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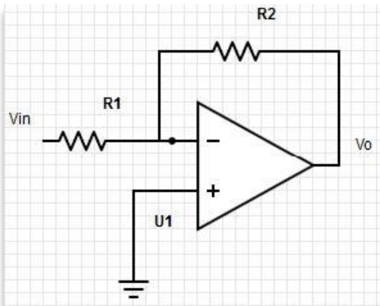
Laboratory 4
Simple Analogue Signal Processing

Part 1: Amplitude Scaling



- ## Task 1

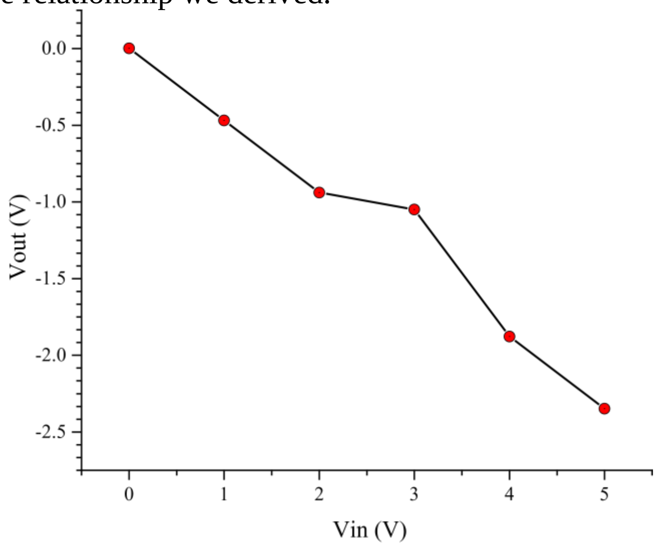
When Vin = 5V, we measured that Vo = -2.348V.

- ## Task 2

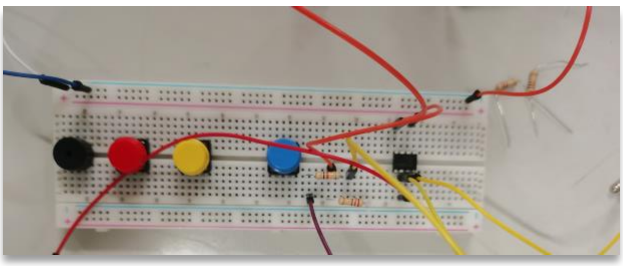
Here is the relationship between Vin and Vout.

Vin	0	1V	2V	3V	4V	5V
Vout	1.949mV	-468.048mV	-938.044mV	-1.048V	-1.878V	-2.348V

This is the figure of the relationship we derived.

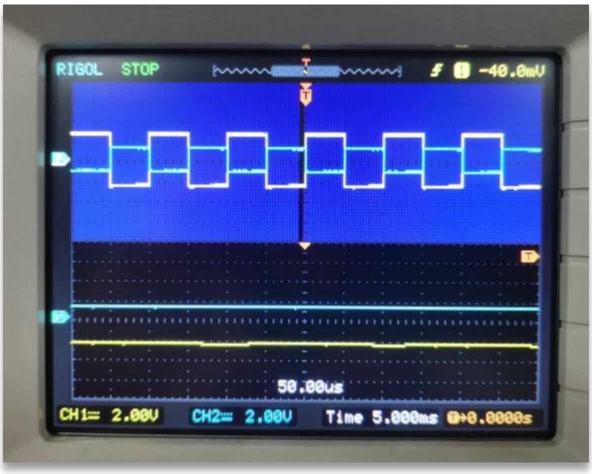


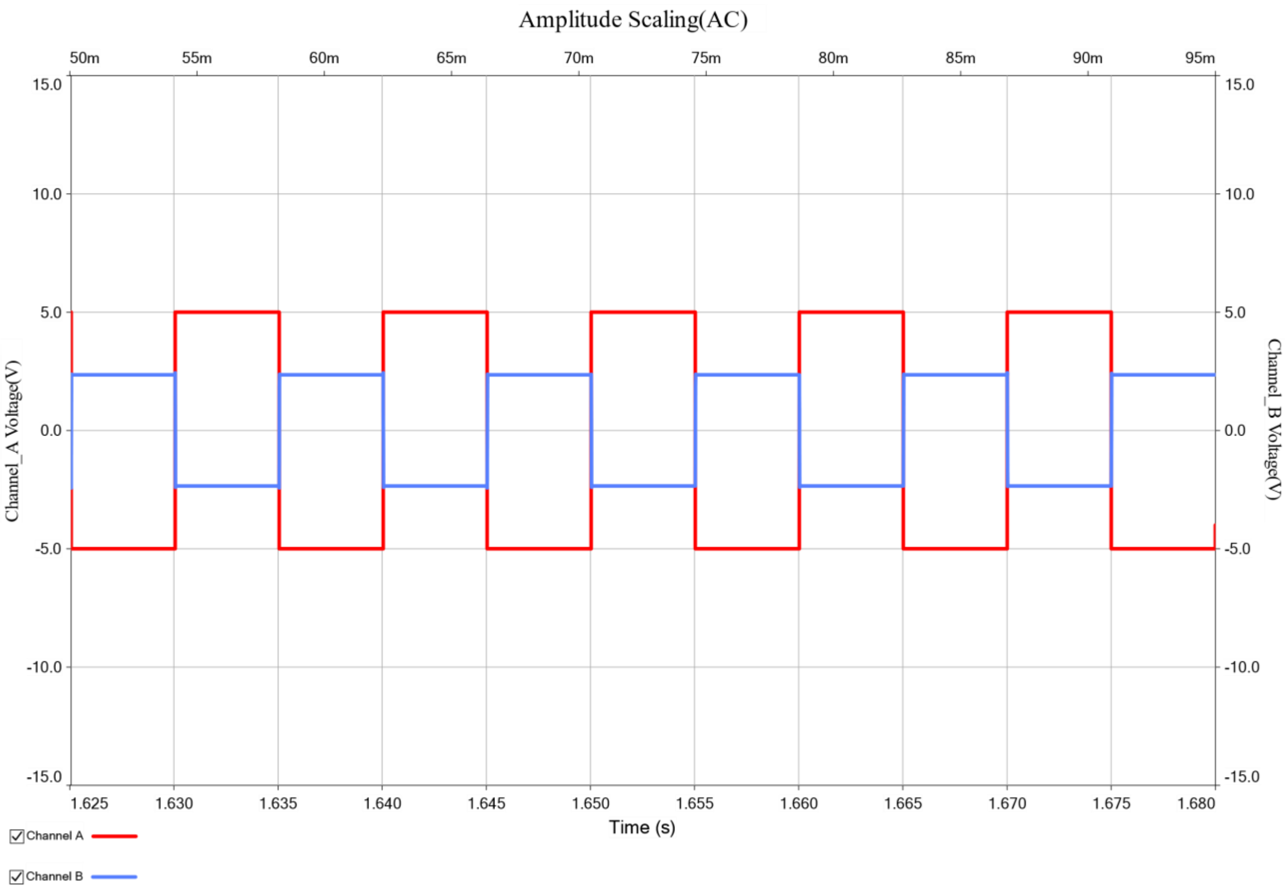
Now we switch to the AC source. Here is our circuit sketch in the lab.



Task 3

And this is the waveform of the Vin and Vout int the lab.

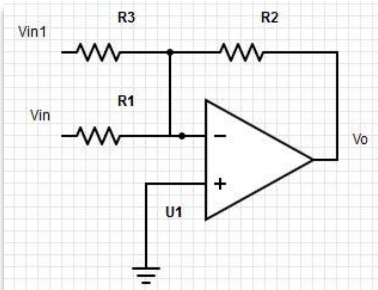




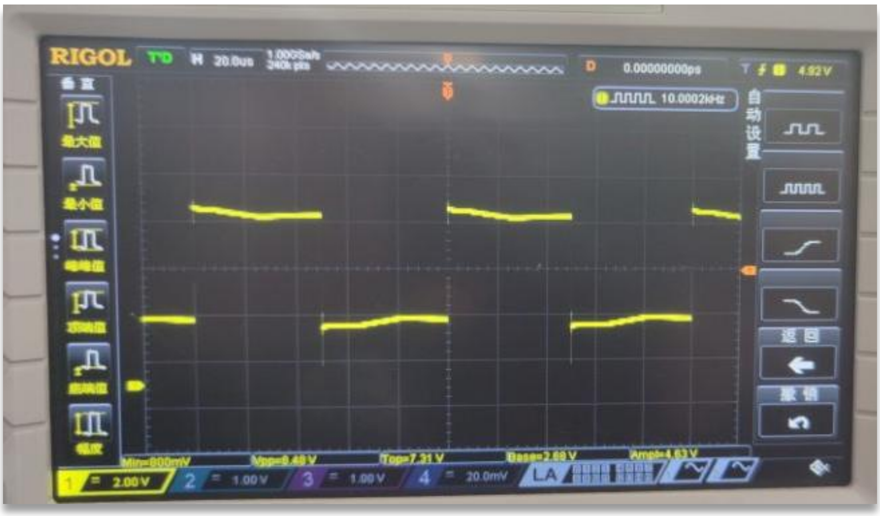
This circuit is a basic inverting amplifier. The circuit shown provides operation as a constant-gain multiplier. An input signal Vin is applied through resistor R1 to the minus input. The output is then connected back to the same minus input through resistor R2. The plus input is connected to the ground. Since the signal V1 is essentially applied to the minus input, the resulting output is opposite in phase to the input signal.

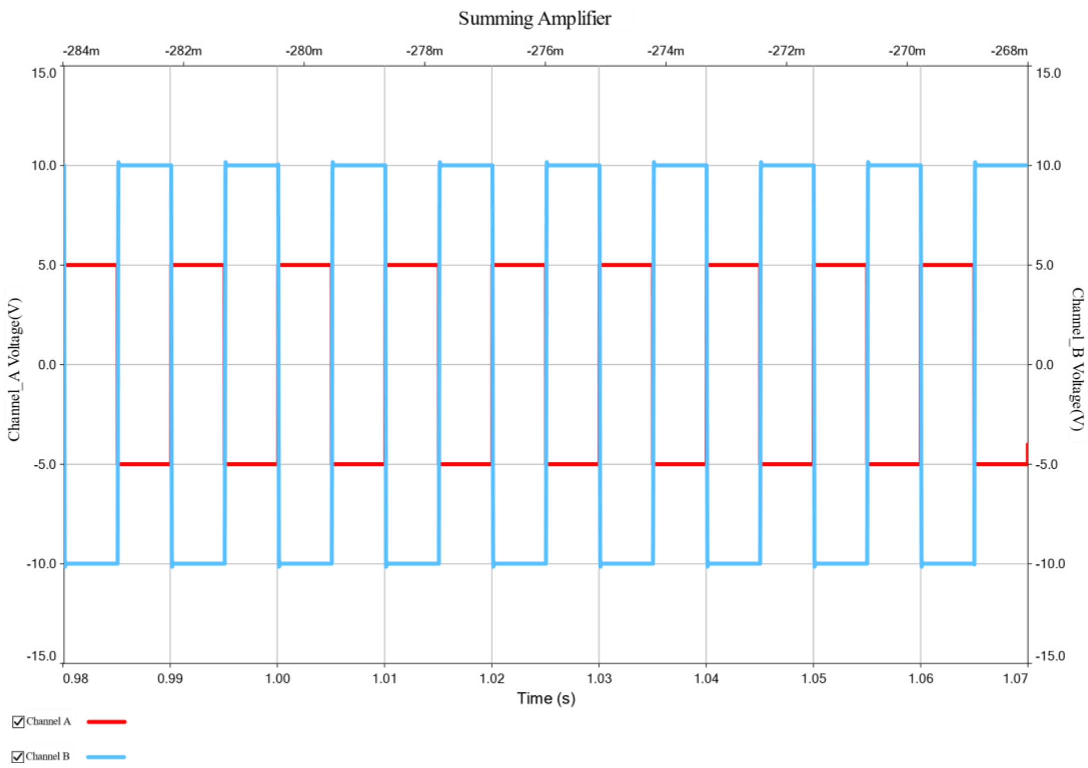
In theoretical analysis, Vin and Vout have a relationship of $\mathrm{Vo} = -\frac{\mathrm{R2}}{\mathrm{R1}}\mathrm{Vi}$. And by comprising the waveform, we can observe that it basically satisfied the law.

Part 2: Summing Amplifier



- **Task 4**



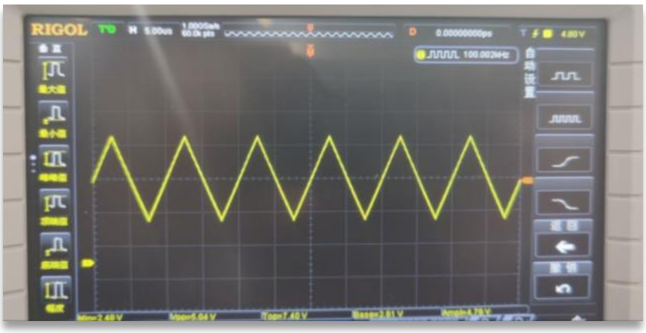


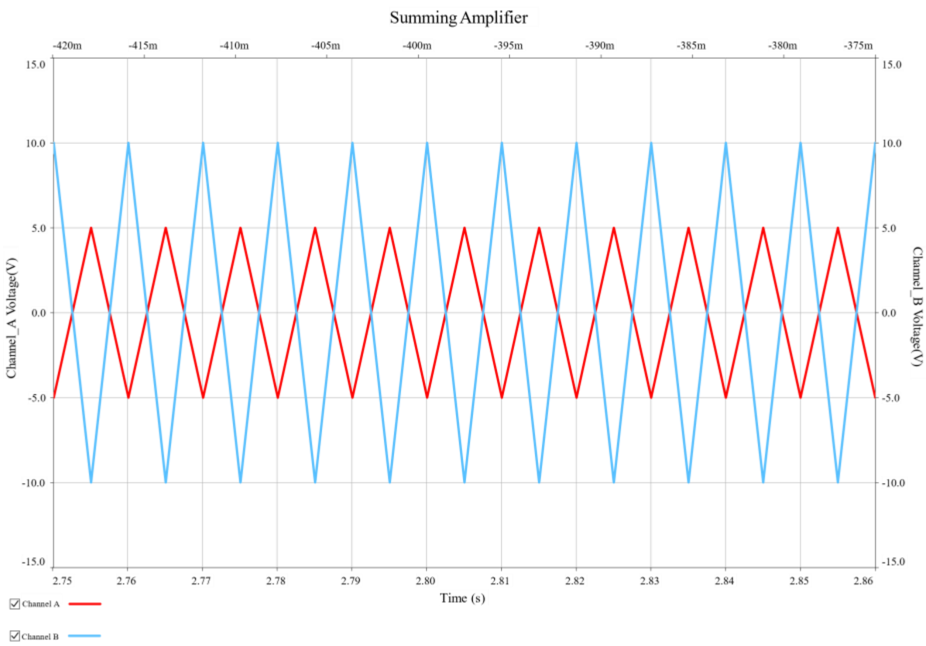
This circuit is named as summing amplifier, which is a popular use of an op-amp. As the figure shown upon the connection, with the output being the sum of the two inputs, each multiplied by a different gain.

From the waveform we derived, we figured out that the Vout is the sum of the two Vin, which satisfied the equation $\mathrm{Vo} = -(\frac{\mathrm{R2}}{\mathrm{R1}}\mathrm{Vin} + \frac{\mathrm{R2}}{\mathrm{R3}}\mathrm{Vin1})$.

Task 5

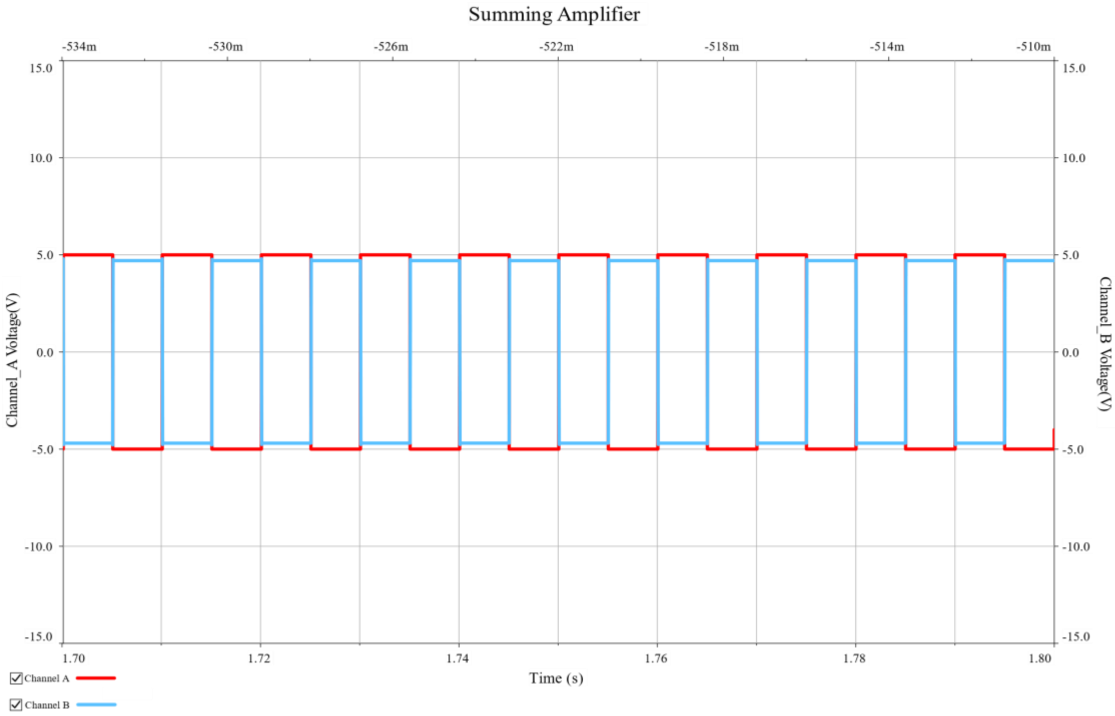
Now we switch to the triangular signal.

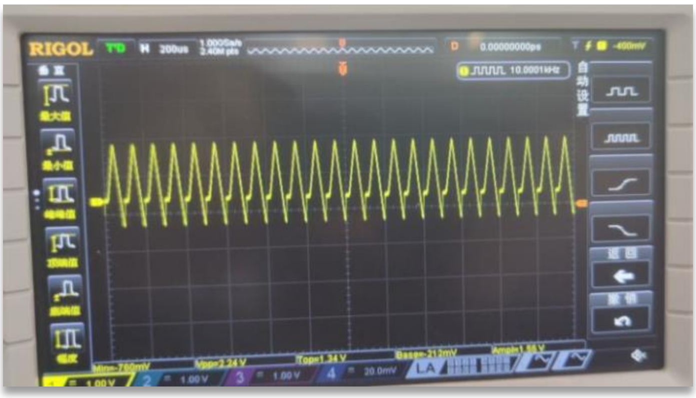


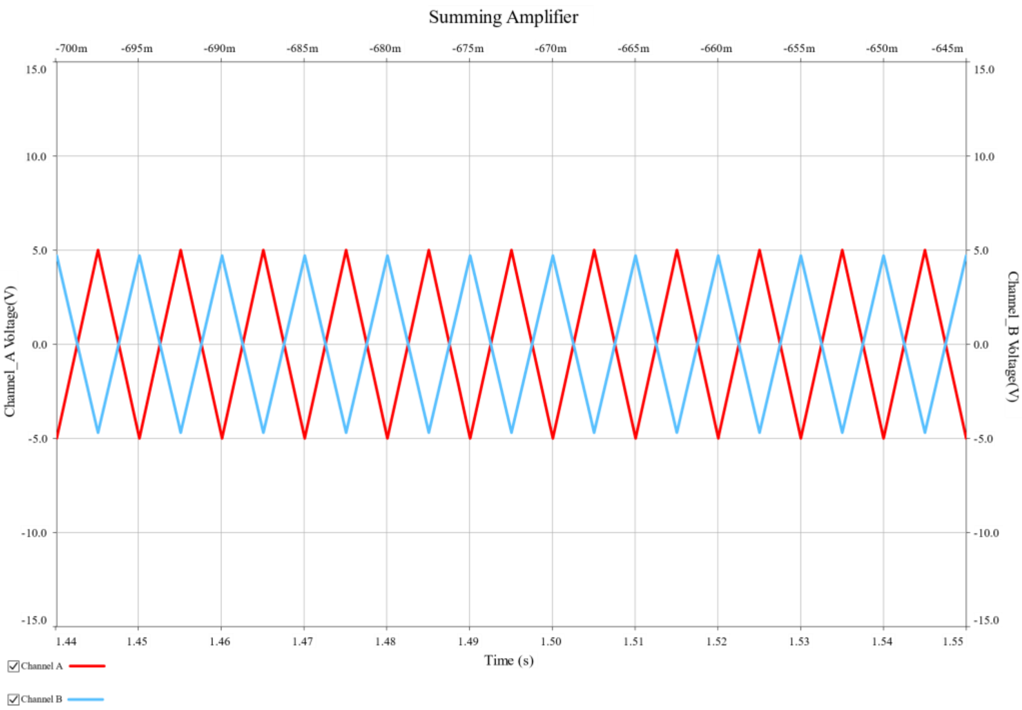


Task 6

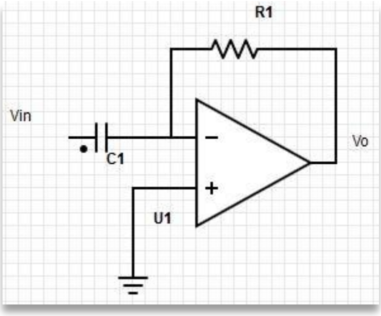
This is the case when R2 = 4.7kΩ.


Summing Amplifier
-534m
-530m
-526m
-522m
-518m
-514m
-510m
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
Channel_A Voltage(V)
Channel_B Voltage(V)
1.70
1.72
1.74
1.76
1.78
1.80
Time (s)
Channel A
Channel B


RIGOL

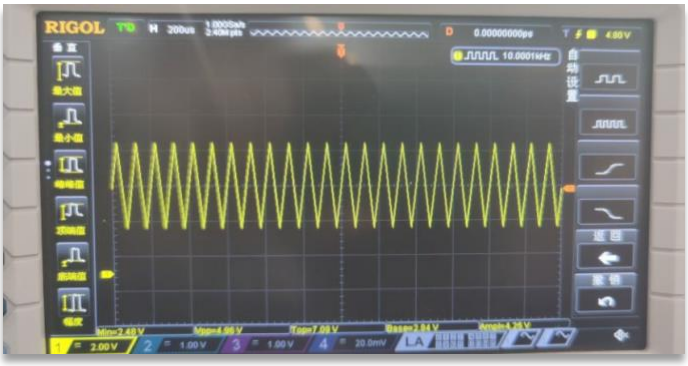

Summing Amplifier
-700m
-695m
-690m
-685m
-680m
-675m
-670m
-665m
-660m
-655m
-650m
-645m
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
Channel_A Voltage(V)
Chanel_B Voltage(V)
1.44
1.45
1.46
1.47
1.48
1.49
1.50
1.51
1.52
1.53
1.54
1.55
Time (s)
Channel A
Channel B

Part 3: Differentiator



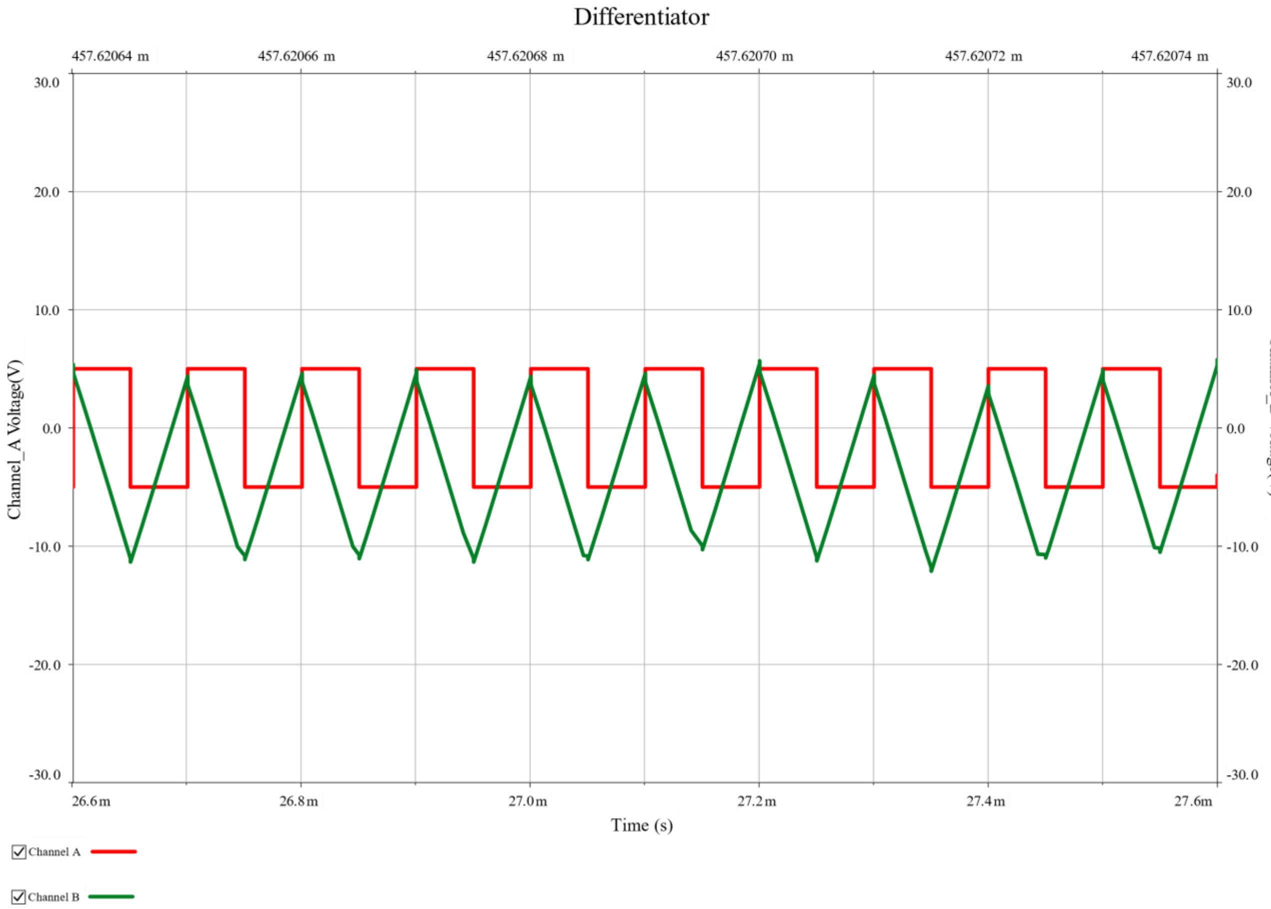
☐ Task 7

A differentiator circuit is shown below. Although it is not as useful as the circuit forms covered above, the differentiator does provide a useful operation, the resulting relation for the circuit being where the scale factor is -RC.

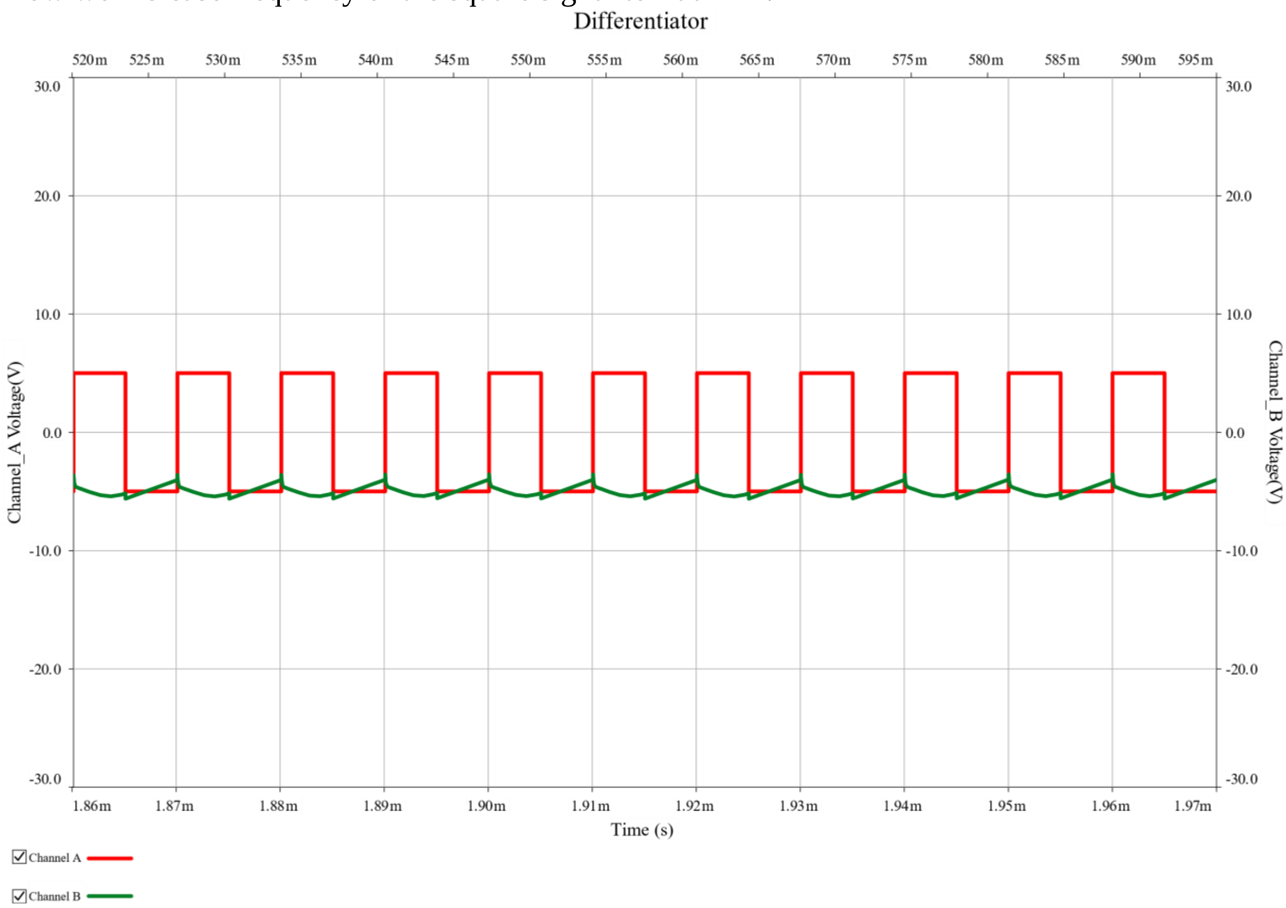


☐ Task 8

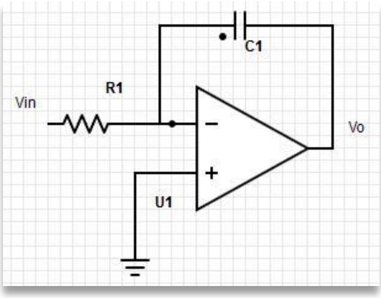
Now the waveform we derive is the square signal when frequency is 10kHz.



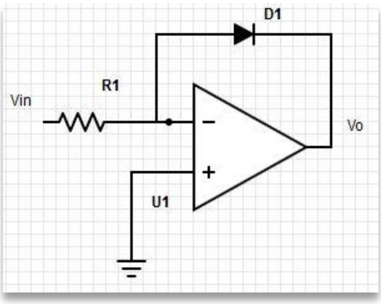
Now we increase frequency of the square signal to 100KHz.



Part 4: Integrator



Part 5: Log operation



Task 13

Using the exponential law of PN junction volt-ampere characteristics, connecting diodes or transistors to the feedback loop and input loop of the integrated operational amplifier, respectively, can realize logarithmic and exponential operations.
According to the basic knowledge of semiconductors, the approximate relationship between the forward current of a diode and its terminal voltage is $i_D \approx I_s e^{\frac{u_d}{U_T}}$.
So that $u_D \approx U_T \ln\frac{i_D}{I_S}$.
Due to $u_p = u_N = 0$,
so $i_D = i_R = \frac{u_1}{R}$.
Above all, $u_o = -u_D \approx -U_T \ln\frac{u_1}{I_s R}$.

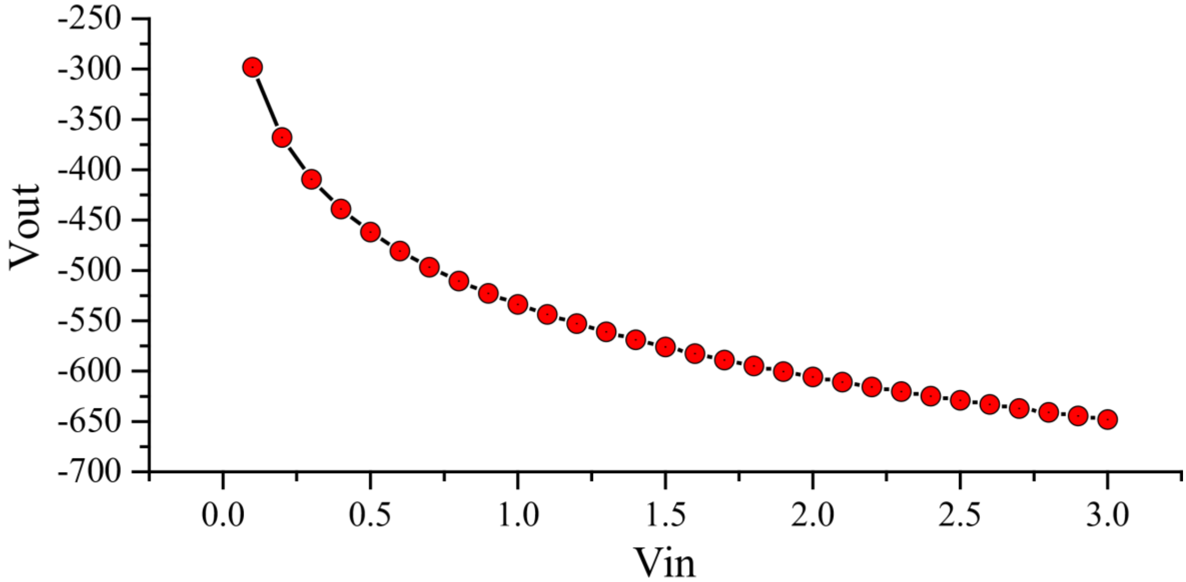
Task 14

Vin (V)	0.1	0.2	0.3	0.4	0.5
Vout (mV)	-298.13	-367.96	-409.411	-438.911	-462.008
Vin (V)	0.6	0.7	0.8	0.9	1
Vout (mV)	-480.853	-496.897	-510.642	-522.855	-533.786
Vin (V)	1.1	1.2	1.3	1.4	1.5
Vout (mV)	-543.68	-552.716	-561.032	-568.733	-575.905
Vin (V)	1.6	1.7	1.8	1.9	2
Vout (mV)	-582.615	-588.92	-594.865	-600.49	-605.827
Vin (V)	2.1	2.2	2.3	2.4	2.5

Vout (mV)	-610.905	-615.746	-620.374	-624.804	-629.055
Vin (V)	2.6	2.7	2.8	2.9	3
Vout (mV)	-633.139	-637.069	-640.856	-644.511	-648.043

Task 15

This is our derived relationship between Vin and Vout.



Task 16