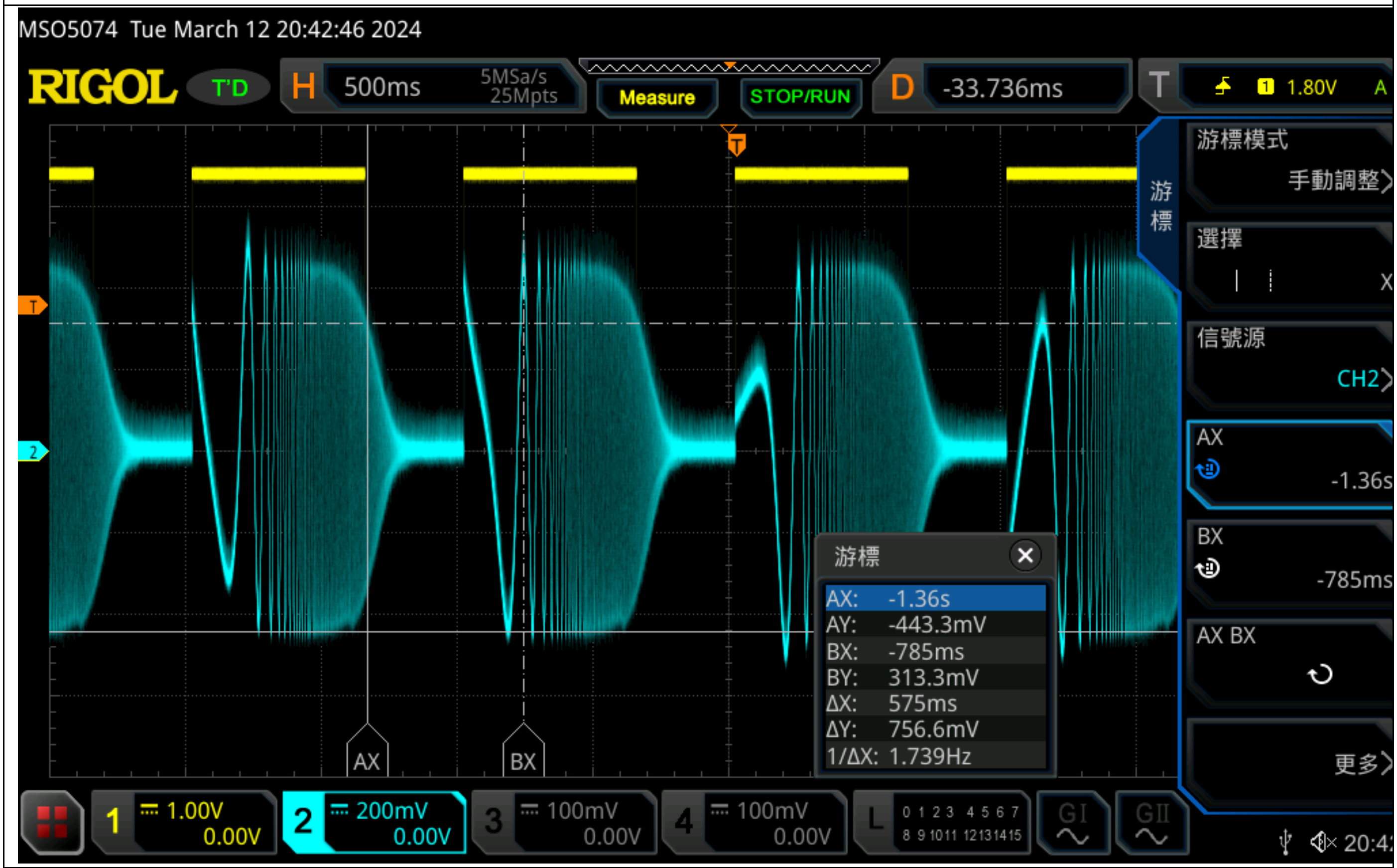
- **Vo / Freq. Plot**
  1. Find the maximum amplitude (not Vpp) of the waveform
  2. Multiply this value by $\frac{1}{\sqrt{2}}$ (0.707)
  3. Adjust the horizontal cursor to match this new value
  4. Adjust the vertical cursor to the intersection between the horizontal cursor and the waveform
  5. Change the marker frequency on the FG so that the marker's edge intersects with the vertical cursor
  6. The marker frequency is approximately the 3dB frequency

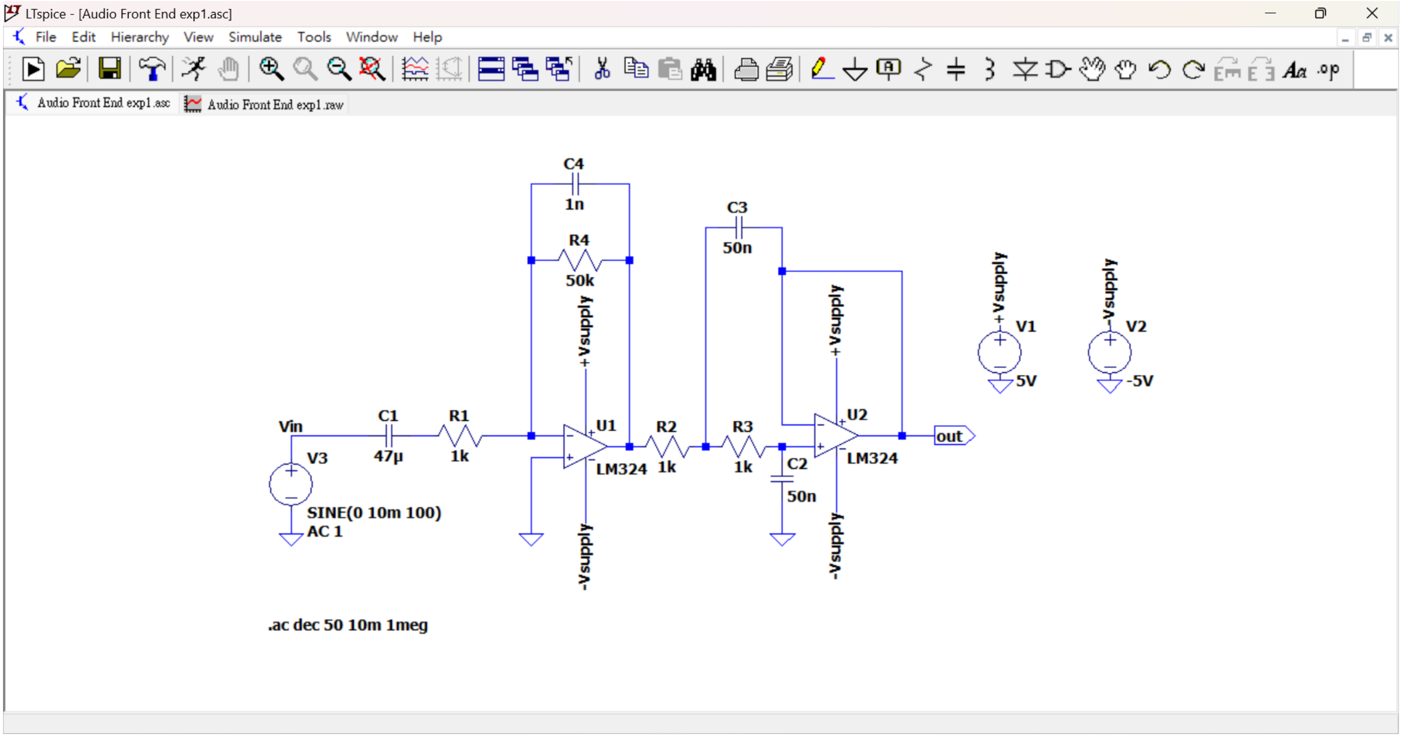
- **Bode Plot**
  1. Place one cursor at the highest point of the plot, marking the maximum gain.
  2. Slide the second cursor to the point where there's a -3dB difference between it and the 1^{st} cursor.
  3. The frequency marked by the 2^{nd} cursor is approximately the 3dB frequency

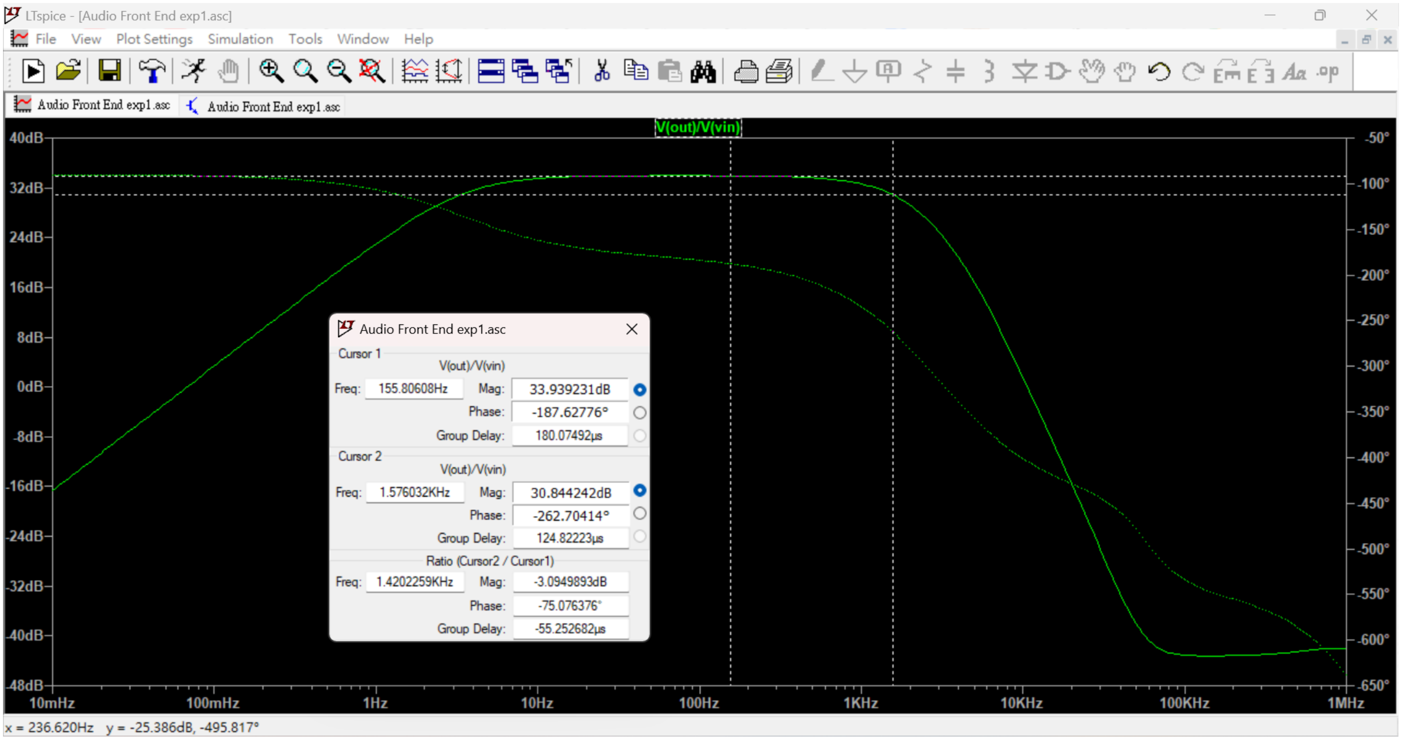
Experiment 1: Split Supply vs. Single Supply

1~3

DC Bias Voltage			
V+ on U1 (V)	Vout on U1 (V)	V+ on U2 (V)	Vout on U2 (V)
0	0	0	0
AC SWEEP result			
High 3dB frequency = 1.5k Hz			

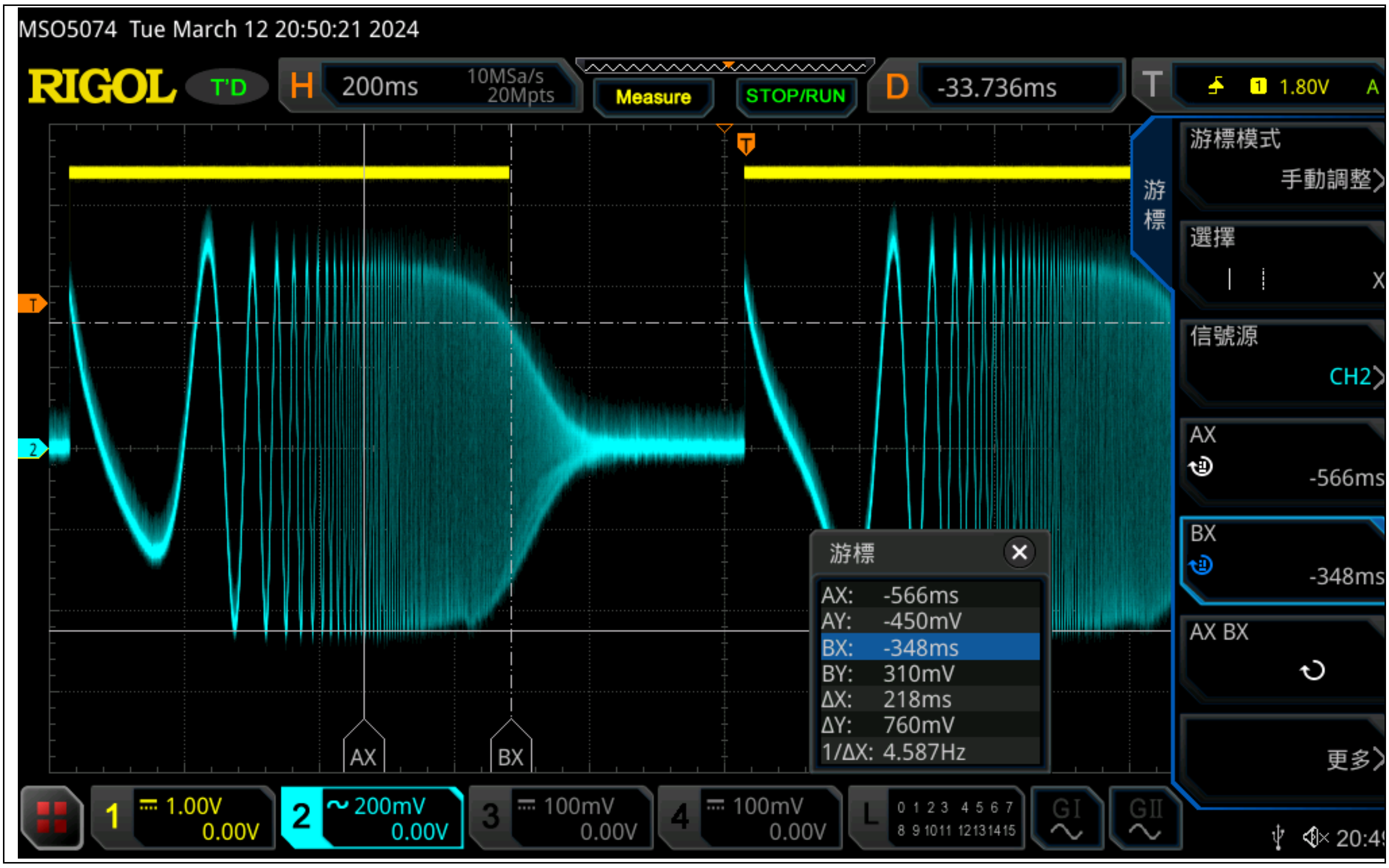


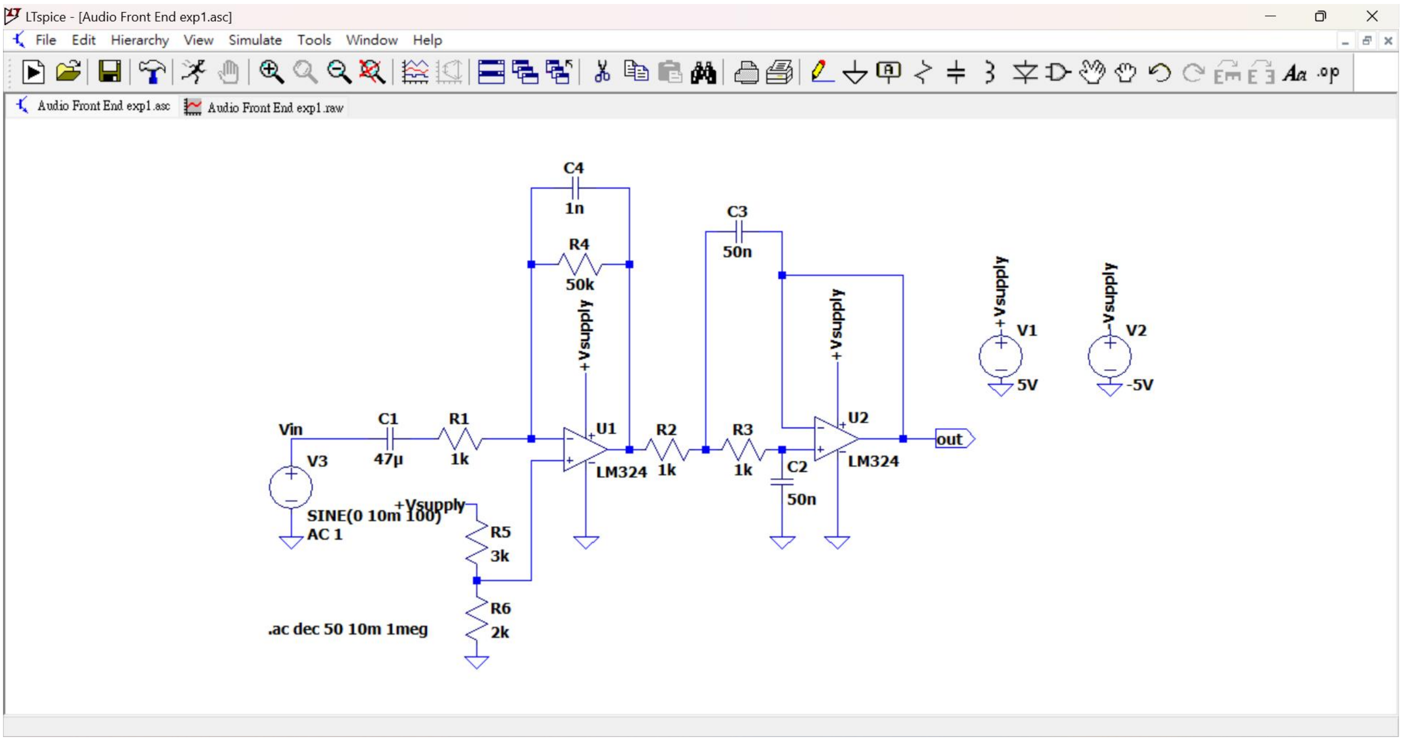


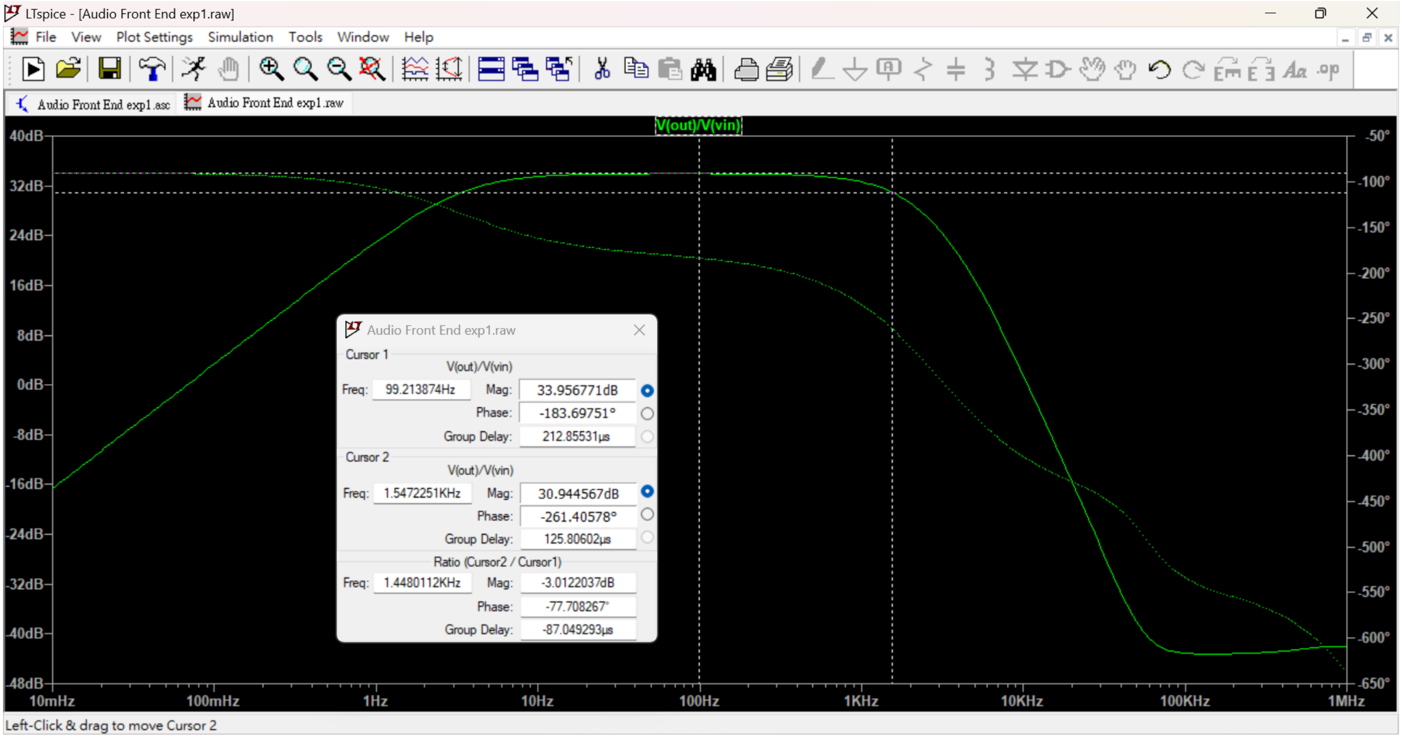


4~6

DC Bias Voltage			
V+ on U1 (V)	Vout on U1 (V)	V+ on U2 (V)	Vout on U2 (V)
1.98	1.98	1.98	1.98
AC SWEEP result			
High 3dB frequency = 1.8k Hz			


MSO5074 Tue March 12 20:50:21 2024
RIGOL
T'D
H 200ms
10MSa/s
20Mpts
Measure
STOP/RUN
D -33.736ms
T 1.80V
游標模式
手動調整
選擇
信號源
CH2
AX
-566ms
BX
-348ms
AX BX
更多
游標
AX: -566ms
AY: -450mV
BX: -348ms
BY: 310mV
ΔX: 218ms
ΔY: 760mV
1/ΔX: 4.587Hz
AX
BX
1 1.00V 0.00V
2 200mV 0.00V
3 100mV 0.00V
4 100mV 0.00V
GI
GII


LTspice - [Audio Front End exp1.asc]
File Edit Hierarchy View Simulate Tools Window Help
Audio Front End exp1.asc
Audio Front End exp1.raw
C4
1n
R4
50k
C3
50n
+Vsupply
+Vsupply
U1
U2
LM324
LM324
Vin
C1
47µ
R1
1k
R2
1k
R3
1k
C2
50n
out
V3
SINE(0 10m 100)
AC 1
+Vsupply
R5
3k
R6
2k
+Vsupply
V1
5V
-Vsupply
V2
-5V
.ac dec 50 10m 1meg



Split Supply:

The split supply op-amps allows for both positive and negative signal swings (in this experiment, it accepts swings from -5V to 5V). This is required for applications such as audio amplifiers, instrumentation systems, and analog signal processing. They provide better symmetry and linearity for both positive and negative input/output signals.

Single Supply:

In a single supply op-amp, the input and output voltage ranges are limited to positive voltages only(0V to 5V in this experiment), usually referenced to ground (0V). In this case, any negative voltage swing in the input signal will be limited or clipped at ground level (0V), resulting in distortion. However, we applied an additional 2V at the non-inverting input. This provides an offset voltage to the signal and prevents it from being clipped.

Filter Terms:

- **Passband:**

  The passband is the range of frequencies in a filter's frequency response where the filter is designed to pass signals with minimal attenuation or signal loss.

- **Stopband:**

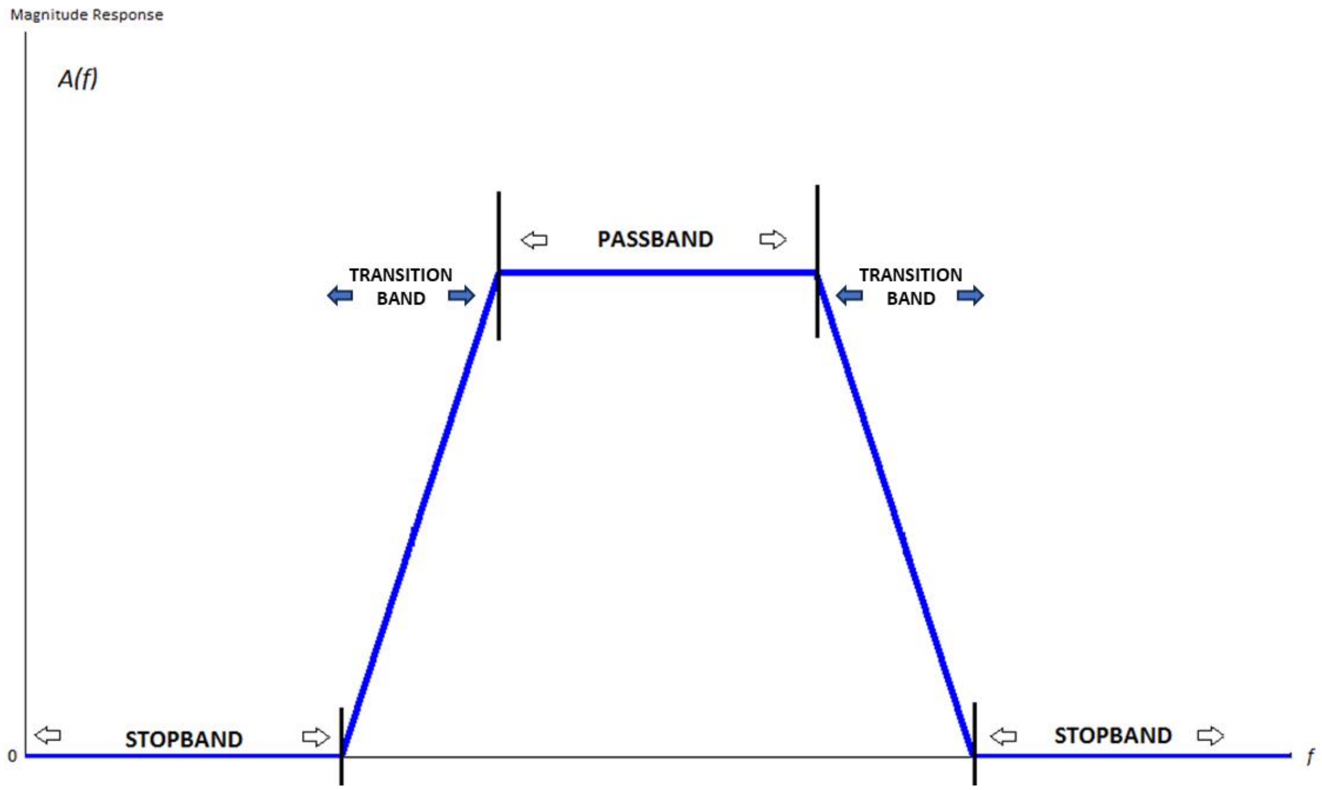
  The stopband refers to the range of frequencies that the filter is intended to attenuate or reject. It is the frequency band where the filter's frequency response is expected to have a very low gain or magnitude.

- **Transition Band (Roll-off Region):**

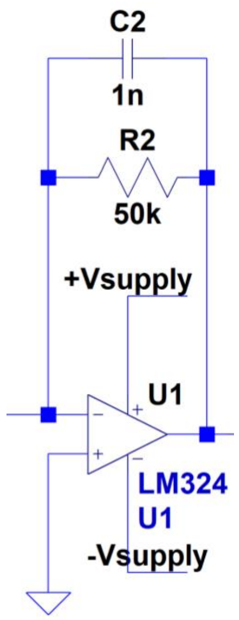
  The frequency range in a filter's frequency response that lies between the passband and the stopband.

- **Roll-off:**

  A filter roll-off refers to the rate at which the filter's frequency response transitions from the passband to the stopband. It describe how quickly the filter attenuates or rejects frequencies beyond the cutoff frequency. The roll-off is typically expressed in decibels per octave (dB/octave) or decibels per decade (dB/decade).



First-Order Low-Pass Filter:



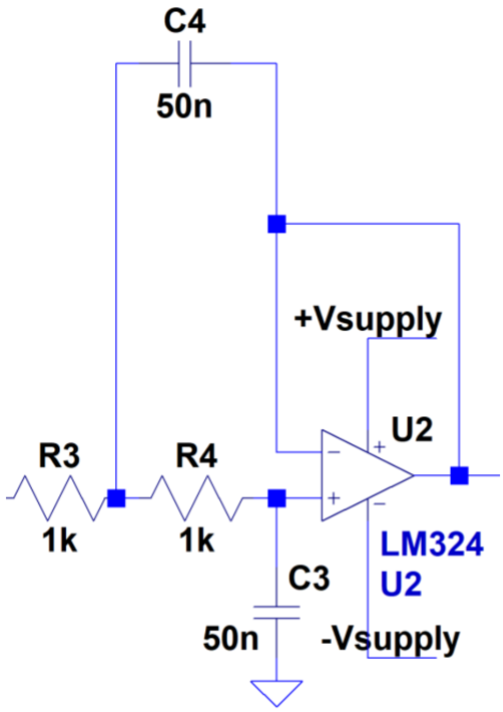
1. Frequency Response: The first-order low-pass filter has a single pole in the transfer function, resulting in a slope of -20 dB/decade or -6 dB/octave in the stop-band region.
2. Roll-off Rate: The roll-off rate of a first-order filter is relatively gradual, with a slope of -20 dB/decade or -6 dB/octave.
3. Attenuation: The maximum attenuation in the stop-band is limited, approaching -40 dB at very high frequencies.
4. Phase Response: -45° at the cutoff frequency.
5. -3dB Cutoff Frequency:

$$f_0 = \frac{1}{2\pi RC}$$

Second-Order Low-Pass Filter:

1. Frequency Response: The second-order low-pass filter has two poles in the transfer function, resulting in a steeper slope of -40 dB/decade or -12 dB/octave in the stop-band region.
2. Roll-off Rate: The roll-off rate of a second-order filter is steeper, with a slope of -40 dB/decade or -12 dB/octave, providing better rejection of unwanted high frequencies.
3. Attenuation: The maximum attenuation in the stop-band can be much higher than a first-order filter, depending on the filter design and specs.
4. Phase Response: -90° at the cutoff frequency.
5. -3dB Cutoff Frequency:

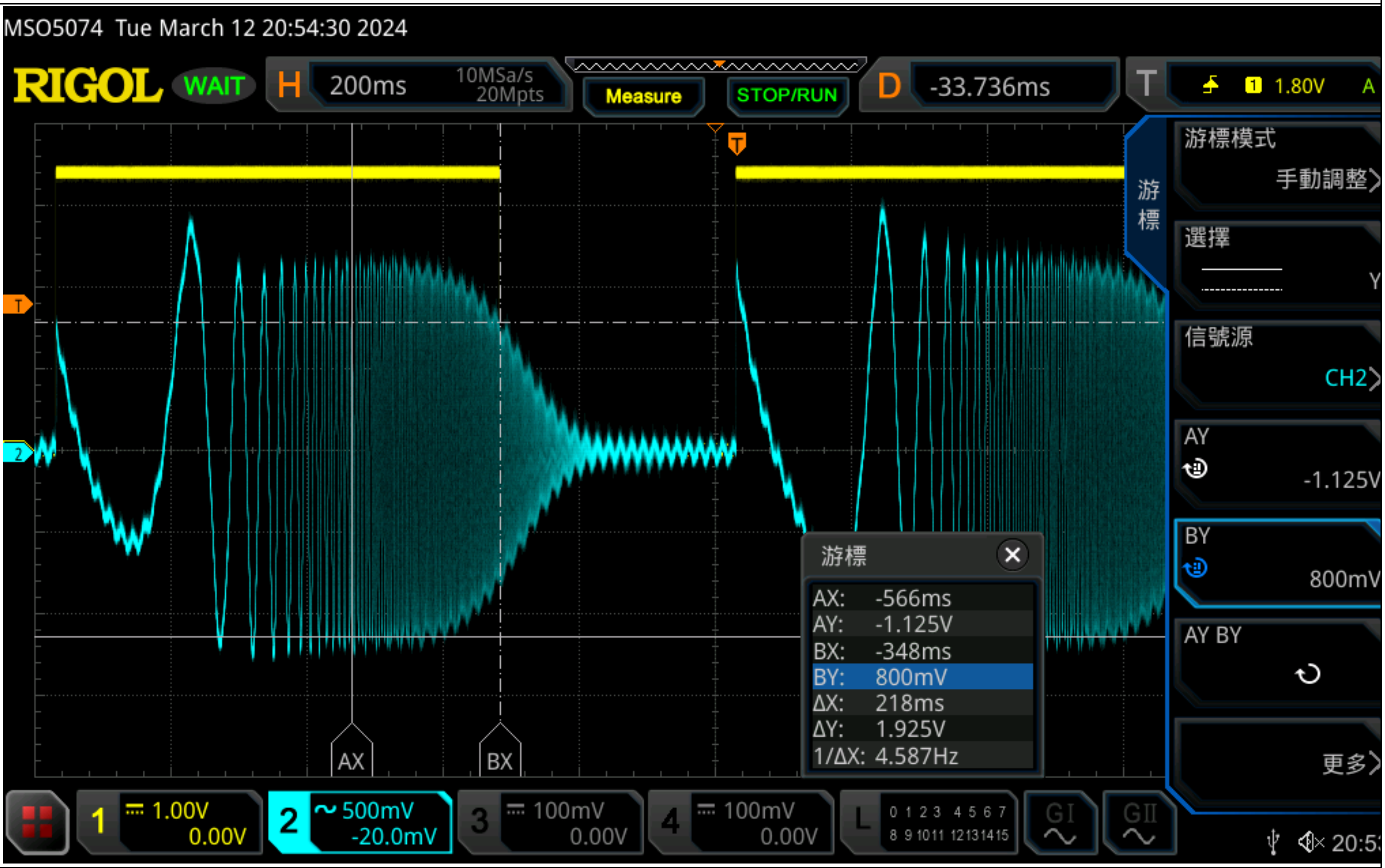
$$f_0 = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$



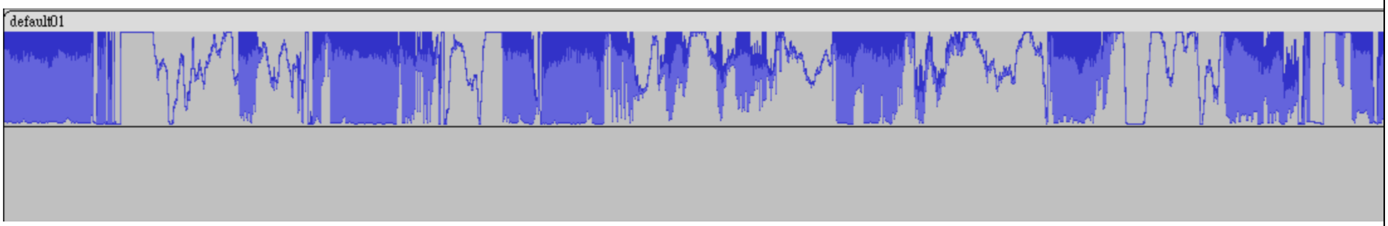
Experiment 2: Audio Front End

DC Bias Voltage					
Vc (V)	Ve (V)	V+ on U1 (V)	Vout on U1 (V)	V+ on U2 (V)	Vout on U2 (V)
3.10	0.18	1.98	1.98	1.98	1.98

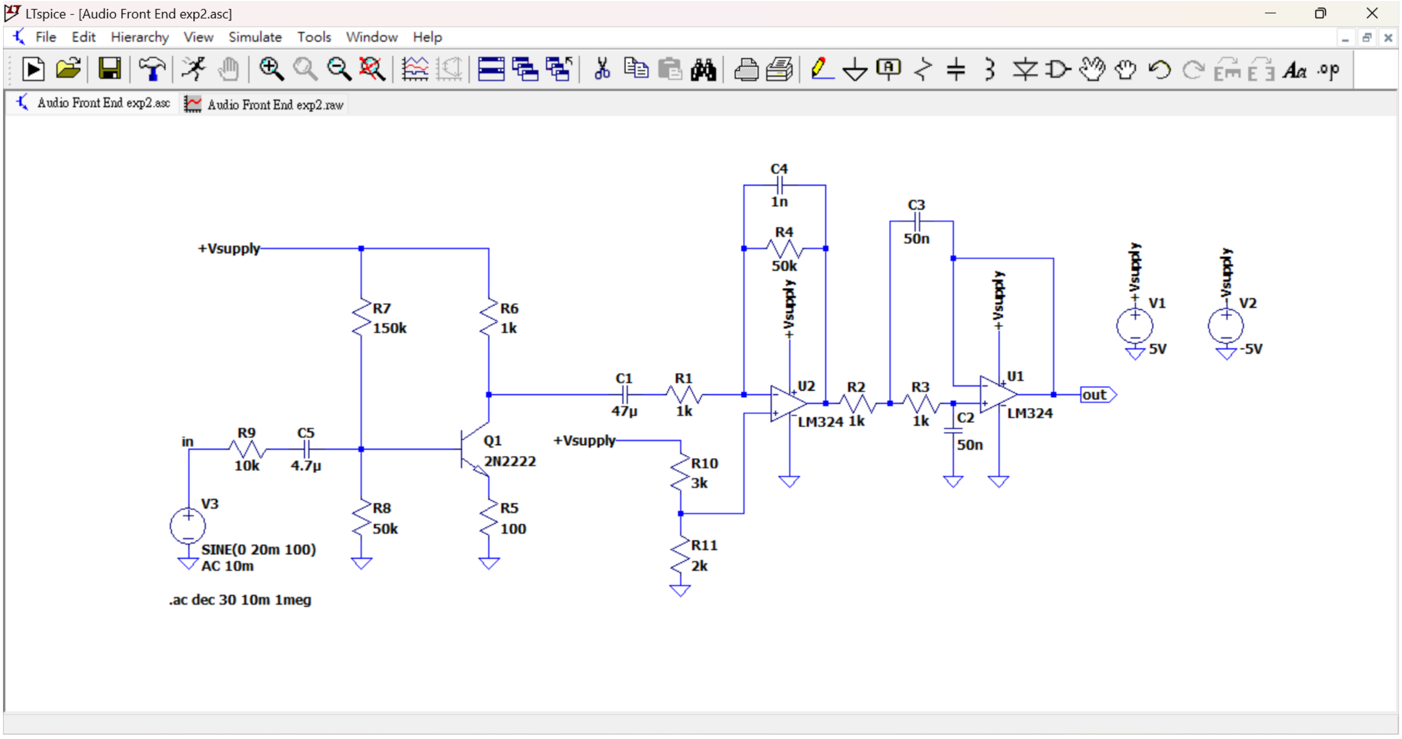
AC SWEEP result
High 3dB frequency =____1.8______ Hz

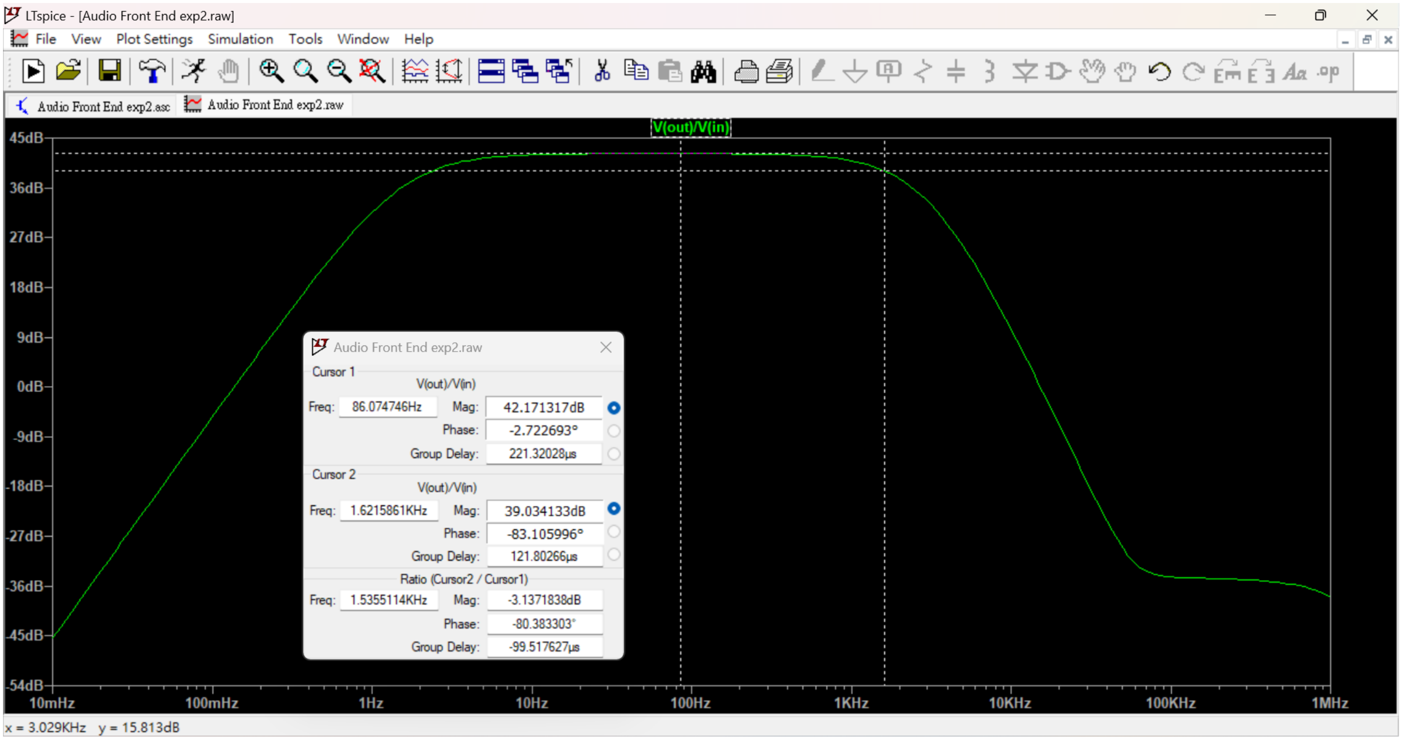


Sound waveform



Play your .wav file to TA





Observation:

The npn transistor serves as an additional amplifier that increases the maximum gain of the system to 42dB.

Usually, a normal recording using the microphone on my laptop has both positive and negative swings. However, the recording from this experiment uses the single supply circuit in Exp1, so the entire signal is offset by 2V. Without this 2V provided by the voltage divider at the non-inverting input, there would have been a loss of information due to clipping. In IC design, single supply amplifier designs like this are often preferred over split supply amplifiers because it's easier, cheaper, and more area-efficient to implement.

Reference:

1. Engineering.com: https://www.engineering.com/Ask@/qactid/1/qaqid/2083.aspx
2. ROHM Semiconductor: https://www.rohm.com/products/faq-search/faqId/1614
3. Learning About Electronics: https://www.learningaboutelectronics.com/Articles/Difference-between-a-single-and-dual-supply-op-amp.php