Lab 4:
Operational Amplifiers – Part II

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ECEN 325 Section 514

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Calculations

(1)

$$V_o = -\left(\frac{R_3}{R_1}V_{i1} + \frac{R_3}{R_2}V_{i2}\right) = -\left(V_{i1} + 2V_{i2}\right) \quad , \quad R_3 = 15k\Omega$$

$$\frac{R_3}{R_1} = 1 \Rightarrow \boxed{R_1 = 15k\Omega} \qquad \frac{R_3}{R_2} = 2 \Rightarrow \boxed{R_2 = 7.5k\Omega}$$

(2)

$$V_o = \frac{R_2}{R_1}(V_{i2} - V_{i1}) = V_{i2} - V_{i1} \quad , \quad R_2 = R_3 = R_4 = 10k\Omega$$

$$\frac{R_2}{R_1} = 1 \Rightarrow \boxed{R_1 = 10k\Omega}$$

(3)

$$V_o = \left(1 + \frac{2R}{R_{Gain}}\right)\left(V_{i2} - V_{i1}\right) = 3\left(V_{i2} - V_{i1}\right) \quad , \quad R_{Gain} = 1k\Omega$$

$$1 + \frac{2R}{R_{Gain}} = 3 \Rightarrow \frac{2R}{1k\Omega} = 2 \Rightarrow \boxed{R = 1k\Omega}$$

(4) $V_{i1} = 0.2\sin(2\pi 1000t)$, $V_{i2} = 0.3V$

Circuit 1 : $V_o = -(V_{i1} + 2V_{i2}) = \boxed{-0.2\sin(2\pi 1000t) - 0.6}$

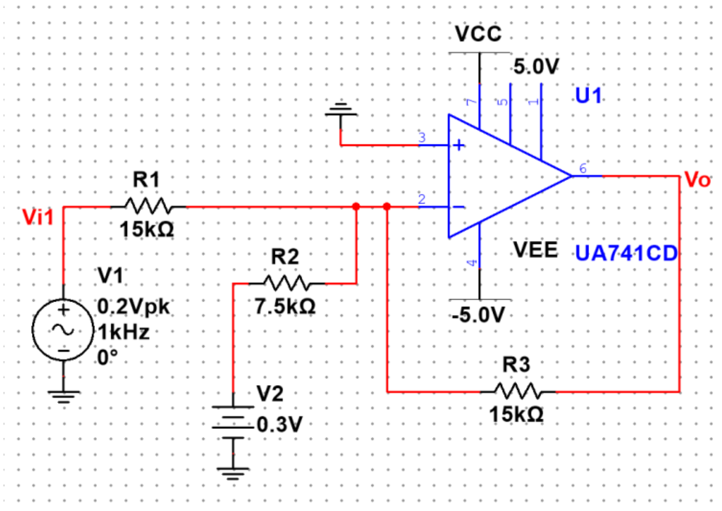
Circuit 2 : $V_o = V_{i2} - V_{i1} = \boxed{0.3 - 0.2\sin(2\pi 1000t)}$

Circuit 3 : $V_o = 3(V_{i2} - V_{i1}) = \boxed{0.9 - 0.6\sin(2\pi 1000t)}$

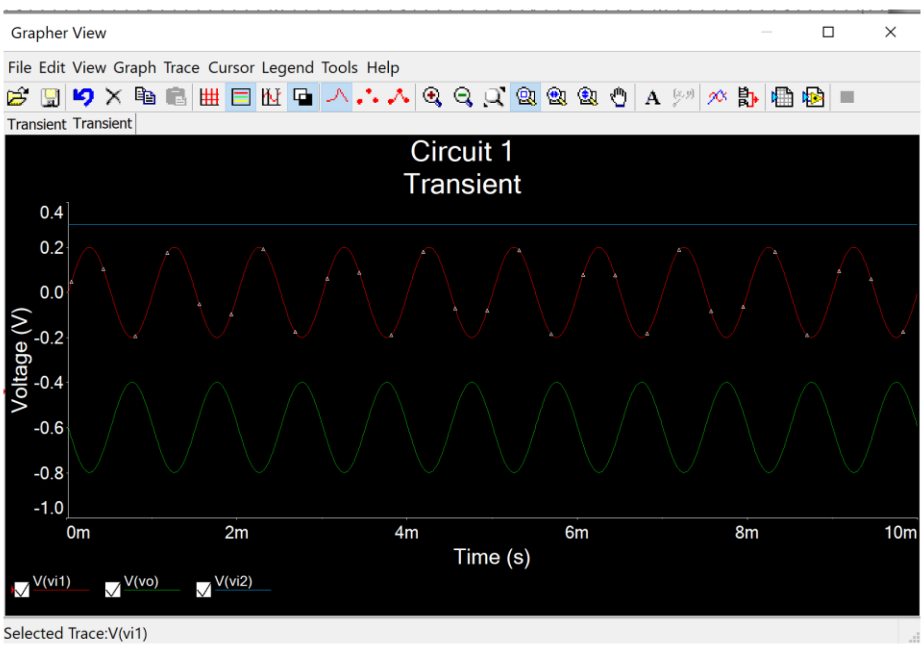
Simulations

Circuit 1 (Summing Amplifier):

(a)



(b)

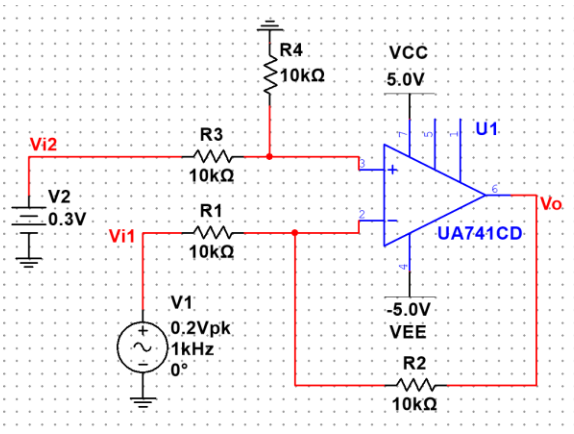


$V_{i1} = 0.2\, sin(2\Pi 1000t)$

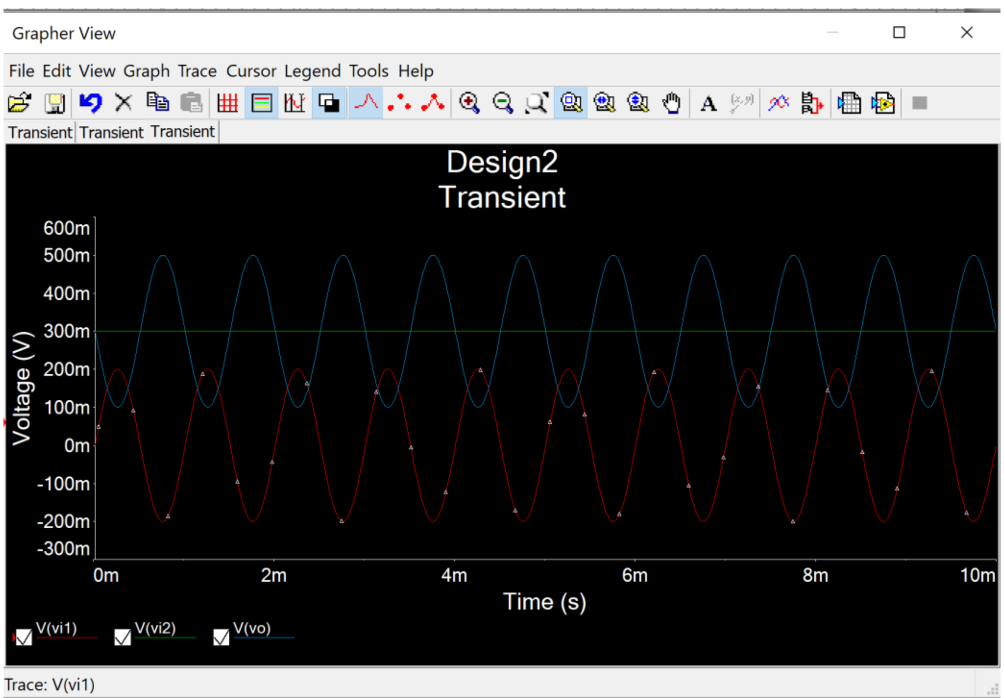
$v_0 = -0.2\, sin(2\Pi 1000t) - 0.6$, which is opposite the V_{i1} and shift down by 0.6.

Circuit 2 (Differential Amplifier):

(a)



(b)

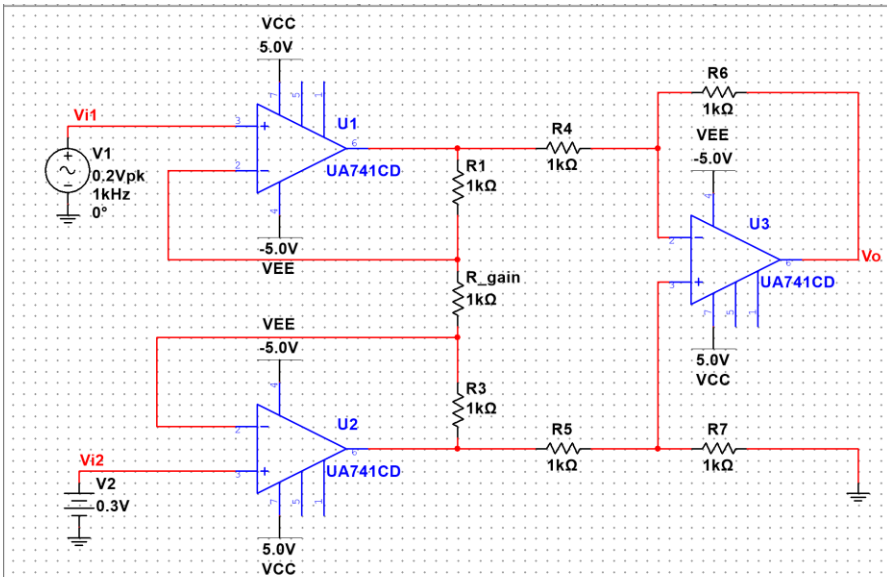


$V_{i1} = 0.2\, sin(2\Pi 1000t)$

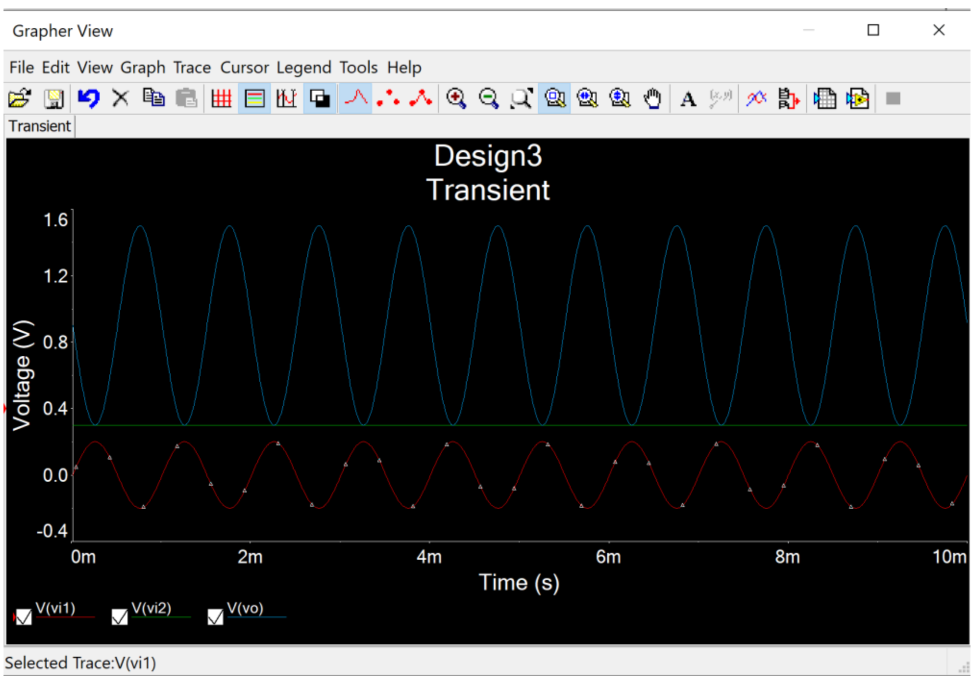
$v_0 = -0.2\, sin(2\Pi 1000t) + 0.3$, which is opposite the V_{i1} and shift up by 0.3.

Circuit 3 (Instrumentation Amplifier):

(a)



(b)



$V_{i1} = 0.2\, sin(2\Pi 1000t)$

$v_0 = -0.6\, sin(2\Pi 1000t) + 0.9$

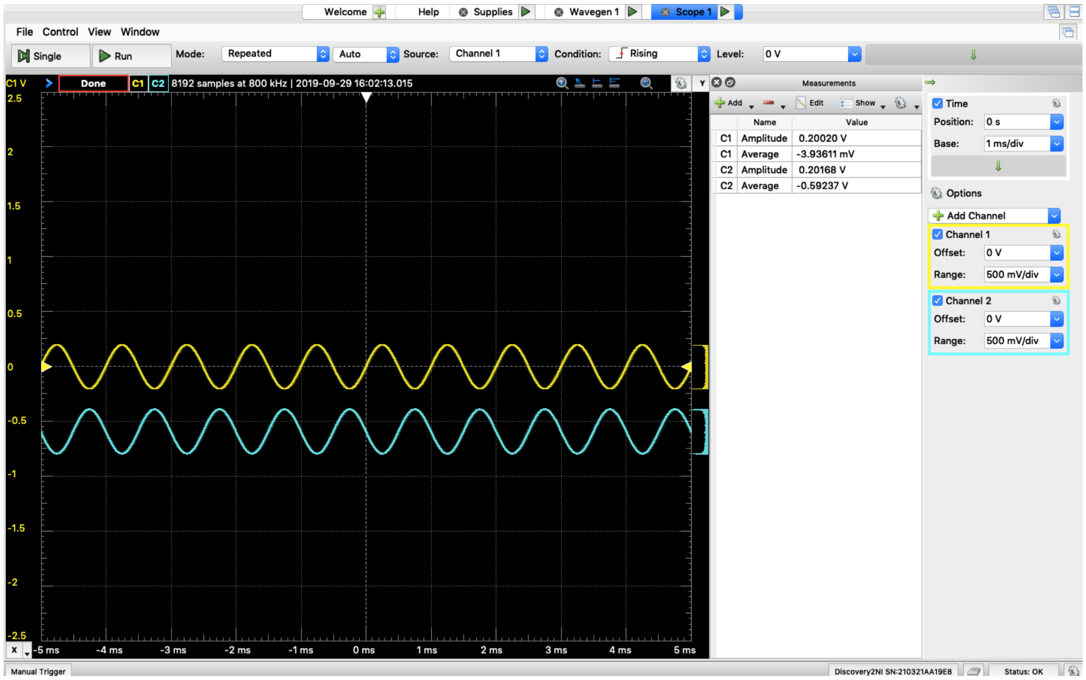
which is opposite the V_{i1} with amplitude of 0.6 and shift up by 0.9.

Measurements

Circuit 1 (Summing Amplifier):

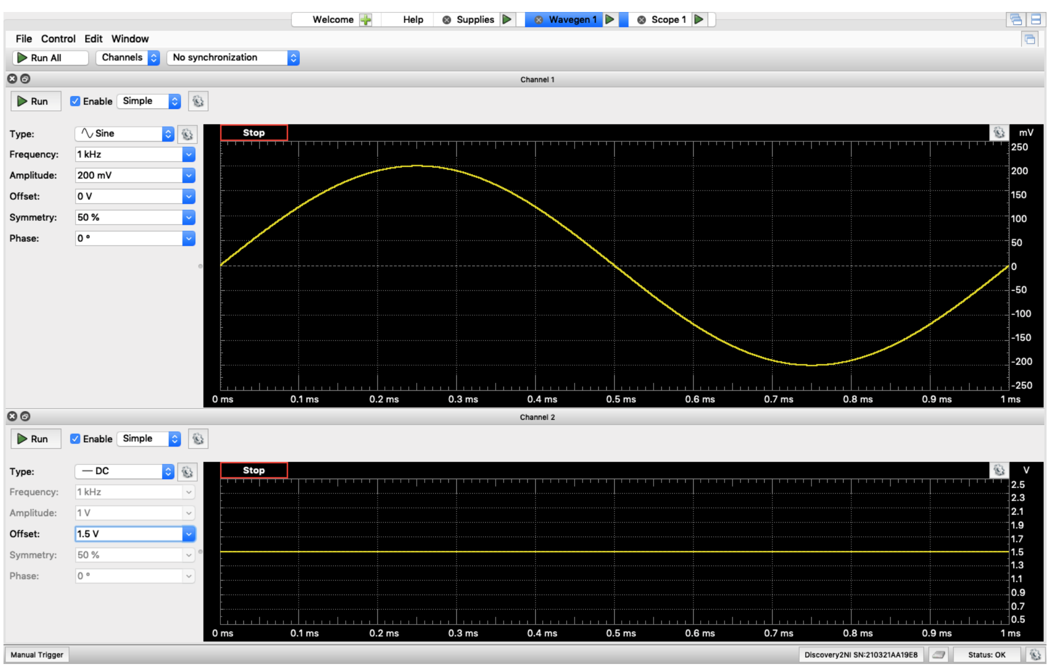
Time-Domain Waveform

V_o (C2) shifted down 0.6 and is opposite to V_1 (C1).

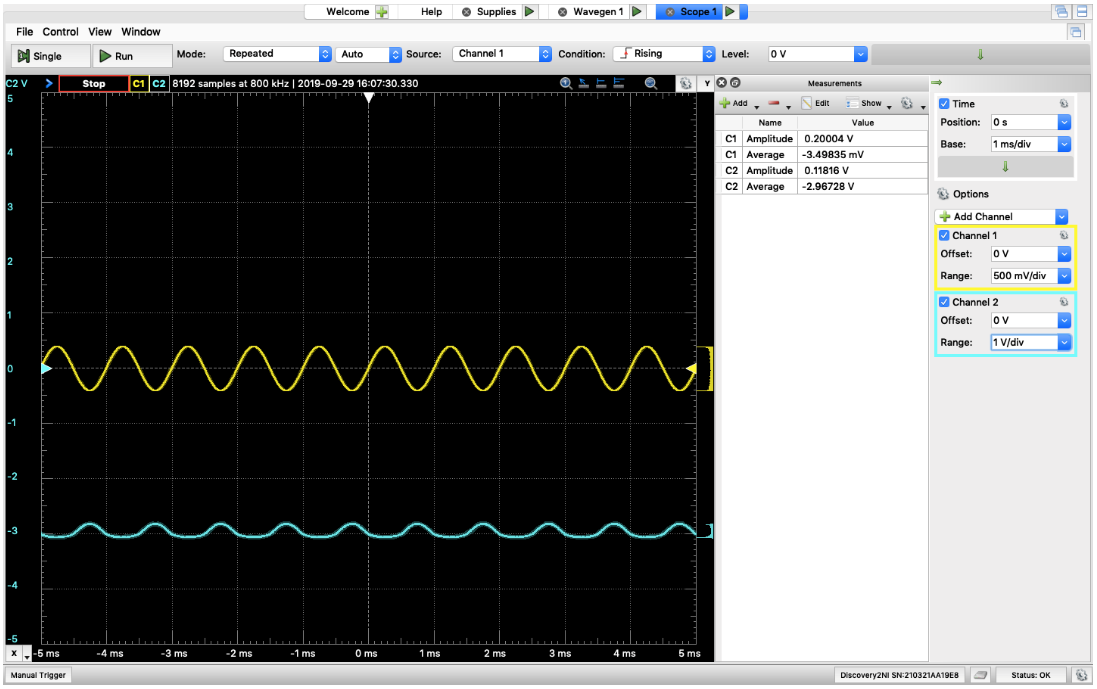


Clipping Waveform Generator

$V_2 = 1.5V$



Clipping Time-Domain Waveform

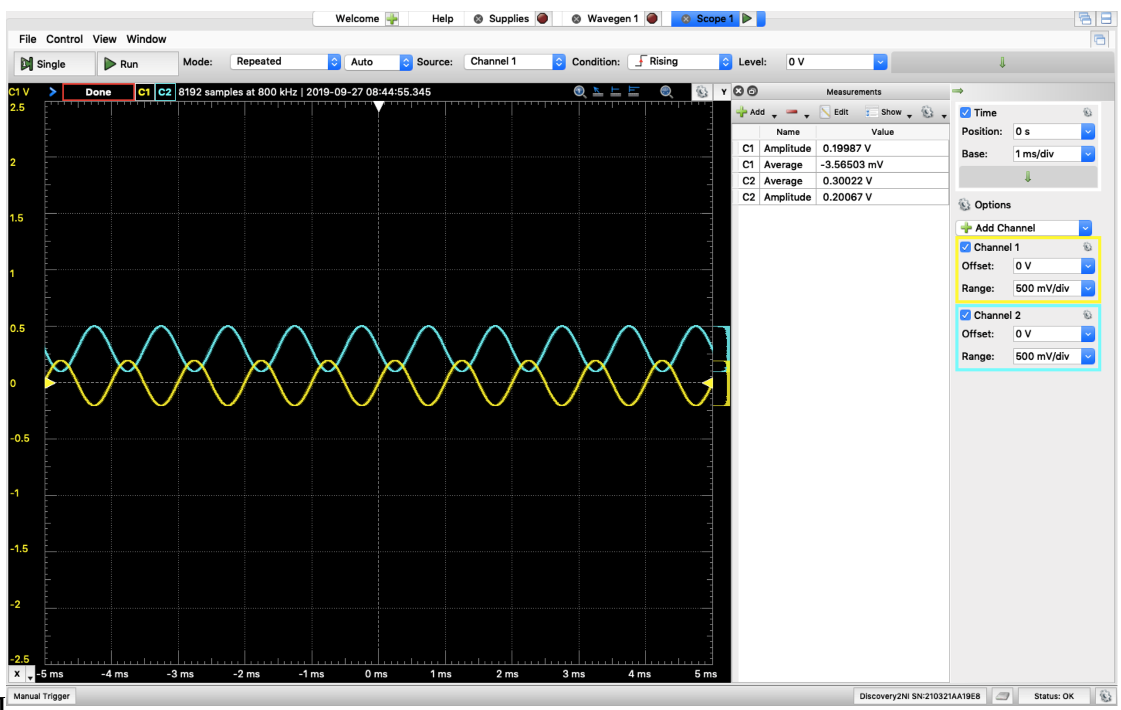


Circuit 2 (Differential Amplifier):

Time-Domain Waveform

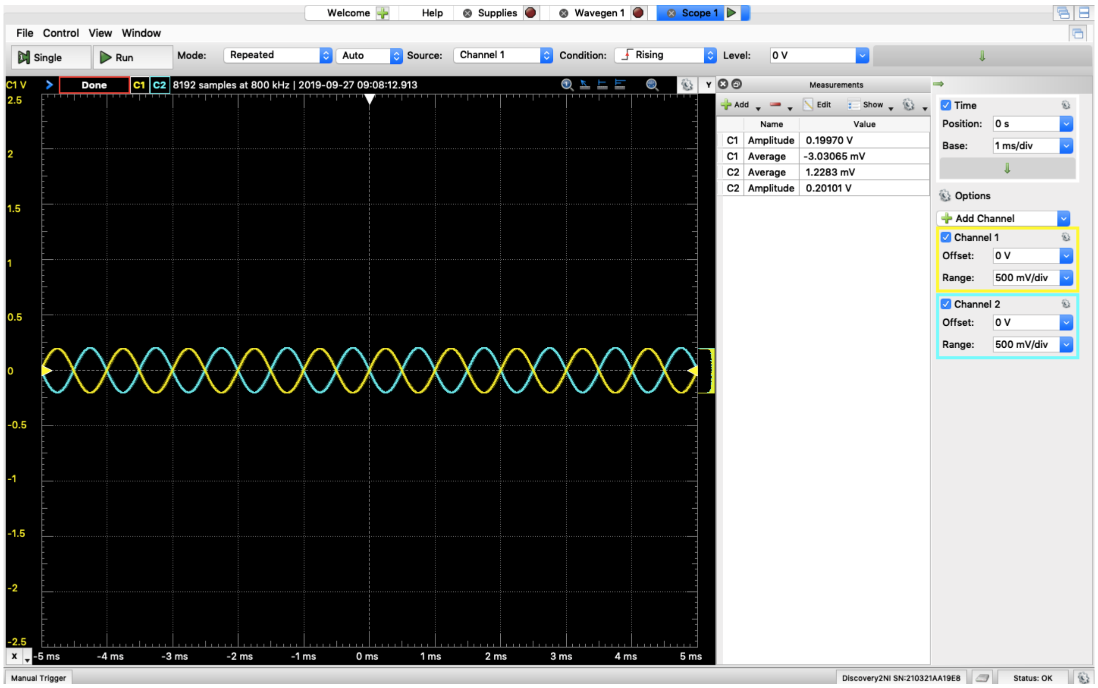
V_o (C1) shifted up 0.3 and opposite to V_1 (C2).

DM



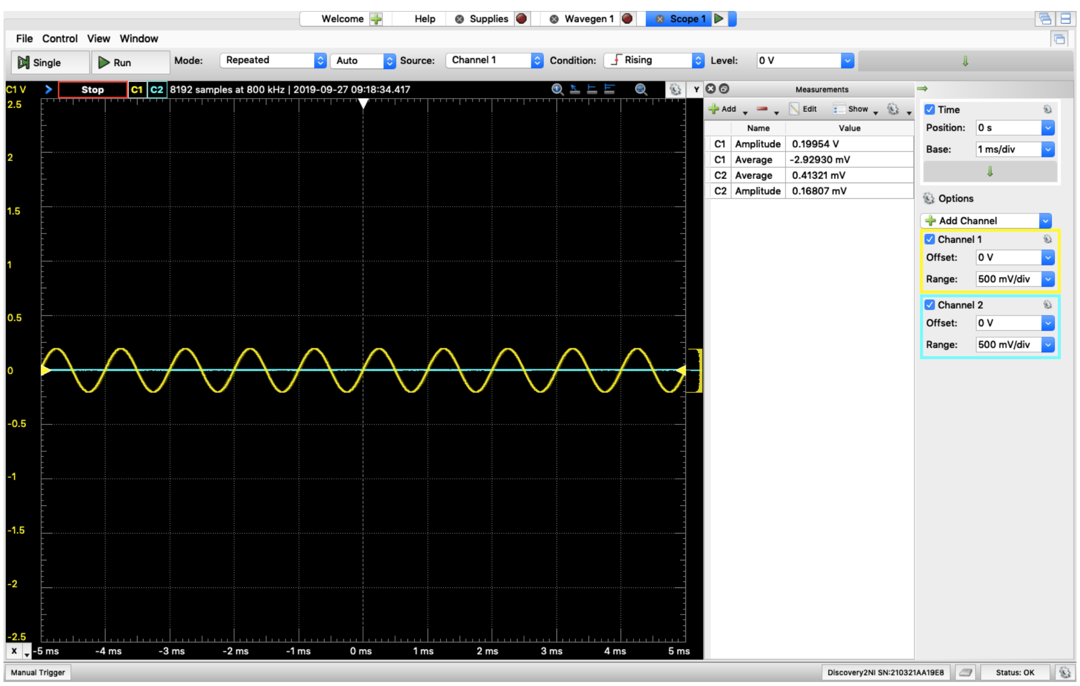
A_{DM} Time-Domain Waveform

$$A_{DM} = \frac{V_{out}}{V_{in}} = \frac{0.201}{0.200} = 1.005$$



A_{CM} Time-Domain Waveform

$$A_{CM} = \frac{V_{out}}{V_{in}} = \frac{0.168 * 10^{-3}}{0.199} = 0.000844$$

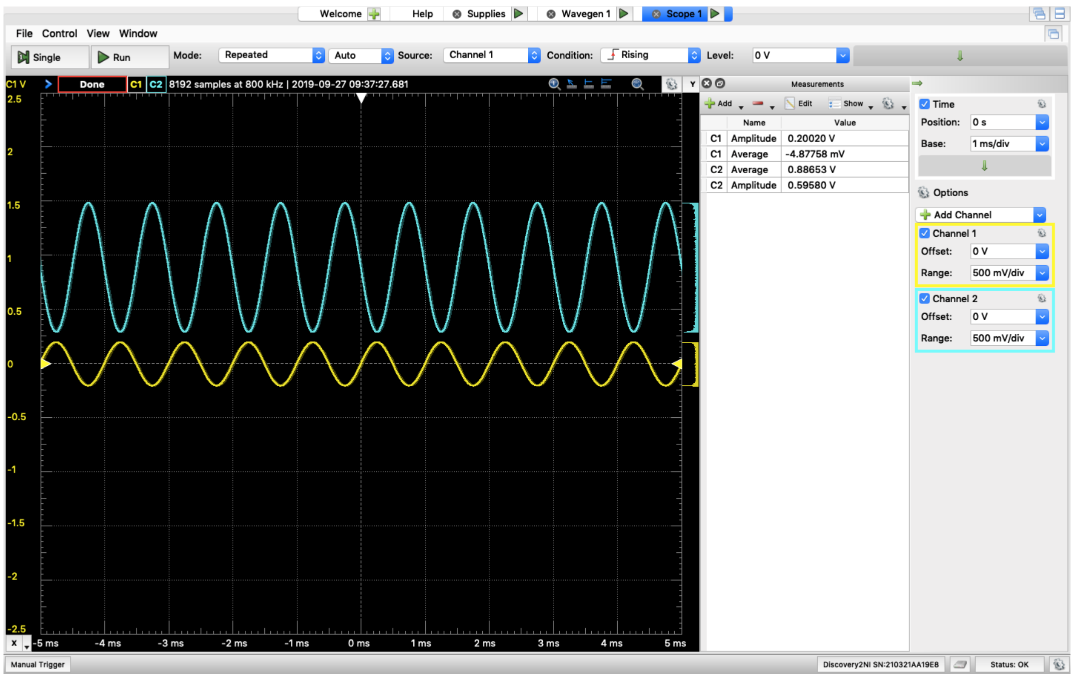


$$\boldsymbol{CMRR} = \frac{A_{DM}}{A_{CM}} = \frac{1.005}{0.000844} = \mathbf{1190.76}$$

Circuit 3 (Instrumentation Amplifier):

Time-Domain Waveform

V_o (C2) shifted up 0.9 and is opposite to V_1 (C1) and the amplitude increase to 0.6.



Saturated Point for UA741 (Extra Question):

Positive V_{sat} = 4.381V

Negative V_{sat} = -3.129V

Tables

	Amplitude	Average	Opposite to V_1
Circuit 1 Calculated	0.2	-0.6	Yes
Circuit 1 Simulated	0.2	-0.6	Yes
Circuit 1 Measurement	0.202	-0.592	Yes
Circuit 2 Calculated	0.2	0.3	Yes
Circuit 2 Simulated	0.2	0.3	Yes
Circuit 2 Measurement	0.201	0.300	Yes
Circuit 3 Calculated	0.6	0.9	Yes
Circuit 3 Simulated	0.6	0.9	Yes
Circuit 3 Measurement	0.596	0.886	Yes

Comments

The results from calculated part, simulated part, and measurement part are similar. The slightly different for measurement results are due to the real-world amplifiers and resistors have some tolerance.

CMRR value calculated in Circuit 2 Measurement part is 1190.76. The ideal CMRR value supposed to be infinity, A_{DM} supposed to be 1, and A_{CM} supposed to be 0. However, in real-world, A_{DM} can only be close to 1, and A_{CM} can only be close to 0. Therefore, CMRR value cannot be infinity but it would be a large value.