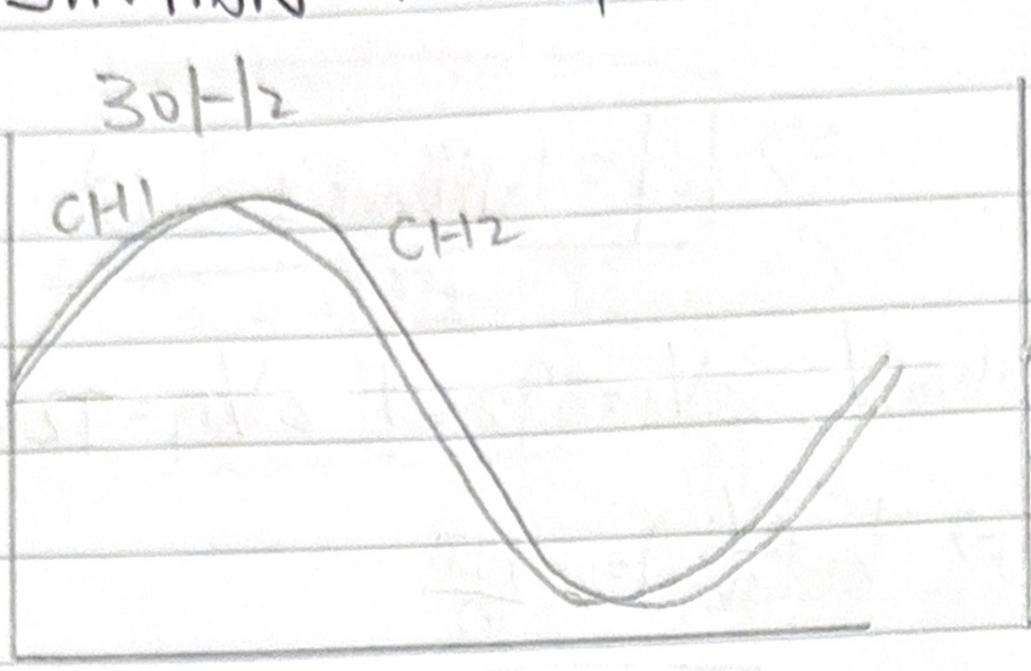
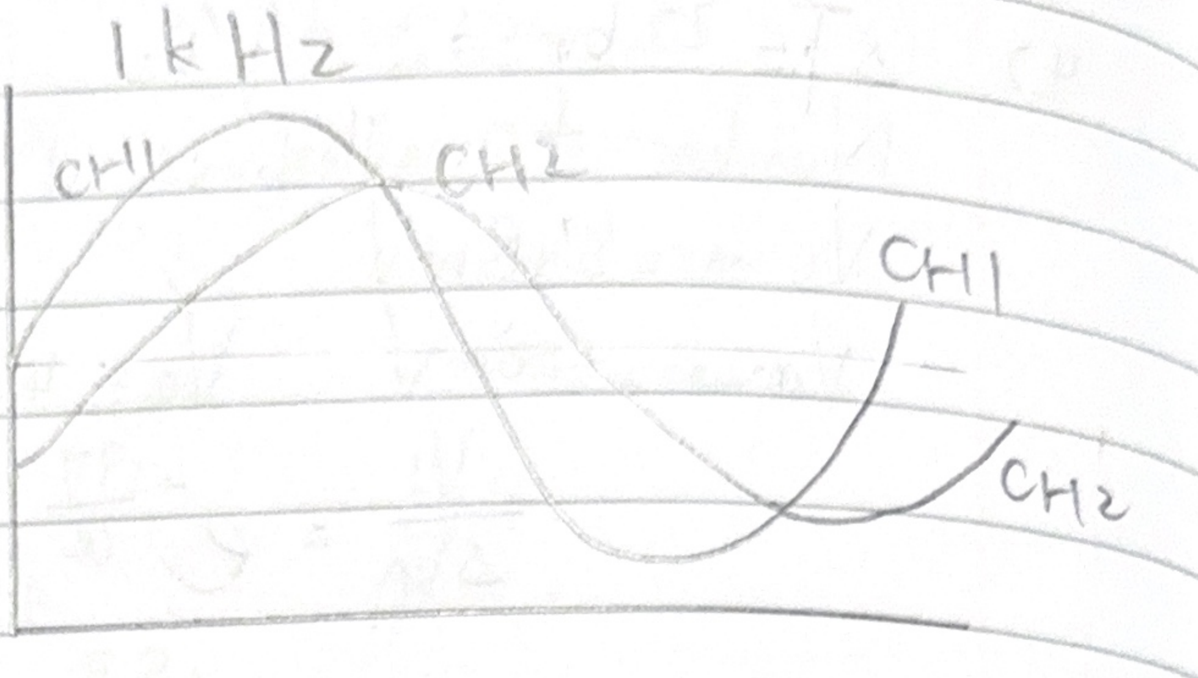
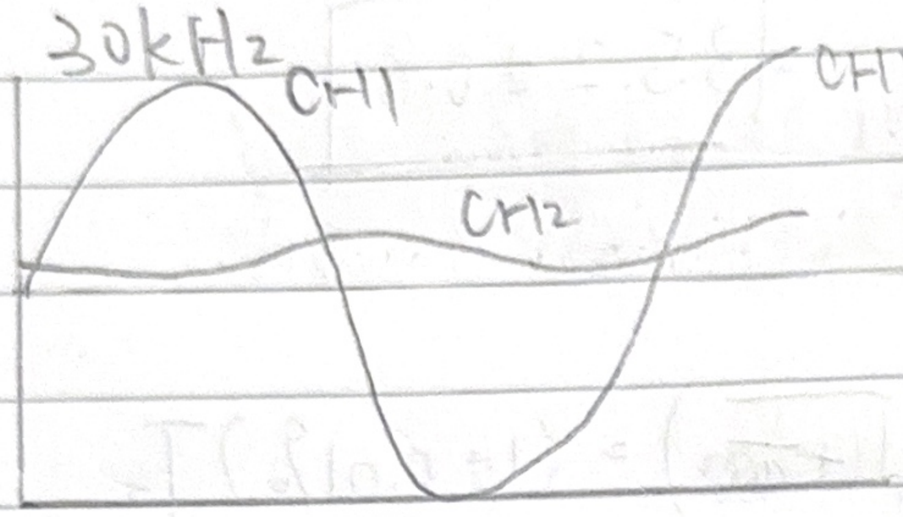
JINTIAN WANG 6th Nov. 2025 EL02

4.2




At transmittance $\frac{1}{\sqrt{2}}$, WCR=1

CR=199.0μs±1.2 ⇒ f=799.77±4.82 Hz

Peak of $V_1$: 460mV. Lowest: -8.00mV

Equilibrium: 218mV

Δt (for zero crossing) = 144.9μs ± 1.2

Period (for CH1 and CH2): $T_3$ = 3.74ms ⇒ T = 1.247 ± 0.006 ms

$$\frac{\Delta I}{T} = \Delta\phi = \boxed{41.6^\circ} \pm 0.5^\circ$$

$V_2$ lags $V_1$ because it has later zero crossings by the measurement. // Another reason is that on screen time runs from left to right, ~~thus~~ and ~~CH~~ $V_2$ has zero crossing on the right hand side of $V_1$.

4.3 $V_1 = 1 + jwCR$

$$|V_1|^2 = 1 + w^2C^2R^2 = 1 + 4\pi^2f^2C^2R^2$$

$$\frac{I^2}{I}^2 = \frac{|V_2|^2}{|V_1|^2} = \frac{1}{1+4\pi^2f^2C^2R^2}$$

4.4

| f/Hz | $\|V_1\|$/mV | $\|V_2\|$/mV |
|---|---|---|
| 100Hz. | 180mV | 179 |
| 160 | 179 | 176 |
| 260 | 178 | 171 |
| 360 | 178 | 165 |
| 500 | 177 | 154 |
| 700 | 177 | 139 |
| 1k | 176 | 116 |

At $V_A$ = 11.2V(pp)

Offset = 0mV, $V_1$ = 0.180V

| f | $\lvert V_1 \rvert$ | $\lvert V_2 \rvert$ |
|---|---|---|
| 1.6k | 173 | 83 |
| 2.6k | 169 | 52 |
| 3.6k | 163 | 35 |
| 5.0k | 153 | 20 |
| 7.0k | 134 | 2 |
| 10k | 103 | 0 |

$\pm \frac{1}{\sqrt{12}}$ for all V measures.

▷ The data and residuals tell me that both fitting gives difference and the fourth set of data may have something wrong which has a large error.

▷ For RCfit 1: $a = 0.9719 \pm 0.0230$

$c = (1.403 \pm 0.0728) \times 10^{-6}$

For RCfit 2: $a = 1.426 \pm 0.0379$

$b = (3.4271 \pm 1.5770) \times 10^{-4}$

$c = (1.6233 \pm 0.1257) \times 10^{-6}$

Thus a is consistent with theoretical value of 1.

▷ Take $f' = f + \Delta f$ where $\Delta f$ is calibration error.

Tried $RCfit(a,b,c,d) = 1/a + b(f+d) + c(f+d)^2$

and referred to $d = (1.6233 \pm 0.6221) \times 10^{-6}$ Hz

$\approx 0.002\%$ (for 100 Hz) which is the systematic error.

Thus this is really small and 0.002% is allowed for the equipment.

▷ $4\pi^2 C^2 R^2 = 1.5634 \times 10^{-6} \pm 0.0189$ where $C = 1.6233 \pm 0.1257 \times 10^{-6}$

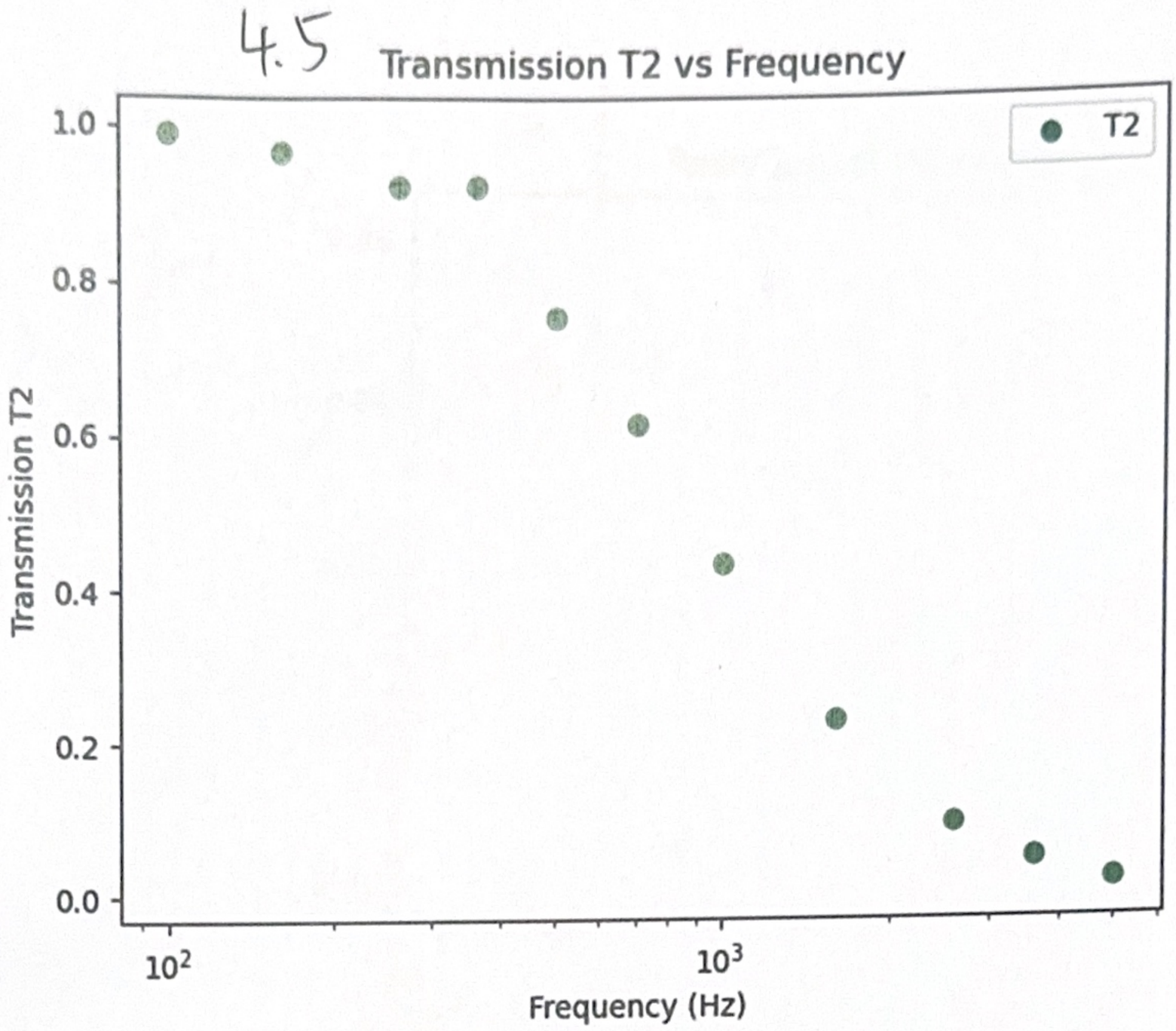
Thus it is consistent.

▷ Not really. Adding 100pF to 100.5nF is not as that significant. Also when paralleling ~~100~~ 10MΩ with 1.7kΩ.

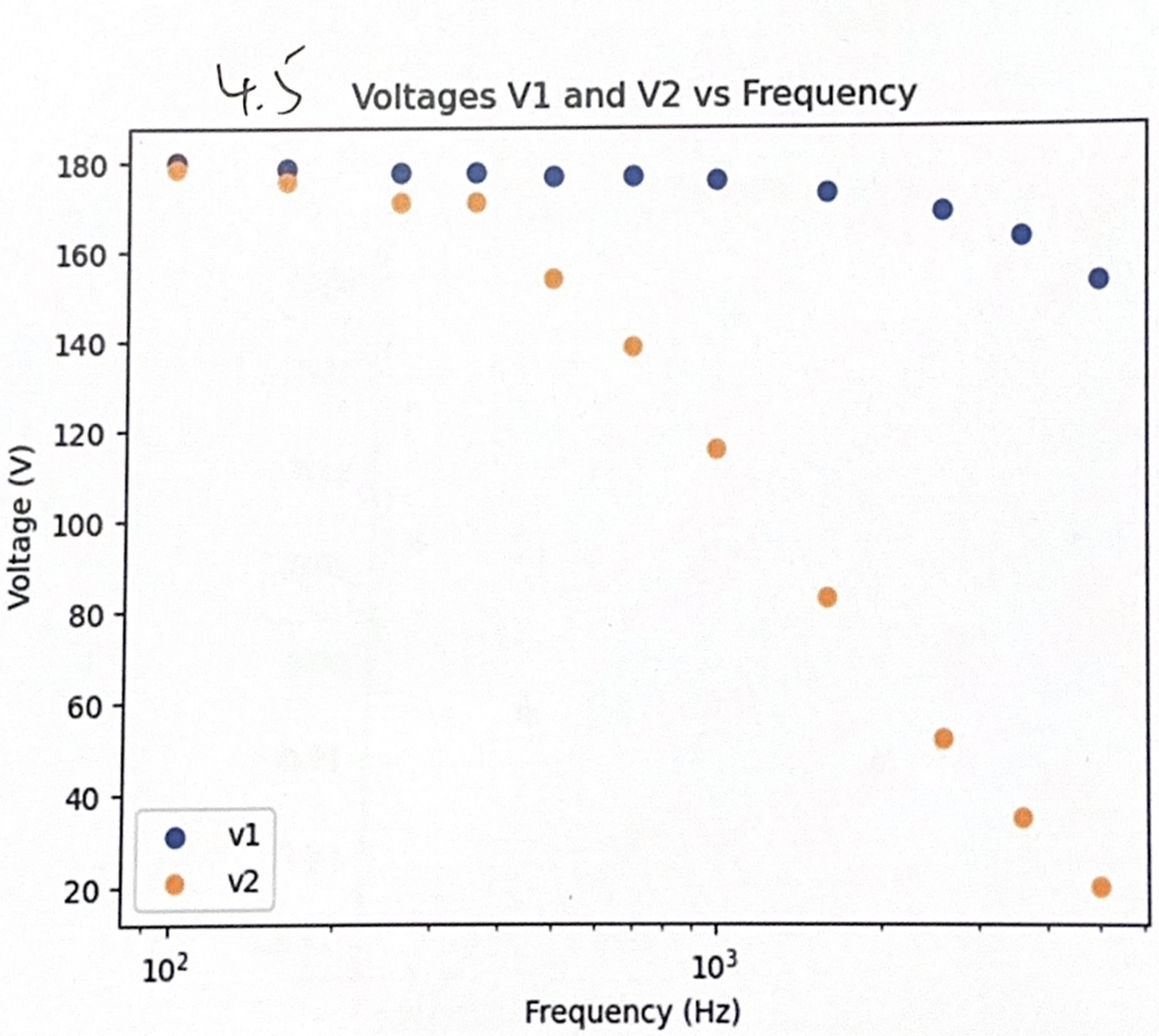
Bryan Hong (4)

Question 4:

4.5

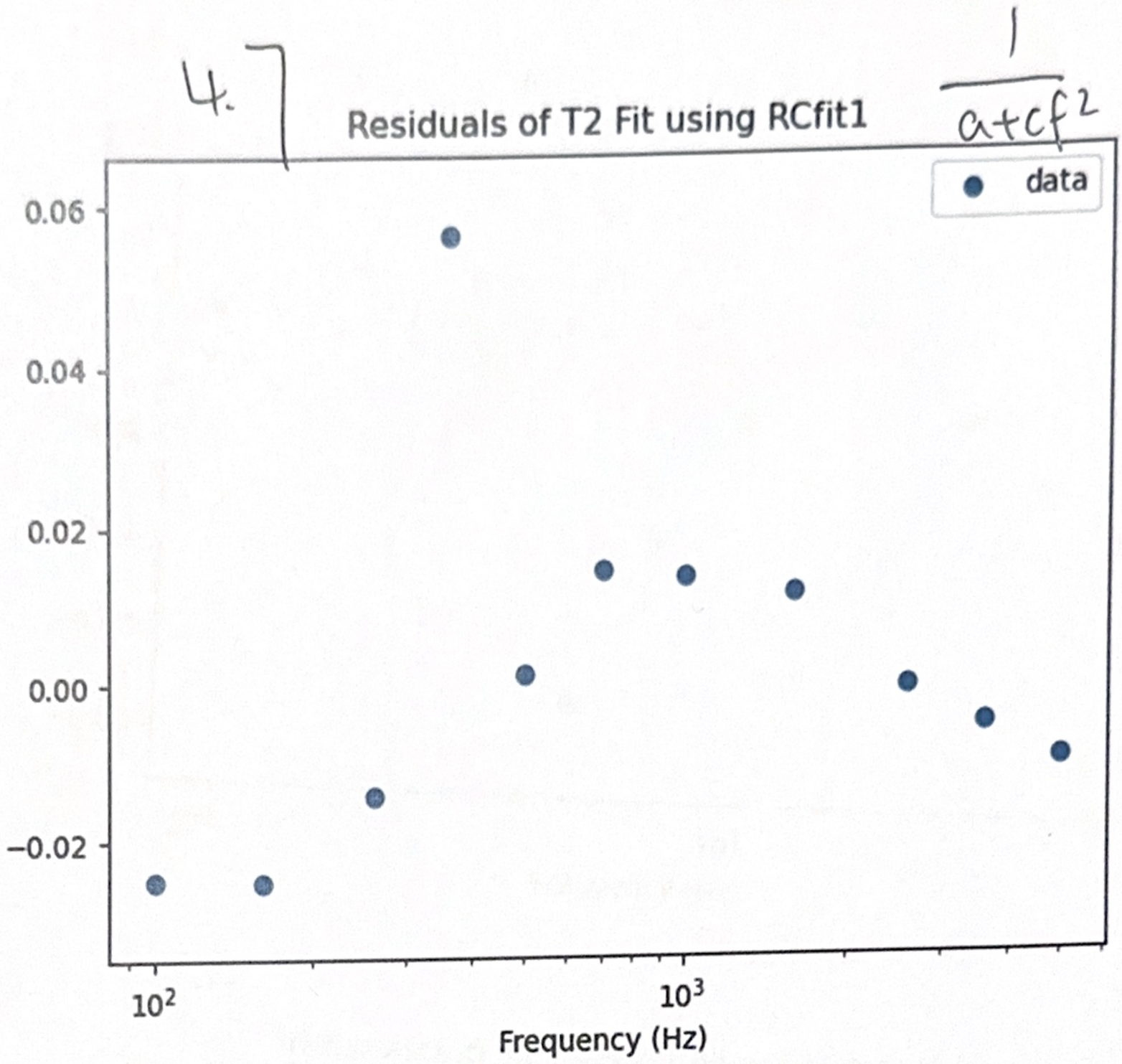



4.5



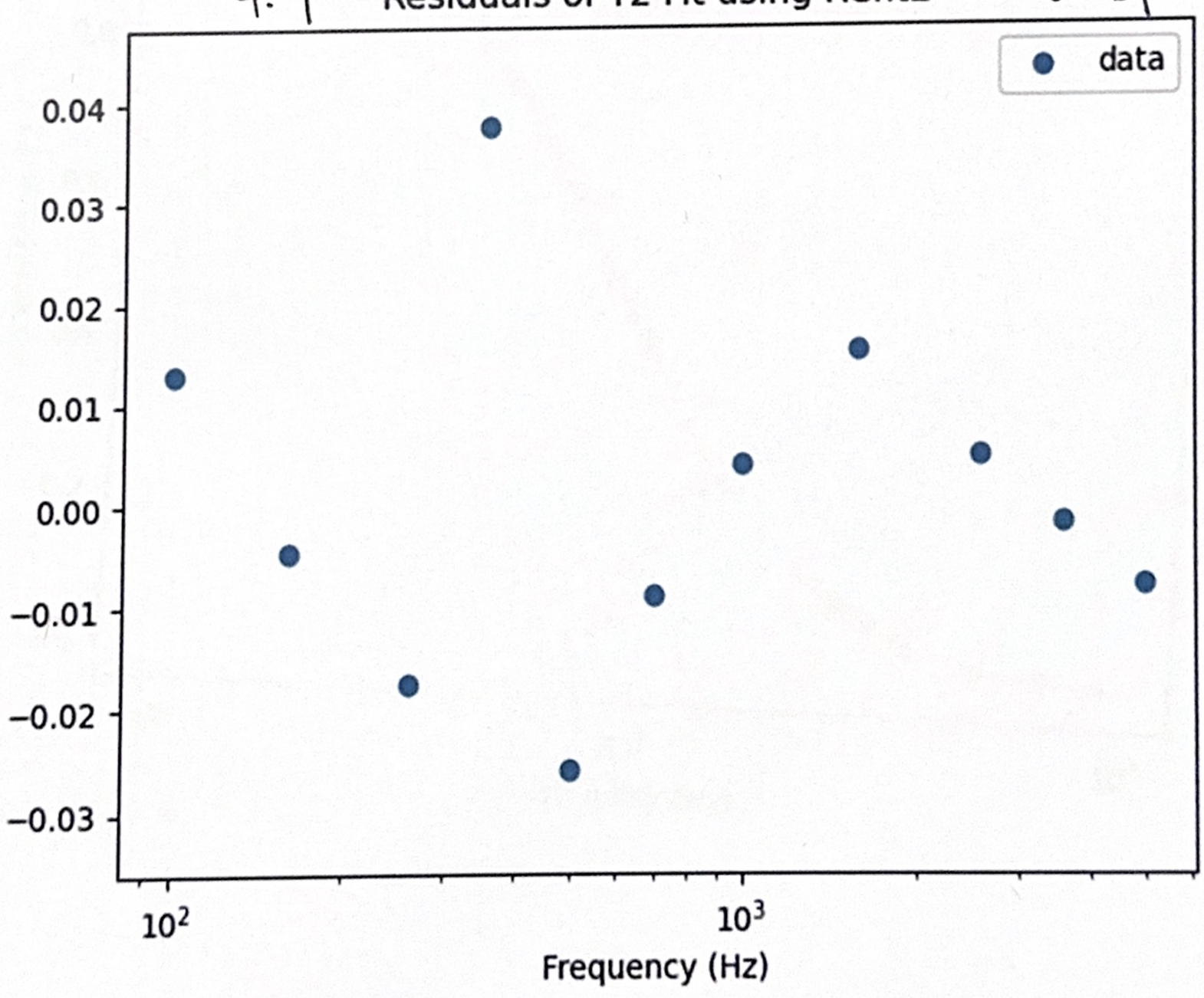
Question 4:

4.7




$$\frac{1}{a+cf^2}$$

4.7

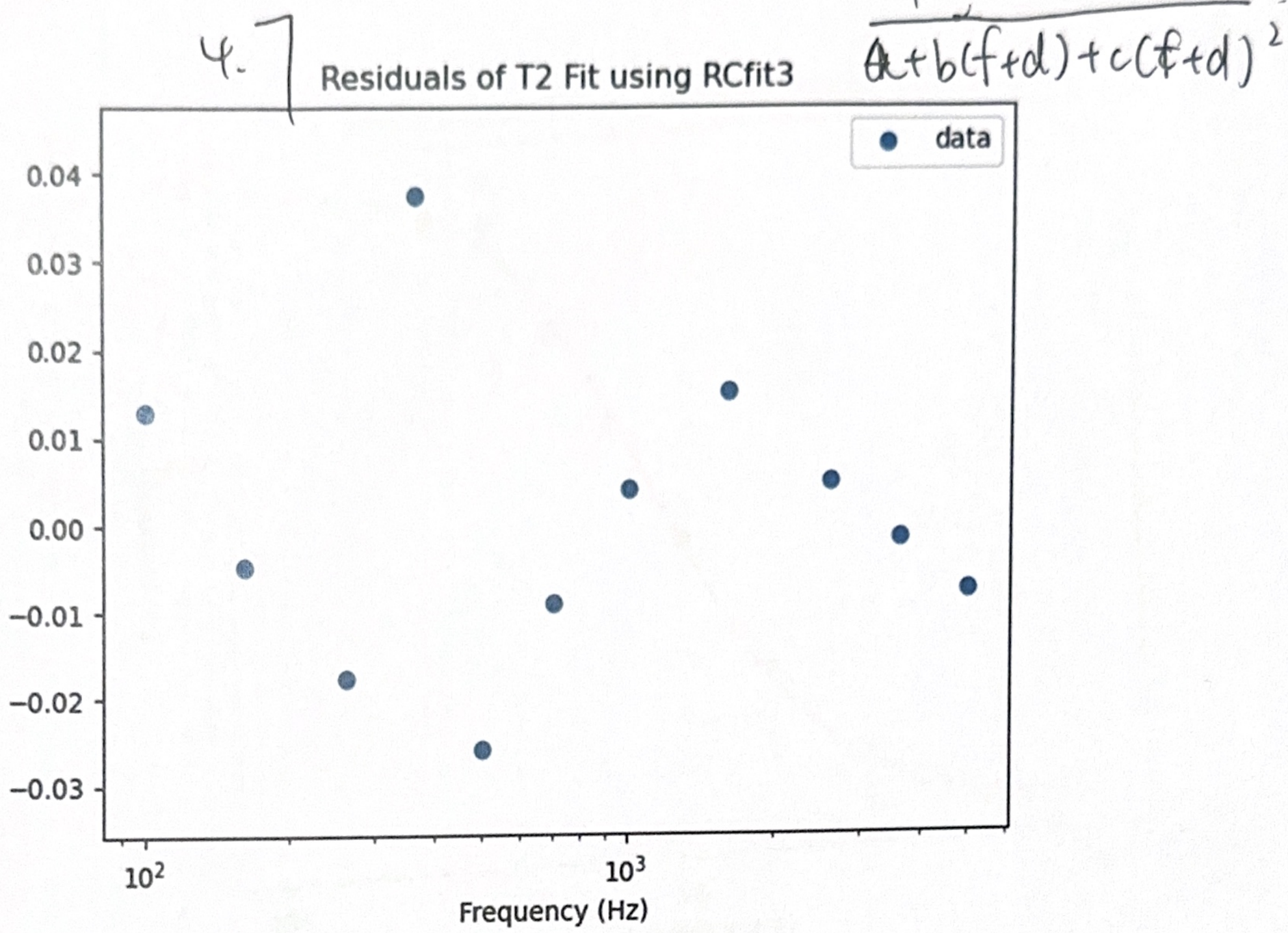



$$\frac{1}{a+bf+cf^2}$$

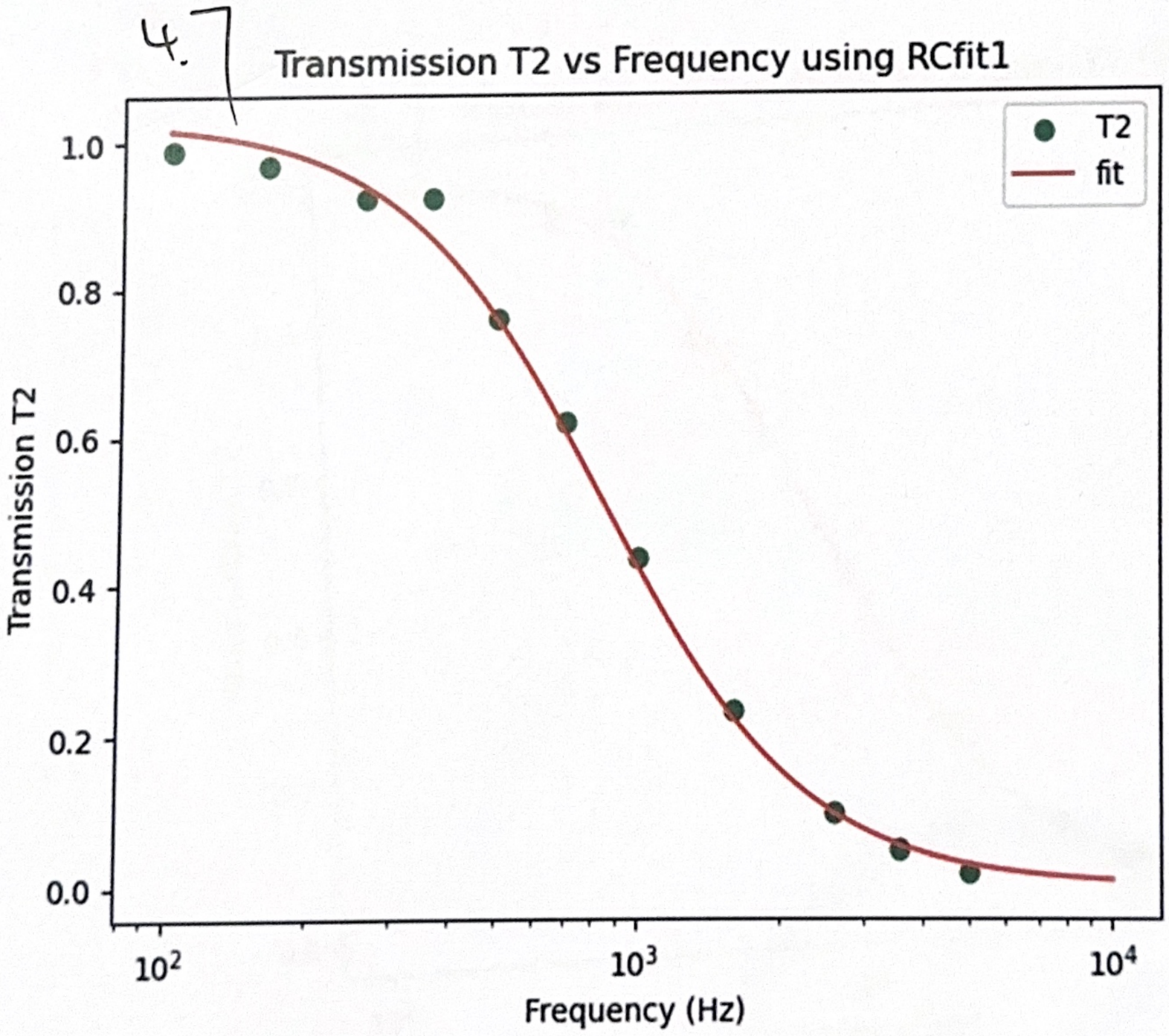
Question 4

$$\frac{1}{a+b(f+d)+c(f+d)^2}$$

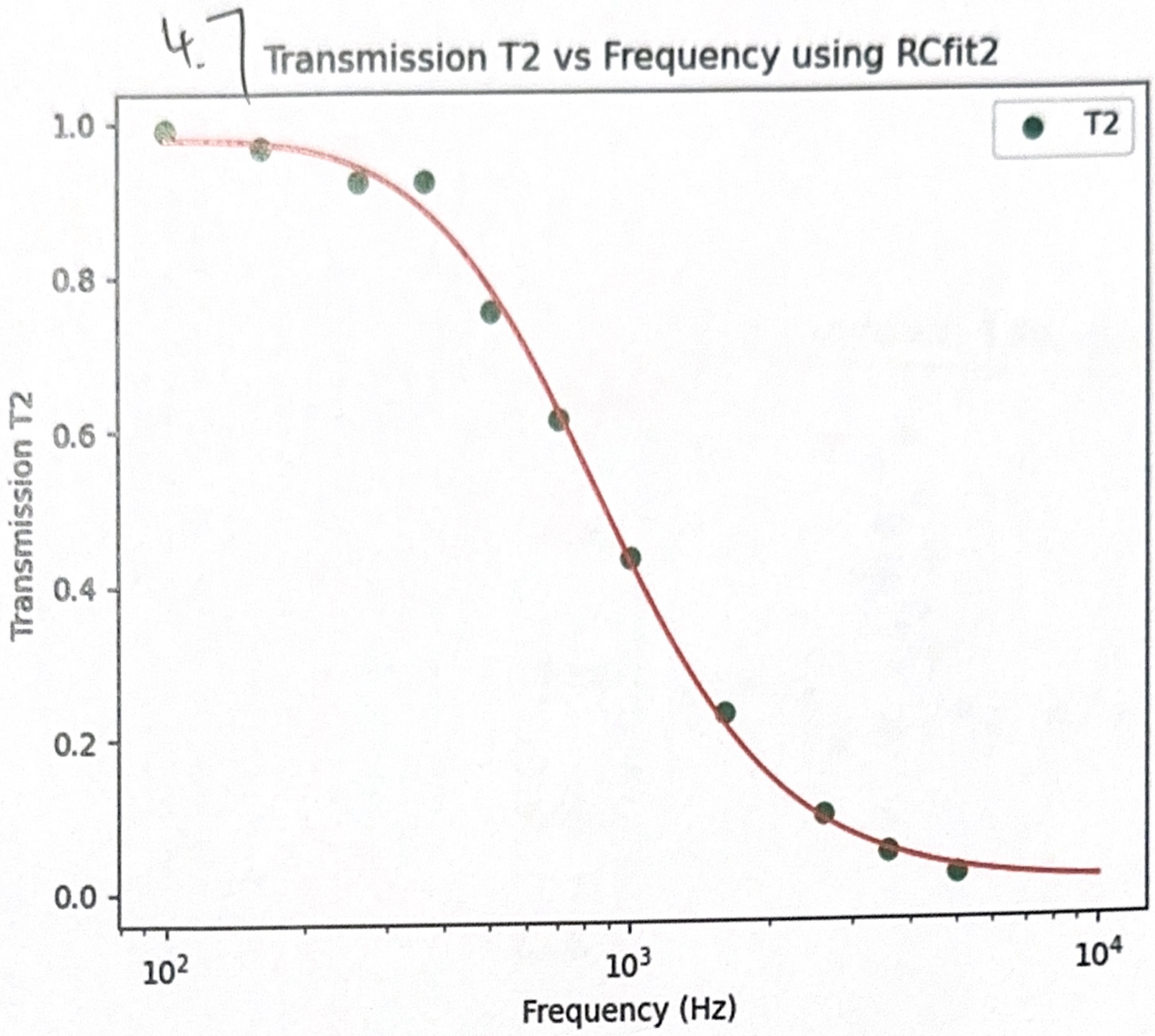
4.



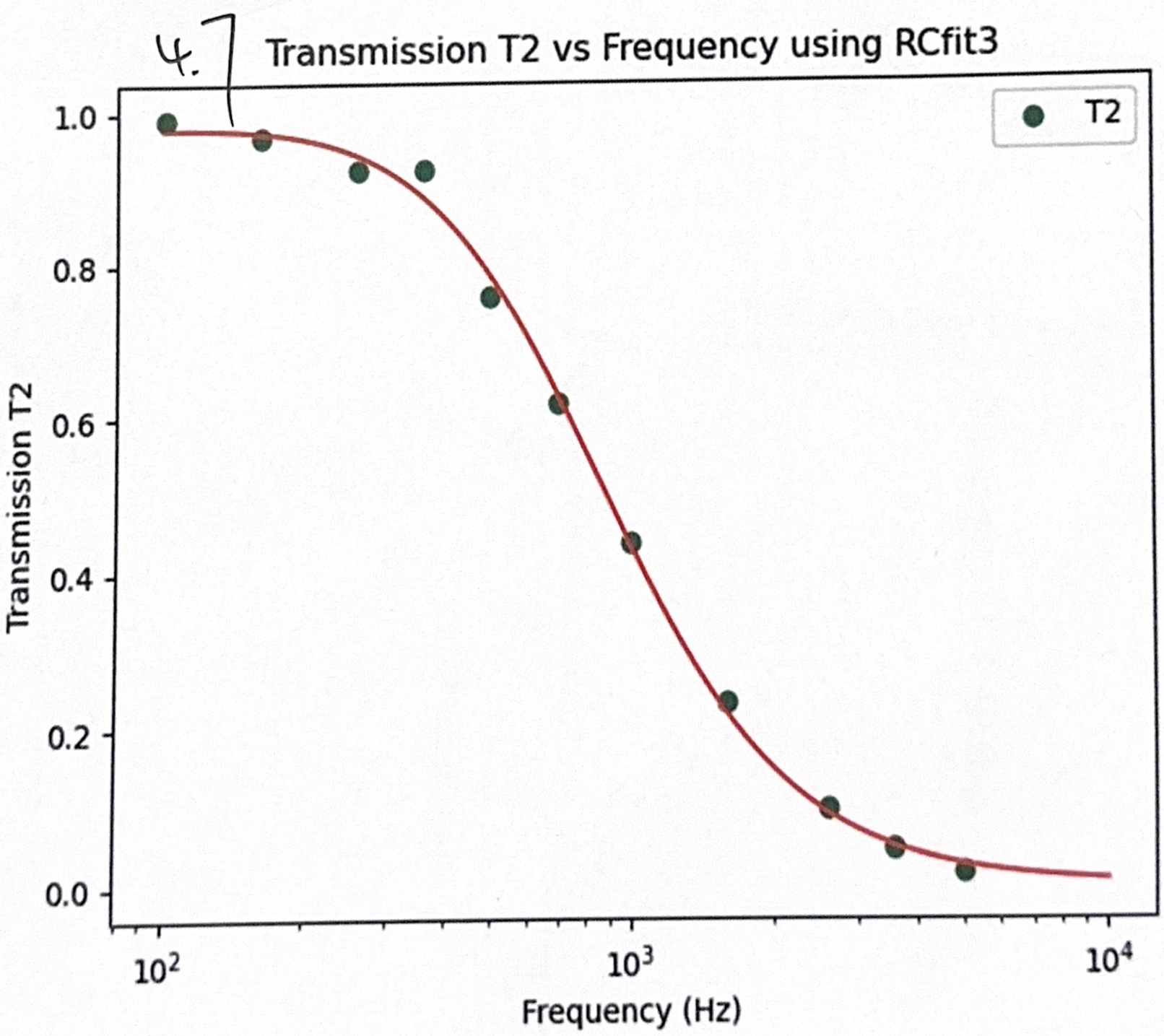

4.



4.7


Transmission T2 vs Frequency using RCfit2
T2
1.0
0.8
0.6
0.4
0.2
0.0
Transmission T2
$10^2$
$10^3$
$10^4$
Frequency (Hz)

4.7


Transmission T2 vs Frequency using RCfit3
T2
1.0
0.8
0.6
0.4
0.2
0.0
Transmission T2
$10^2$
$10^3$
$10^4$
Frequency (Hz)

5. At the beginning from 800 Hz, the amplitude of $V_2$ increases, and then decreases again until 1 kHz.
The phase difference increases ($V_2$ lags $V_1$) and the change in phase difference decreases and almost no change around 1 kHz.
At about $f = 839.3$ Hz, peak detected.

$$y = \frac{1}{(1+c)^2 + \frac{b^2}{a^2}\left(\frac{f^2}{a^2} + \frac{a^2}{f^2} - 2\right)}$$

$a = f_0 \quad b = 1/2\pi CR \quad c = r/R$

5.4 $R = 46.8\,\Omega \pm 0.1/\sqrt{12}$
$r = 44.4\,\Omega \pm 0.1/\sqrt{12}$
$\in [500, 2000]$

At $V_A = 11.2\ V_{pp}$.

| f/Hz | $\lvert V_1\rvert$/mV | | $\lvert V_2\rvert$/mV |
|---|---|---|---|
| 500 | 97 | 177 | 3 |
| ~~550~~ | 132 | | ~~4~~ |
| 600 | 184 | 177 | 6 |
| 650 | 264 | | 7 |
| 700 | 401 | 176 | 11 |
| 750 | 684 | 176 | 17 |
| 800 | ~~1534~~ | 174 | 38 |
| 850 | ~~3.00~~ 2.99 V | 170 | 72 |
| 900 | 1.280 mV | 175 | 28 |
| 950 | 794 | 175 | 16 |
| 1k | 595 | 175 | 11 |
| 1.1k | 422 | 175 | ~~8~~ 7 |
| 1.2k | 345 | 175 | 5 |
| 1.3k | 301 | 175 | 3 |
| 1.4k | 273 | 174 | 3 |
| 1.5k | 254 | | 2 |
| 1.6k | 240 | 173 | 2 |
| 1.7k | 230 | | 1 |
| 1.8k | 222 | | 1 |

| f/kHz | $\lvert V_1\rvert$/mV | | $\lvert V_2\rvert$/mV |
|---|---|---|---|
| 1.9 | 215 | 172 | 1 |
| 2.0 | 209 | | 1 |
| 2.1 | 2.1 | 171 | |
| 2.2 | | | |
| 2.3 | 2.3 | 170 | |
| 2.4 | 2.5 | 169 | |
| 2.5 | 191 | | 0 |

| | | | |
|---|---|---|---|
| 810 | 1916 | 173. | ~~#5~~47 |
| 820 | 2.39V | 172 | 59 |
| 830 | 2.97V | 169 | 73 |
| → 840 | 3.26V | 168 | 79 |
| → 850 | ~~3.00~~ 2.99 | 170. | 72 |
| 860 | 2.48 | 172. | 59 |
| 870 | | 173 | 47 |
| 840 | 3.26 | 168 | 79 |
| 842 | 3.25 | 168 | 79 |
| 844 | 3.21 | 169 | 78 |
| 838 | 3.25 | 168 | 79 |
| ~~839~~ | ~~3.26~~ | | ~~79~~ |
| → 840 | 3.26 | | 79 |
| 836 | | 168 | 77 |
| 880 | | 174 | 39 |

5.b $C = 100.5 \text{nF} \pm 1\%$

$R = 46.8\,\Omega \pm 0.1/\sqrt{12}$

From ELO1 $r = 44.4\,\Omega \pm 0.1/\sqrt{12}$ (225)

$\frac{1}{RC} = 212612.0 \pm 2257.3\ s^{-1}$

Calculated:

$a = 839.654 \pm 0.348\ Hz$

$b = 3609.8 \pm 524.3\ s^{-1}$

$c = 1.1175 \pm 0.0141$

$2\pi b = 226381.9 \pm 3294.3\ s^{-1}$.

226381.9
329

They are consistent with each other.

$L = \frac{1}{4\pi^2 a^2 C} = 0.3575 \pm 0.0039\ H$

$= 357.5 \pm 3.9\ mH$

Comment on residuals.

Varies a lot near peak frequency, since random and systematic errors are about not changing, fluctuat a lot near the value.

6. ~~$Q = \frac{W_0 L}{R_{total}} = \frac{2\pi f_0 L}{R_{total}} = \frac{2\pi f_0 L_1}{r+R}$~~

6. $r = cR = 1.1175 \times 46.8 = 52.299\Omega \pm 0.650$

$r$ in ELO1 $= 44.4 \pm (3.8\% + 0.1/\sqrt{12})\Omega = 44.4\Omega \pm 0.002$

$L = 357.5 \pm 3.9\,mH$

$L$ in ELO1 $= 356.3mH \pm 22.6$

$\Rightarrow$ $r$ is not consistent, but $L$ is almost the same as that in ELO1.

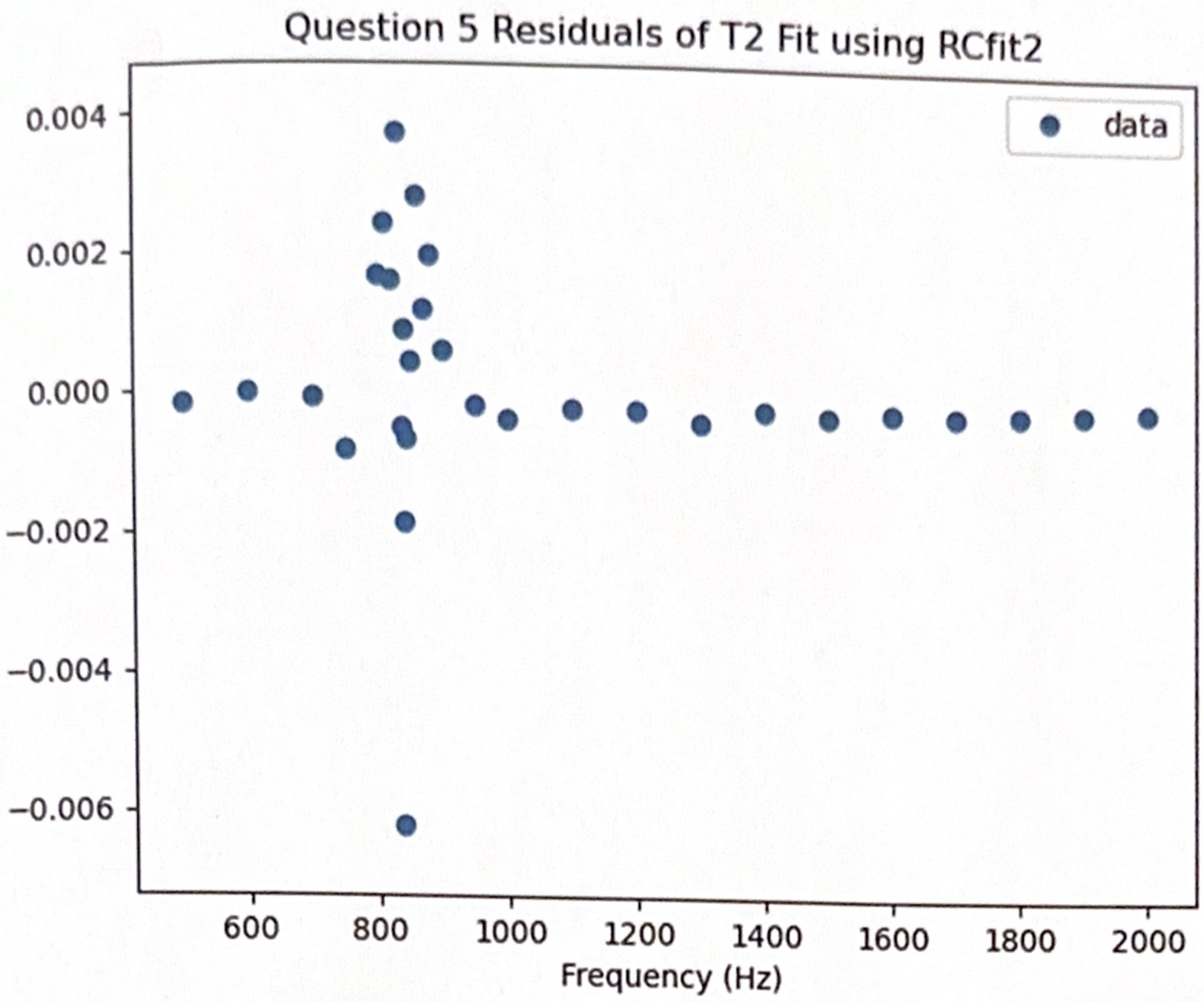
Summary:

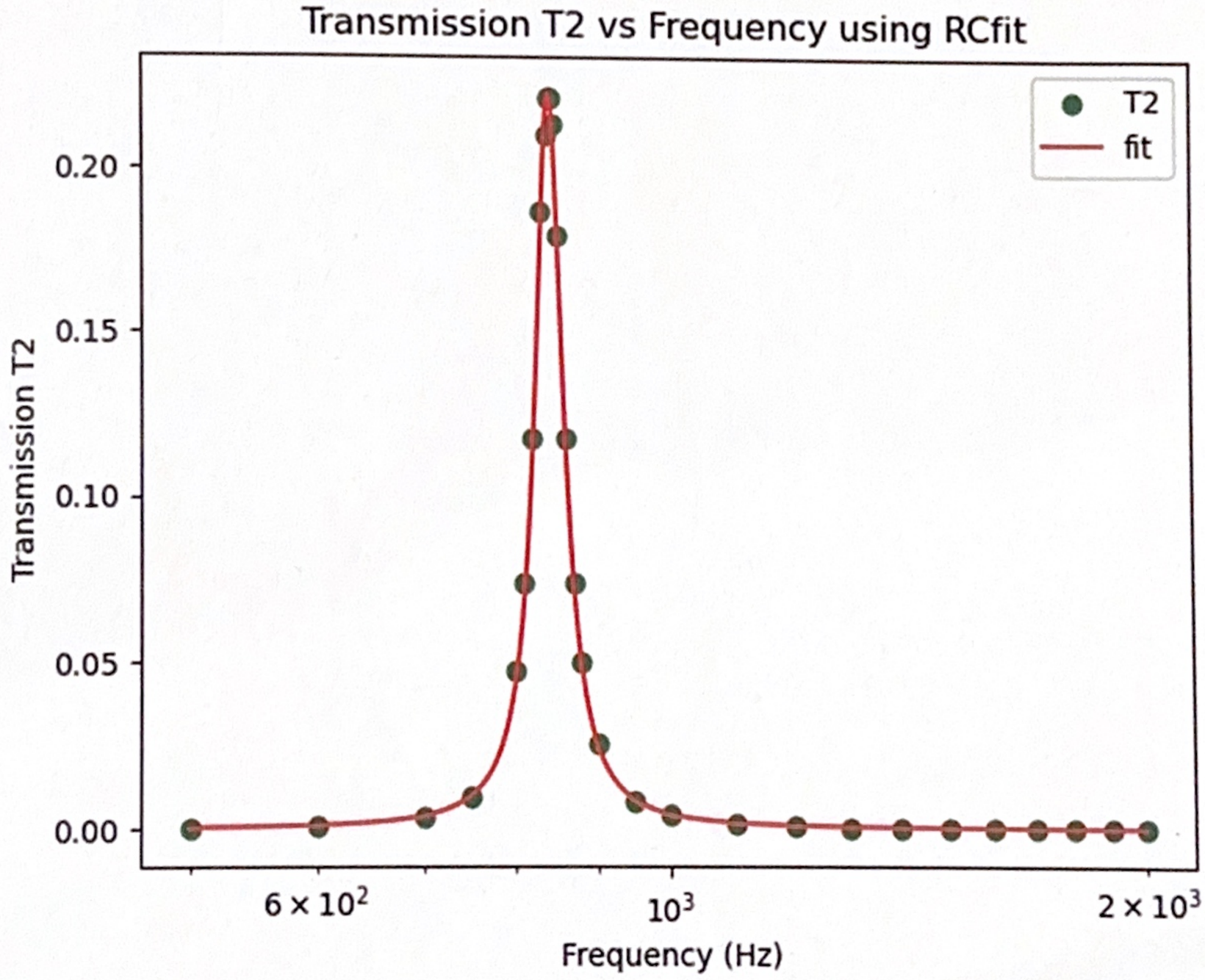
6/11/25

(4)

In the experiment, I used Python to plot data and calculate errors in to practice. By analysing and fitting curves, using theories to predict passive component properties and use equipments to verify them. Although $r$ is not consistent, (and I believe something went wrong last time), $L$ fits very well. I am satisfied with the result.

Question 5:


Question 5 Residuals of T2 Fit using RCfit2
data
0.004
0.002
0.000
−0.002
−0.004
−0.006
600
800
1000
1200
1400
1600
1800
2000
Frequency (Hz)


Transmission T2 vs Frequency using RCfit
T2
fit
Transmission T2
0.20
0.15
0.10
0.05
0.00
$6 \times 10^2$
$10^3$
$2 \times 10^3$
Frequency (Hz)