**Lab 4: Operational Amplifiers – Part 2**

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**Calculations**

1. Summing amplifier

R3 = 15kΩ

R3 = R1

**R1 = 15kΩ**

R3 / R2 = 2

**R2 = 7.5kΩ**

1. Differential amplifier

R2 = R3 = R4 = 10kΩ

R2 / R1 = 1

**R1 = 10kΩ**

1. Instrumentation amplifier

Rgain = 1kΩ

3 = 1 + 2R/Rgain

**R = 1kΩ**

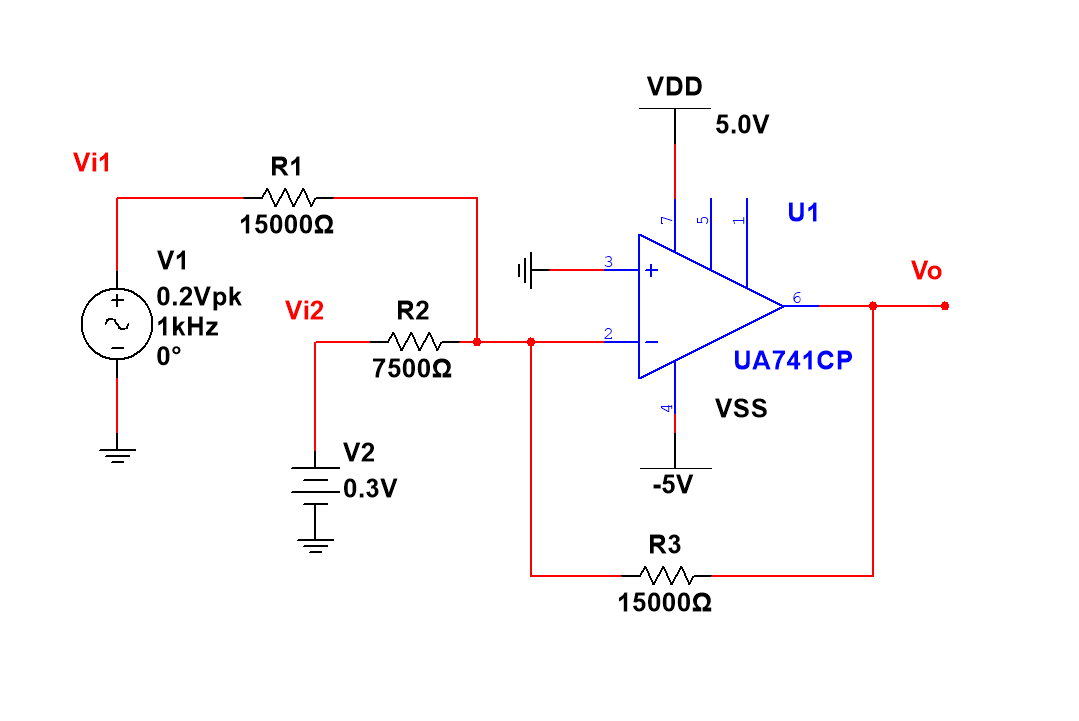
1. Summing amplifier

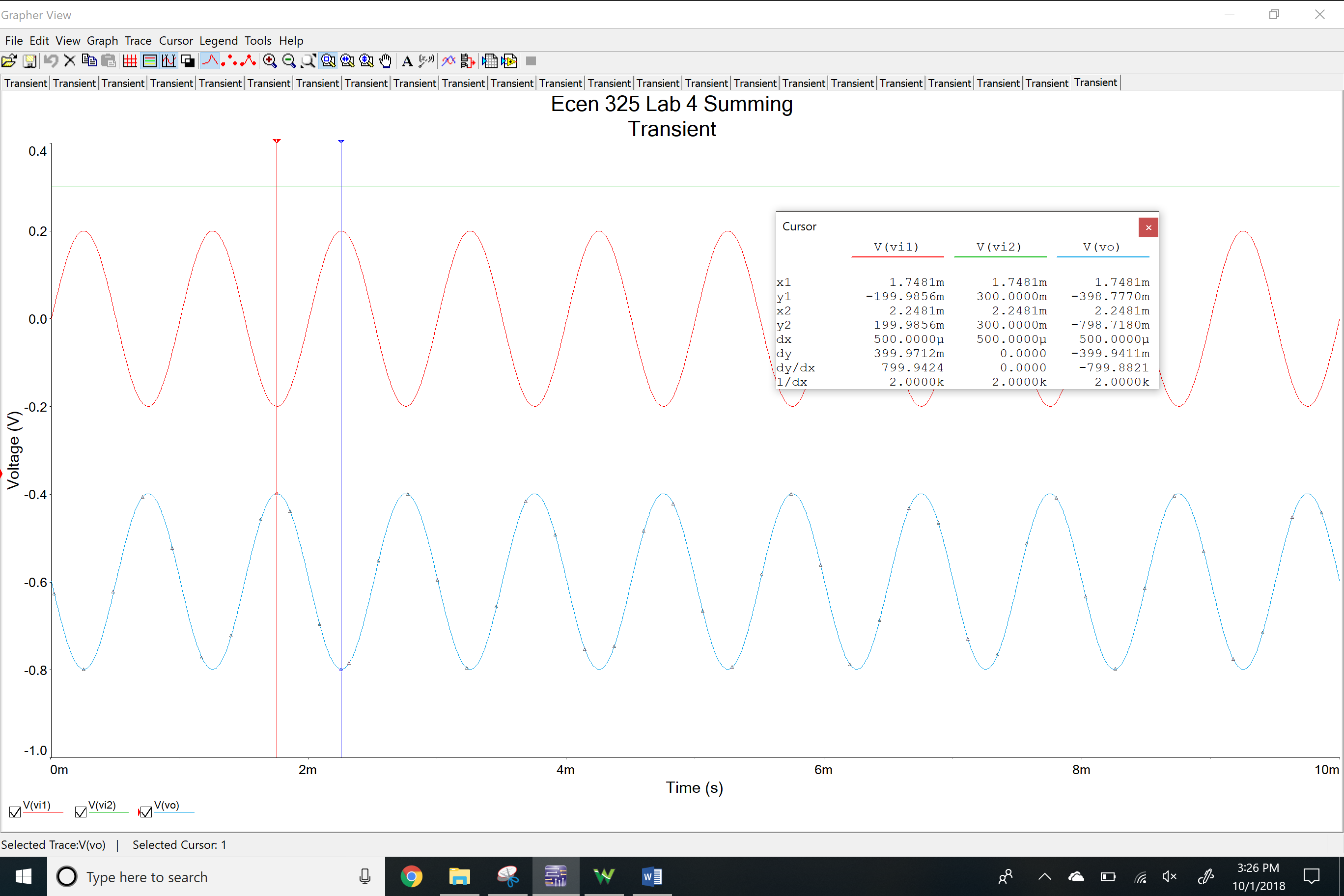
Differential amplifier

Instrumental amplifier

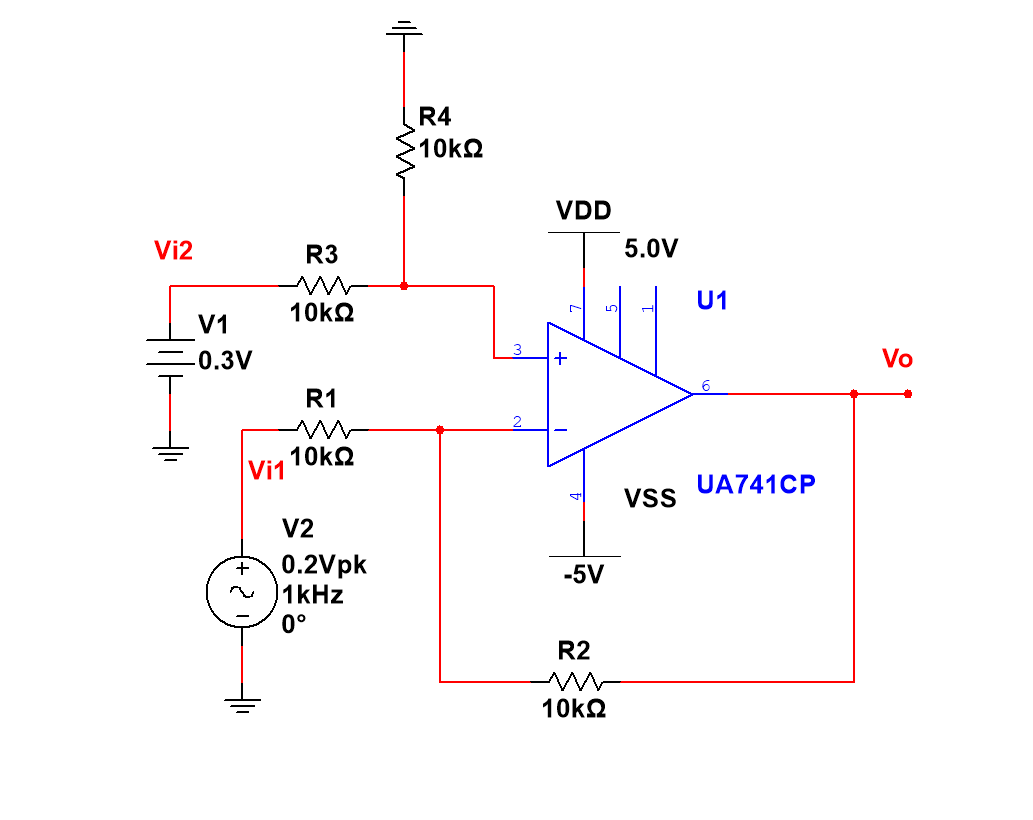
**Simulations**

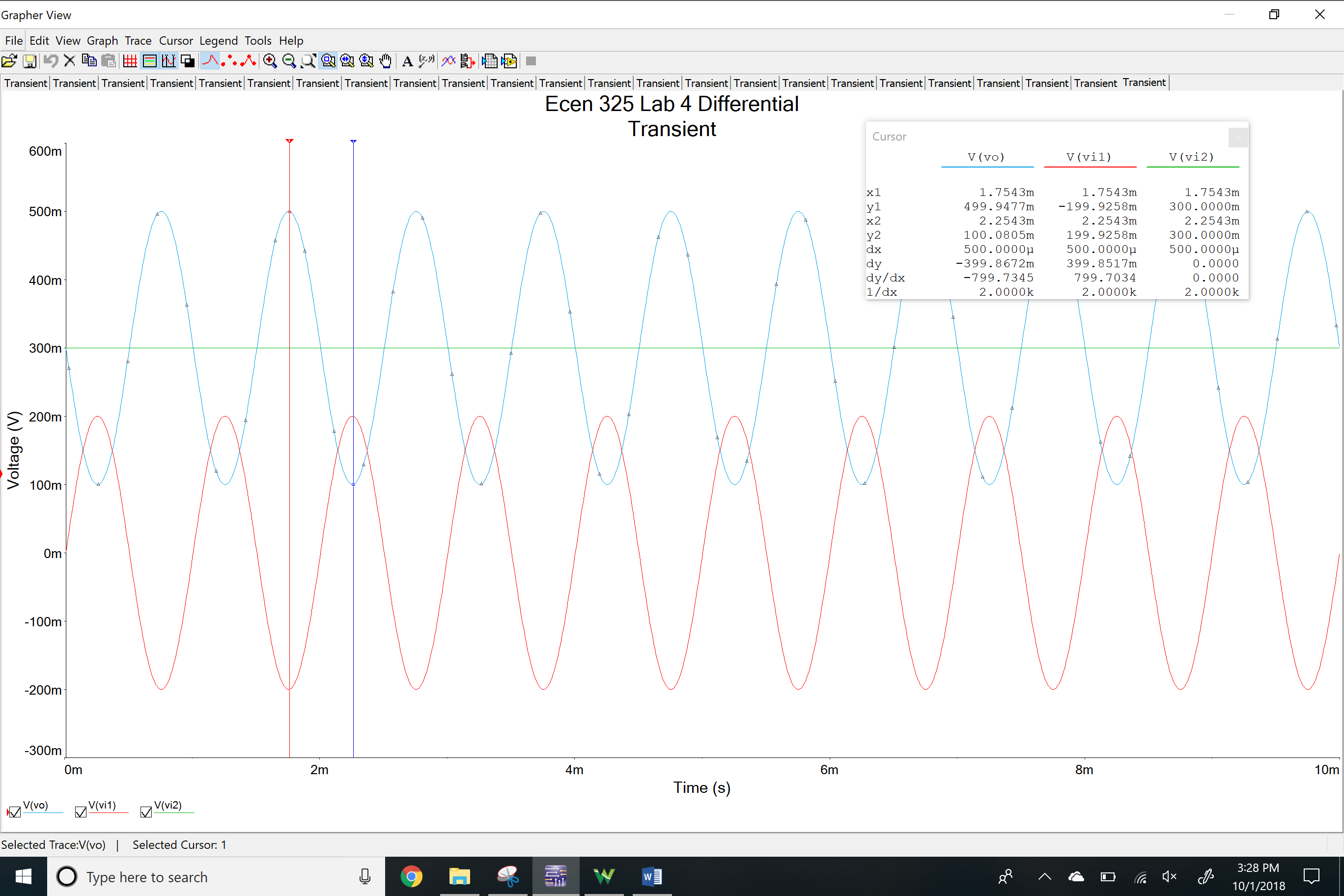
Summing amplifier



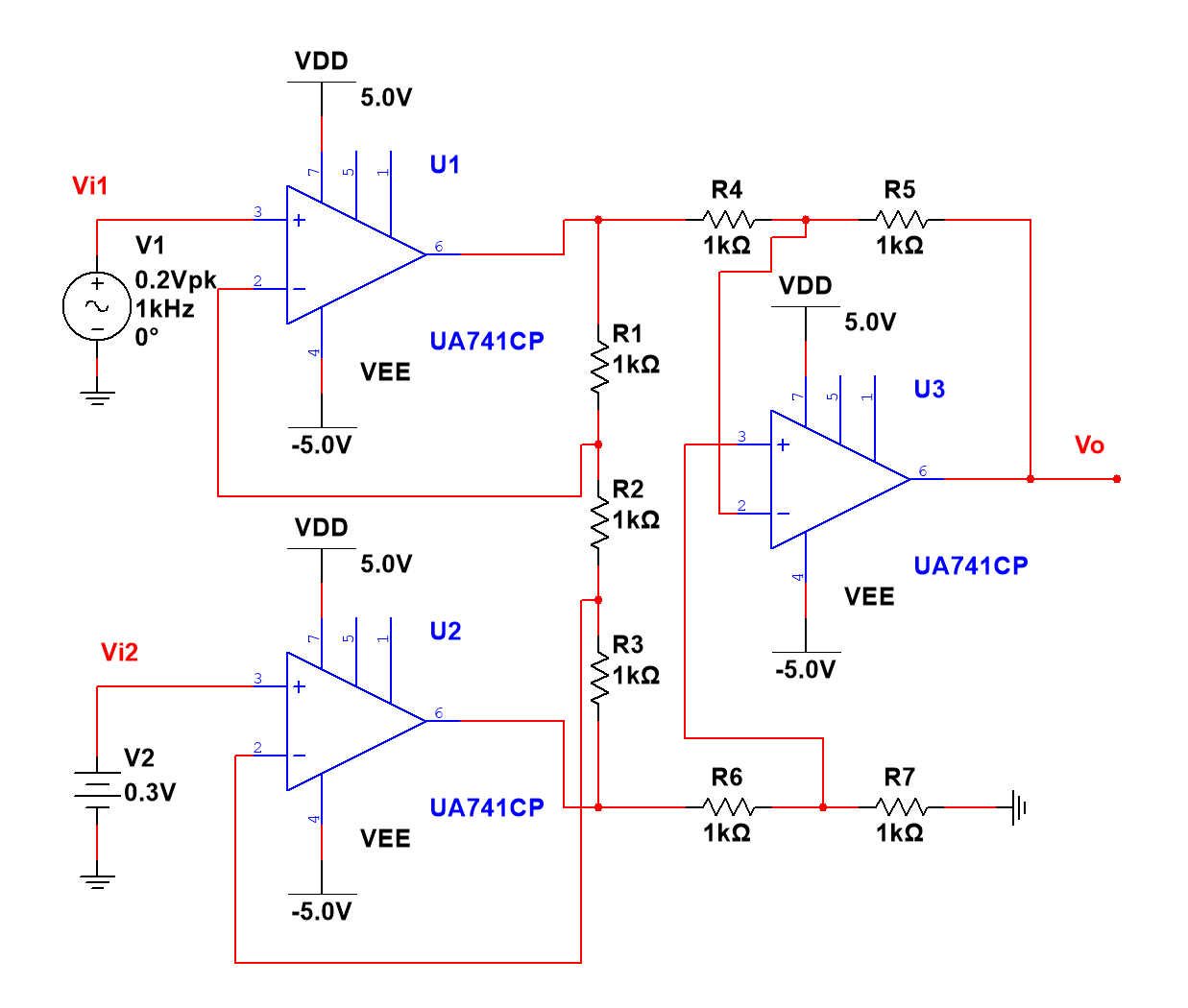


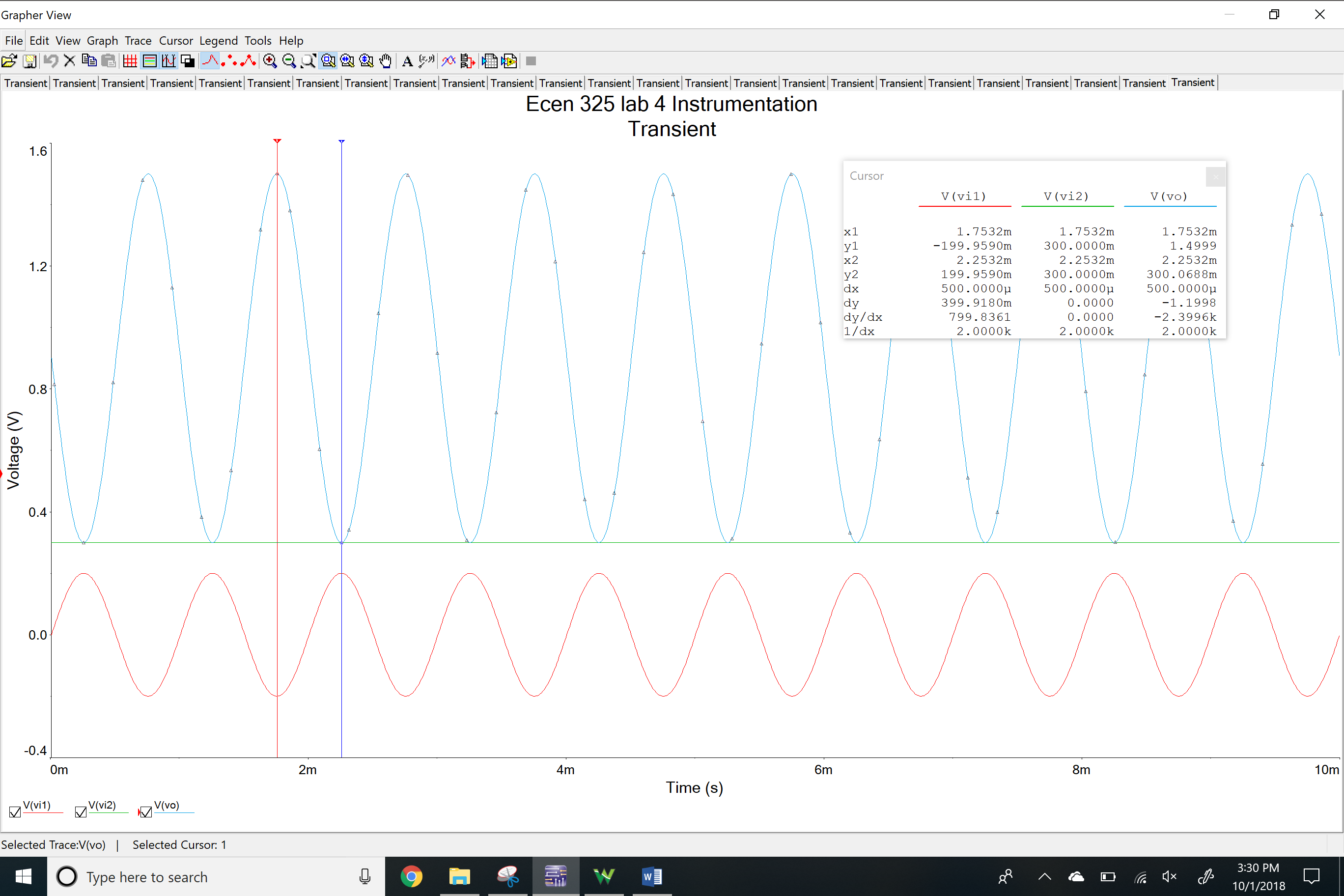
Differential amplifier





Instrumentation amplifier

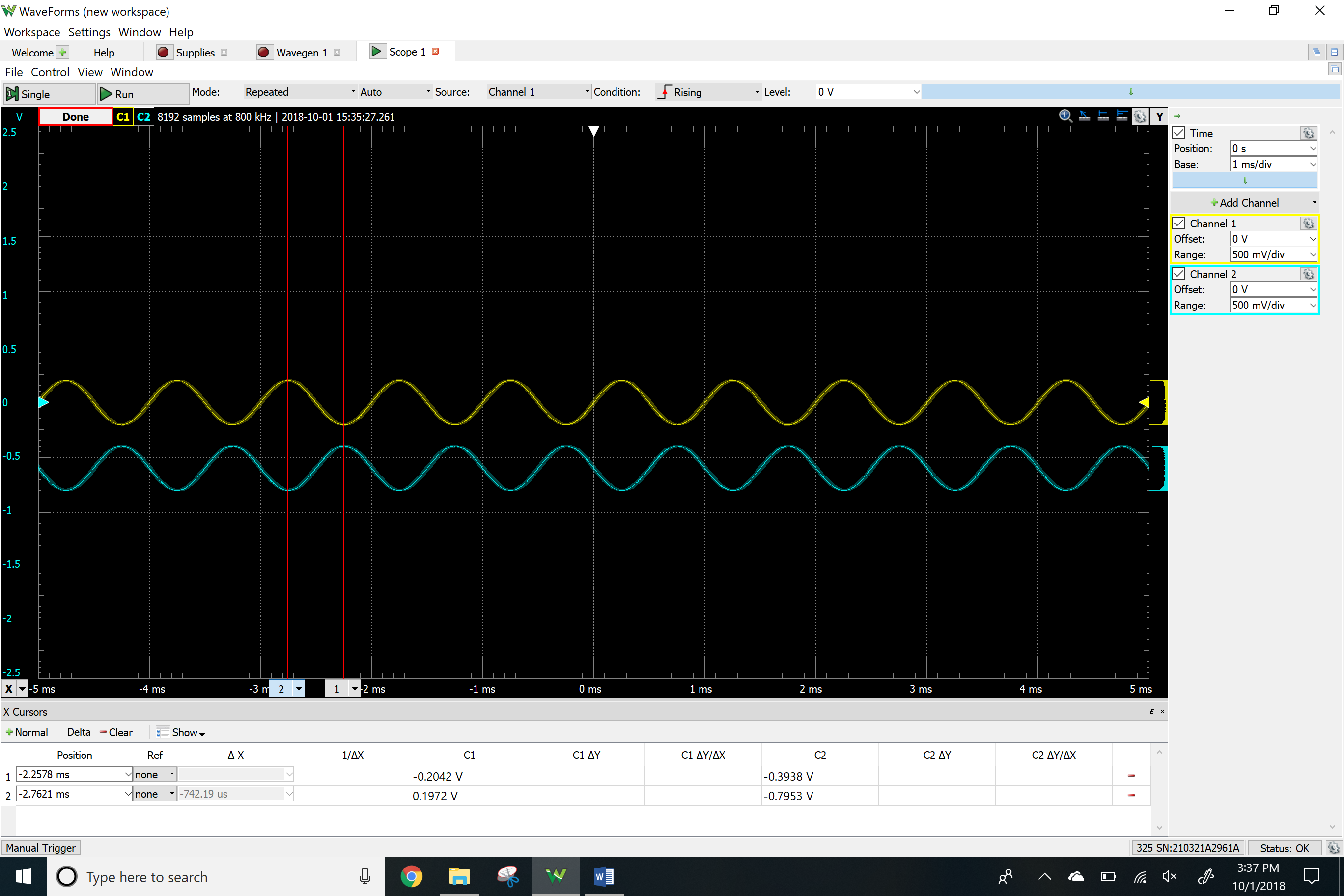




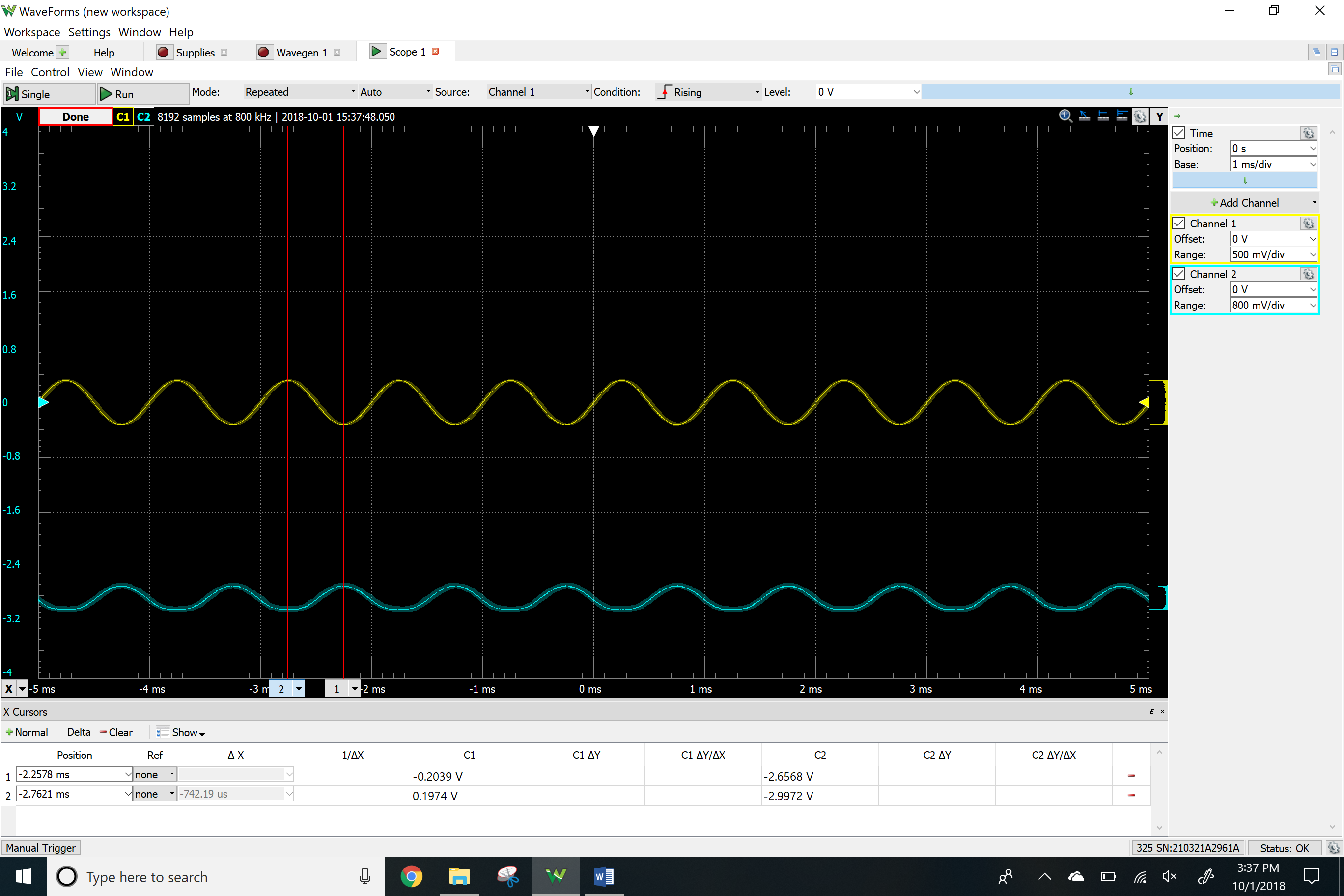
**Measurements**

Summing amplifier

Time-domain waveform

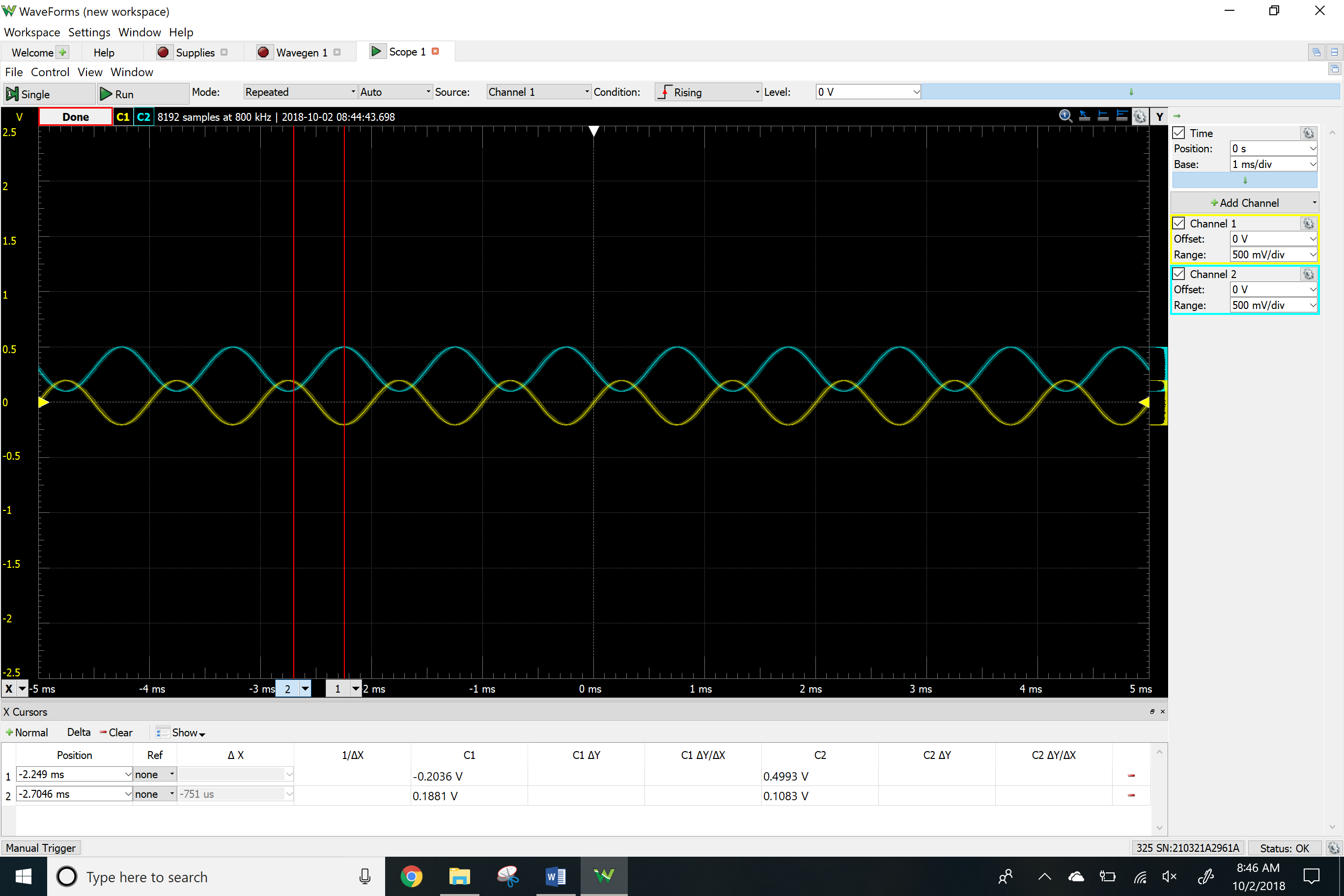


Clipping

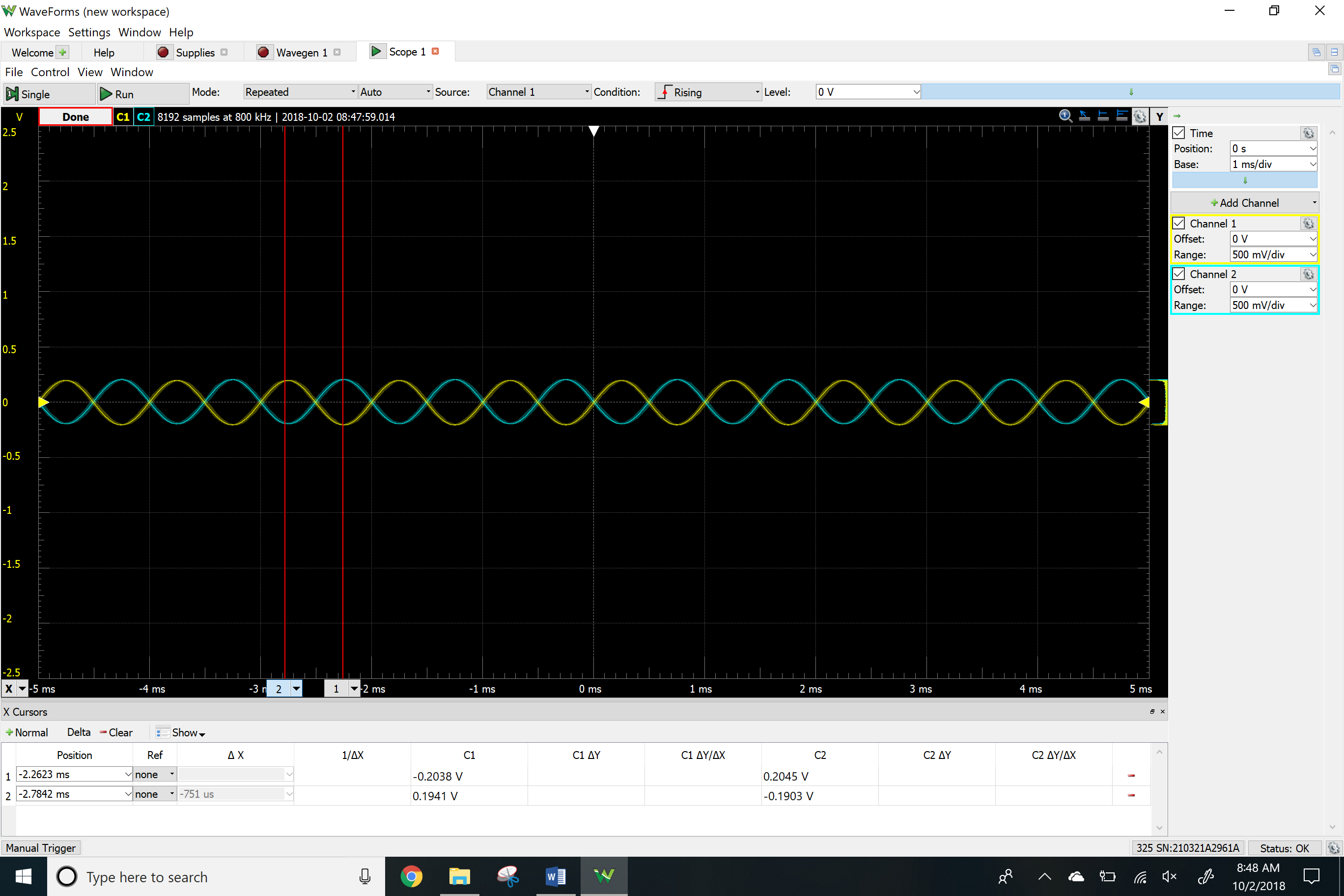


Differential amplifier

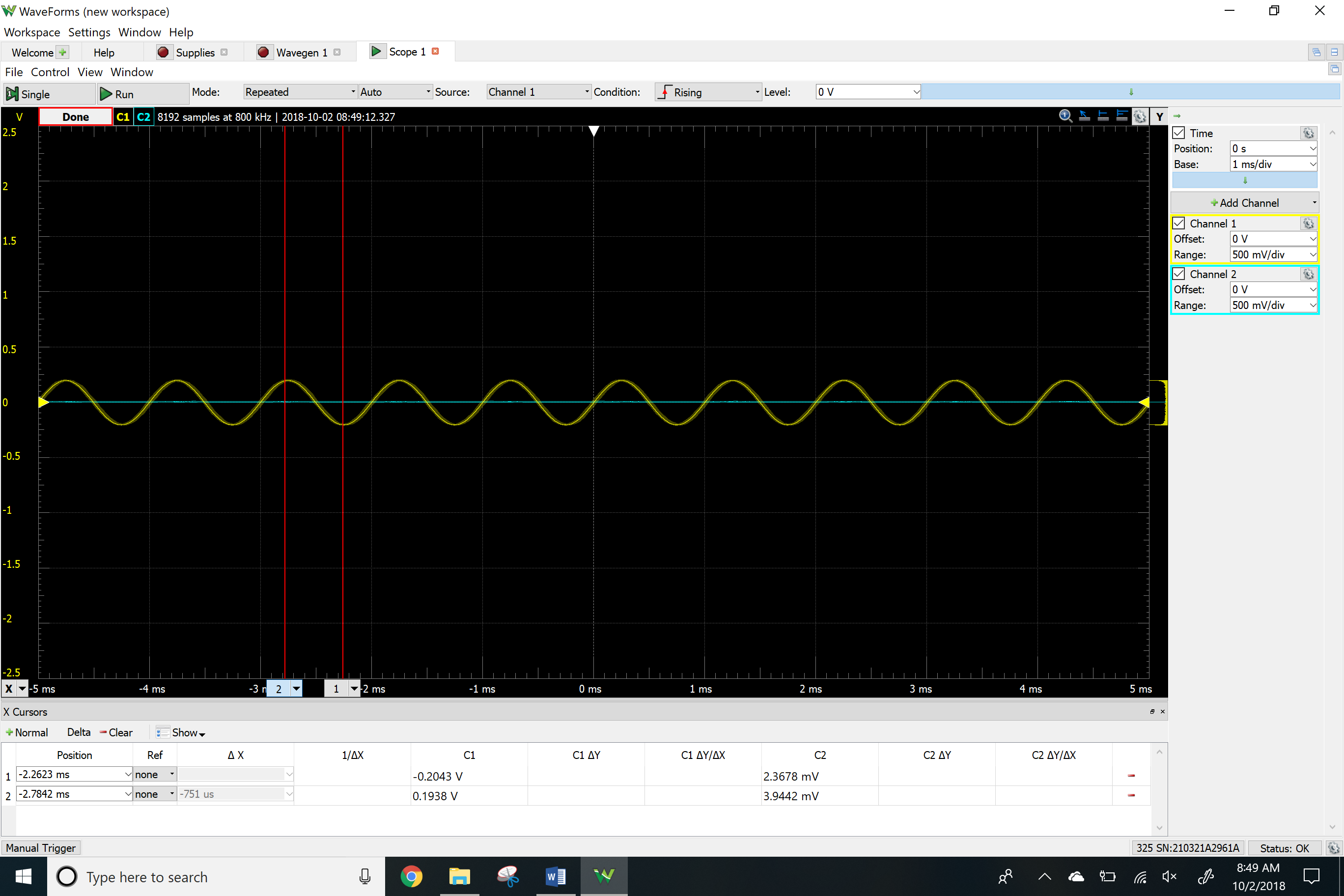
Time-domain waveform



ADM

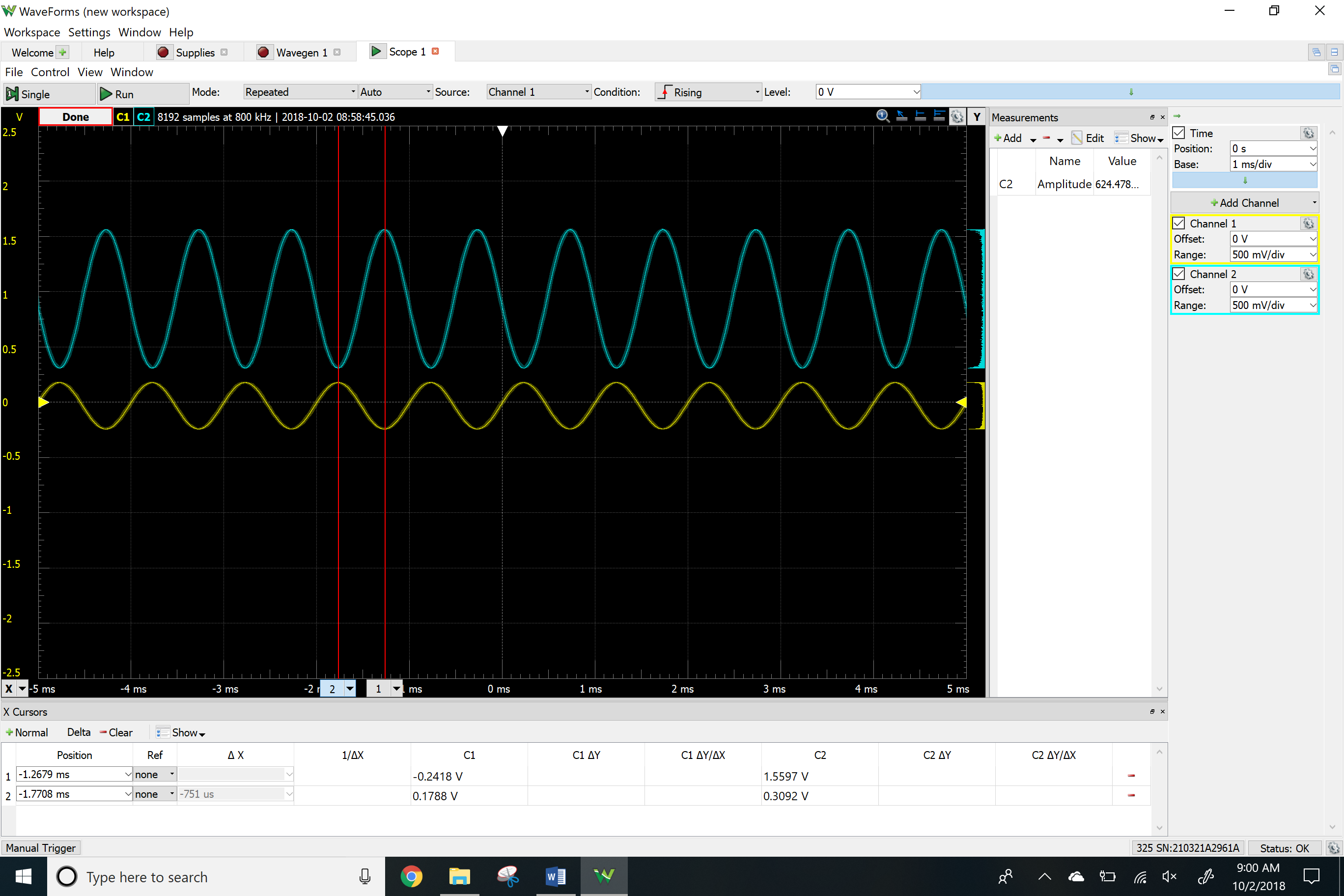


ACM



Instrumentation amplifier

Time-domain waveform



**Results**

Calculated

|  |  |
| --- | --- |
|  | Summing |
| Vi1 | 0.2 V @ 1kHz |
| Vi2 | 0.3 V |
| Vo | -0.2sin(2π1000t)-0.6 V |

|  |  |
| --- | --- |
|  | Differential |
| Vi1 | 0.2 V @ 1kHz |
| Vi2 | 0.3 V |
| Vo | 0.3-0.2sin(2π1000t) V |

|  |  |
| --- | --- |
|  | Instrumentation |
| Vi1 | 0.2 V @ 1kHz |
| Vi2 | 0.3 V |
| Vo | 0.9-0.6sin(2π1000t) V |

Simulated

|  |  |  |  |
| --- | --- | --- | --- |
|  | Summing | Differential | Instrumentation |
| Vi1 | 0.2 V @ 1kHz | 0.2 V @ 1kHz | 0.2 V @ 1kHz |
| Vi2 | 0.3 V | 0.3 V | 0.3 V |
| Vo | 0.199 V | 0.199 V | 0.599 V |

Measured

|  |  |  |  |
| --- | --- | --- | --- |
|  | Summing | Differential | Instrumentation |
| Vi1 | 0.2 V @ 1kHz | 0.2 V @ 1kHz | 0.2 V @ 1kHz |
| Vi2 | 0.3 V | 0.3 V | 0.3 V |
| Vo | 0.200 V | 0.195 V | 0.625 V |
| ADM | - | 1 V | - |
| ACM | - | 0 V | - |
| CMRR | - | 0 V | - |
| Clipping Point | ~1.4 V | - | - |

**Conclusion**

Differences between calculated and simulated results:

There were no differences between the calculated and simulated results.

Differences between all of the results:

Unsurprisingly, the differences between all of the results, from the calculated, simulated and experimental, were negligible. I calculated the common mode rejection ration. This ratio helps us design circuit that are affected by minimum amount of noise. Any differences between the simulated and experimental can be attributed to unaccounted resistances in the breadboard and to resistance values not being exactly as calculated due to not having the proper resistors.