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INVERTING AND NON INVERTING OPERATIONAL AMPLIFIERS

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Table of Contents

Aim:

The aim of this project is to implement both inverting and noninverting operational amplifier (op amp) circuits using ADALM1000 and obtain accurate results.

Theory:

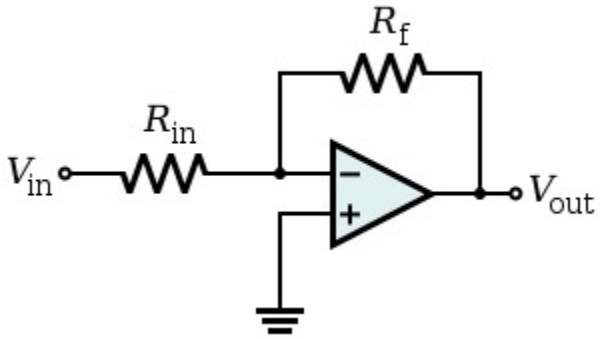
Operational Amplifiers:

An operational amplifier multiplies the voltage difference between its non-inverting and inverting inputs with a gain A and outputs this value. The equation representing this is:

$V_{out} = A(V_{in}^{+} - V_{in}^{-})$

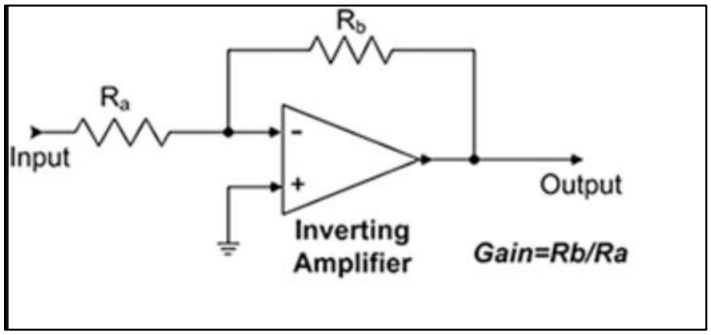
Where V_{in}^{+} is non-inverting and V_{in}^{-} is inverting.

OP-AMPS are used with feedback resistors so as to control the gain as shown.



Inverting OP-AMP:

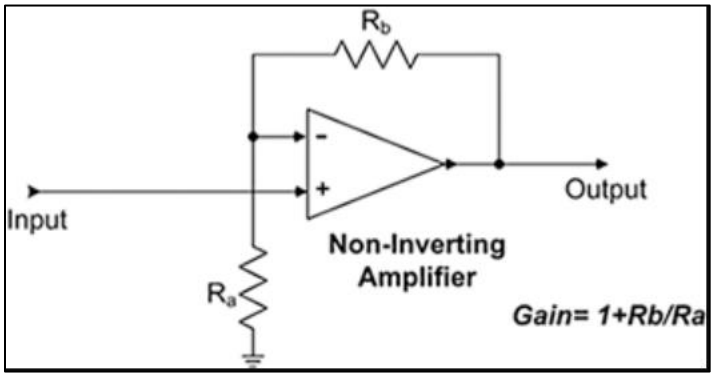
The output of this circuit is out of phase with its input by 180º. Consequently the output is an inverted and amplified version of the input. Two external resistors are used to create a feedback circuit and make a closed loop circuit across the amplifier.



Gain of inverting op-amp will be:

$$Gain = \frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$$

Non-Inverting Op-Amp:



The output signal is in-phase with the input signal.

$$\frac{V_{in}}{V_{out}} = \frac{R1}{(R1 + R_f)}$$

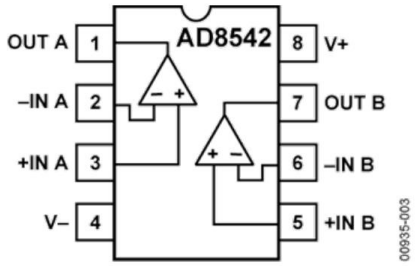
$$A = \frac{V_{out}}{V_{in}} = \frac{R1 + R_f}{R1}$$

Materials required:

- ADALM1000 hardware module
- Solder-less breadboard and jumper wire kit
- AD8542 devices (CMOS rail-to-rail amplifier)
- 1kΩ and 470Ω resistors

Pin Diagram AD542:

OP AMP – PIN CONFIGRATION

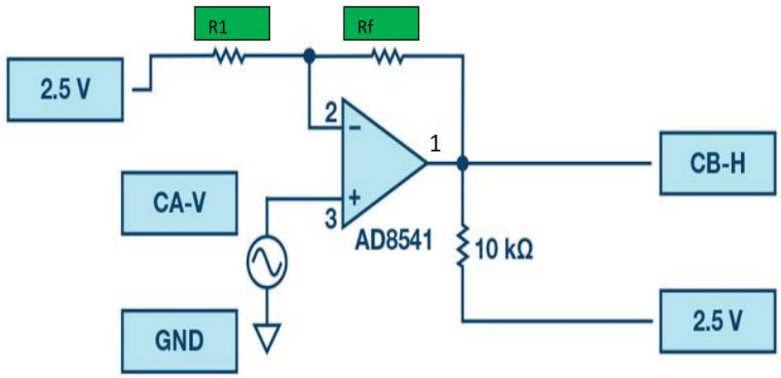


8-LEAD STANDARD SMALL OUTLINE PACKAGE [SOIC_N] NARROW BODY (R-8)

8-LEAD MINI SMALL OUTLINE PACKAGE [MSOP] (RM-8)

8-LEAD THIN SHRINK SMALL OUTLINE PACKAGE [TSSOP] (RU-8)

Challenge 1: Non-inverting



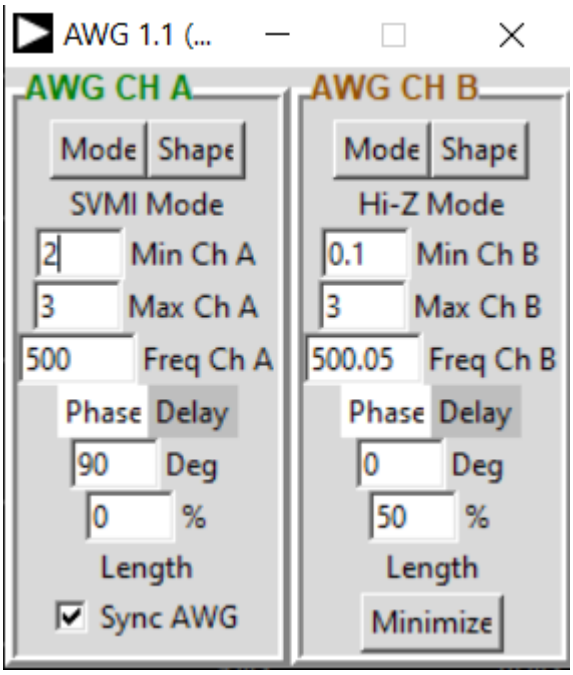
Procedure:

1. Connect the circuit according to the diagram above.
2. In order to get the gain in a non-inverting amplifier, we use $A=1+R_f/R_{in}$.
3. Taking different values of Rin, use the above formula to calculate gain(A).
4. Record the values in a table, shown as the P-P value in CA and CB.
5. Check if the ratio of obtained channel B voltage to channel A voltage is equal to the calculated gain
6. Check if channel B is equal to calculated gain*Vin

Rf	Rin	Calculated gain $= 1+\frac{R_f}{R1}$	Channel A	Channel B	Voltage gain= (ChB/ChA)	Vout=A*Vin where A=gain
1000	470	3.12	1.00	3.113	3.113	3.113=3.12*1
1000	1000	2	1.0006	2.0045	2	2.0045=2*1.0006
1000	20000	1.05	1.00	1.0504	1.05	1.0504=1.05*1.00

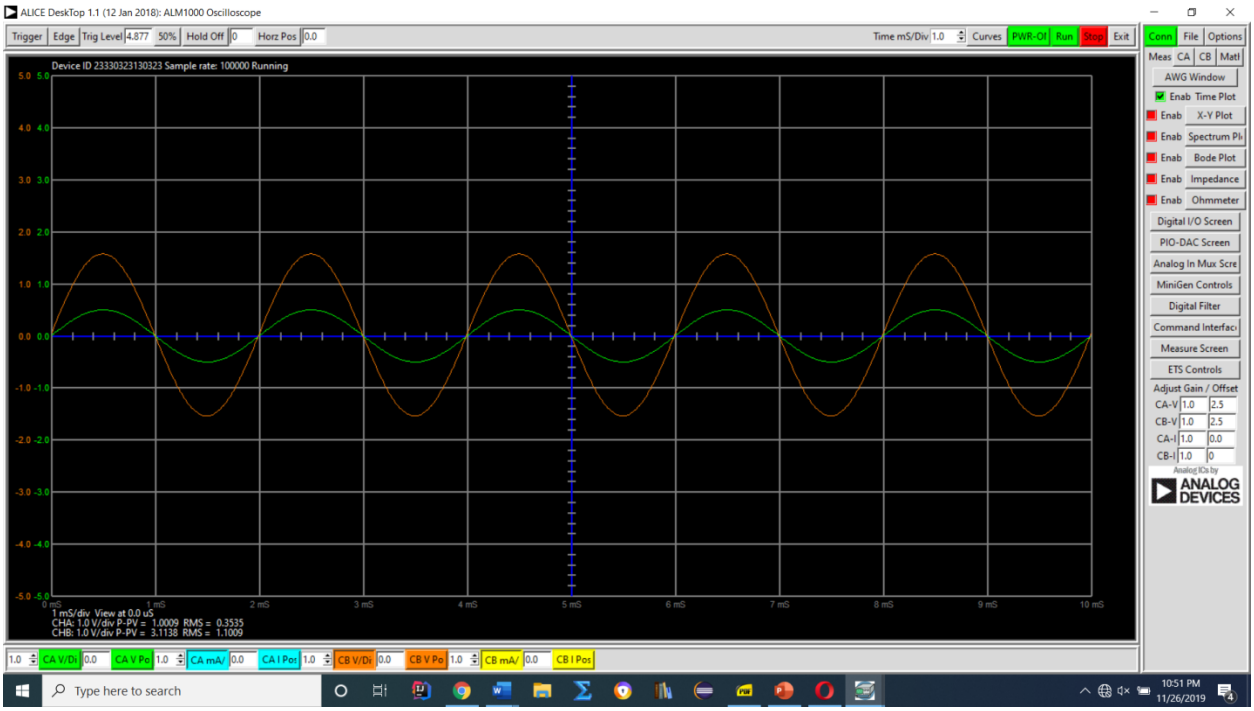
Screenshots:

Setting for all three shapes & cases:



Case 1:

SINE



Calculation:

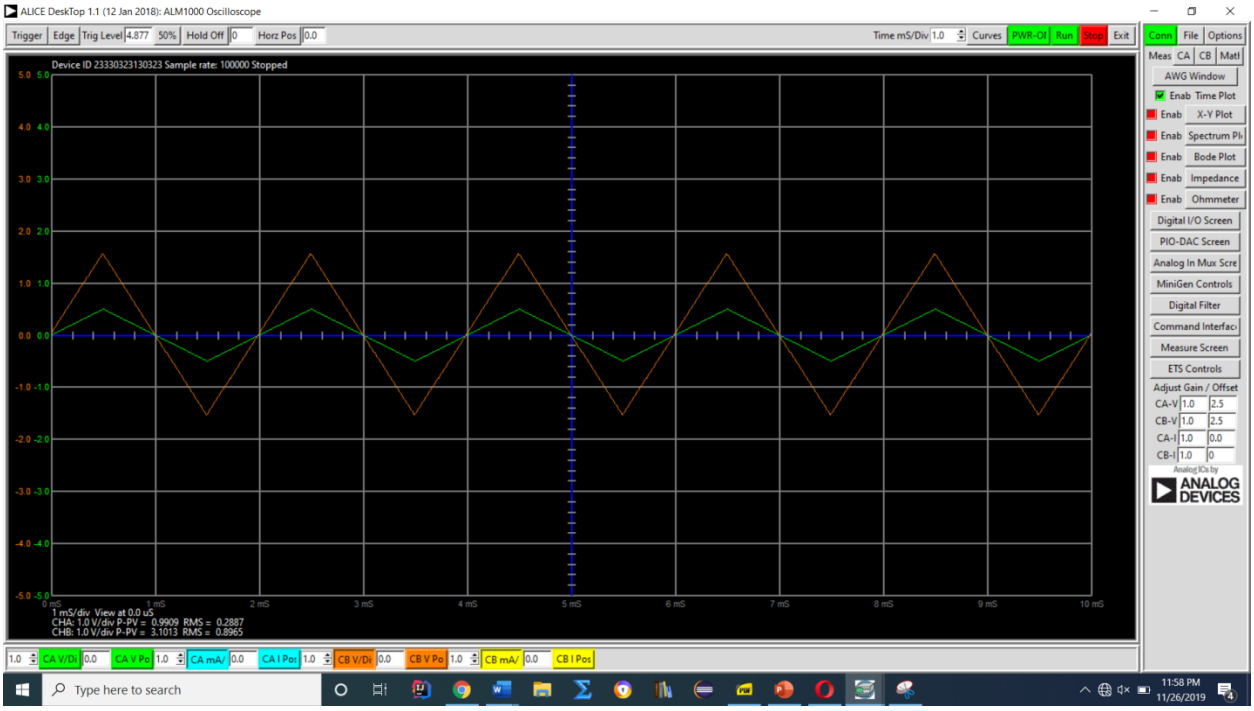
R1=470

Rf=1000

Gain=1+1000/470=3.12

Obtained voltage gain= CH B/CH A = 3.113/1.00 = 3.113

TRIANGLE



Calculations:

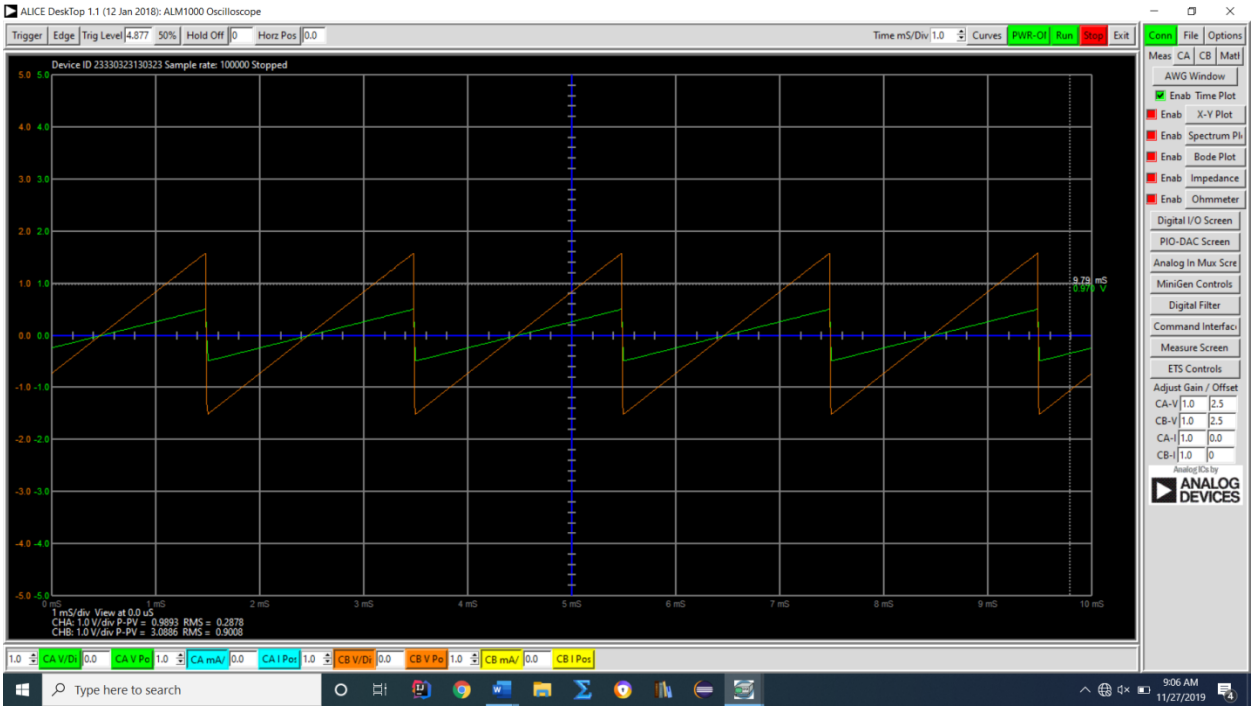
R1=470

Rf=1000

Gain=1+1000/470=3.12

Obtained voltage gain=CH B/CH A=3.1013/0.9909=3.129

SAWTOOTH



Calculations:

R1=470

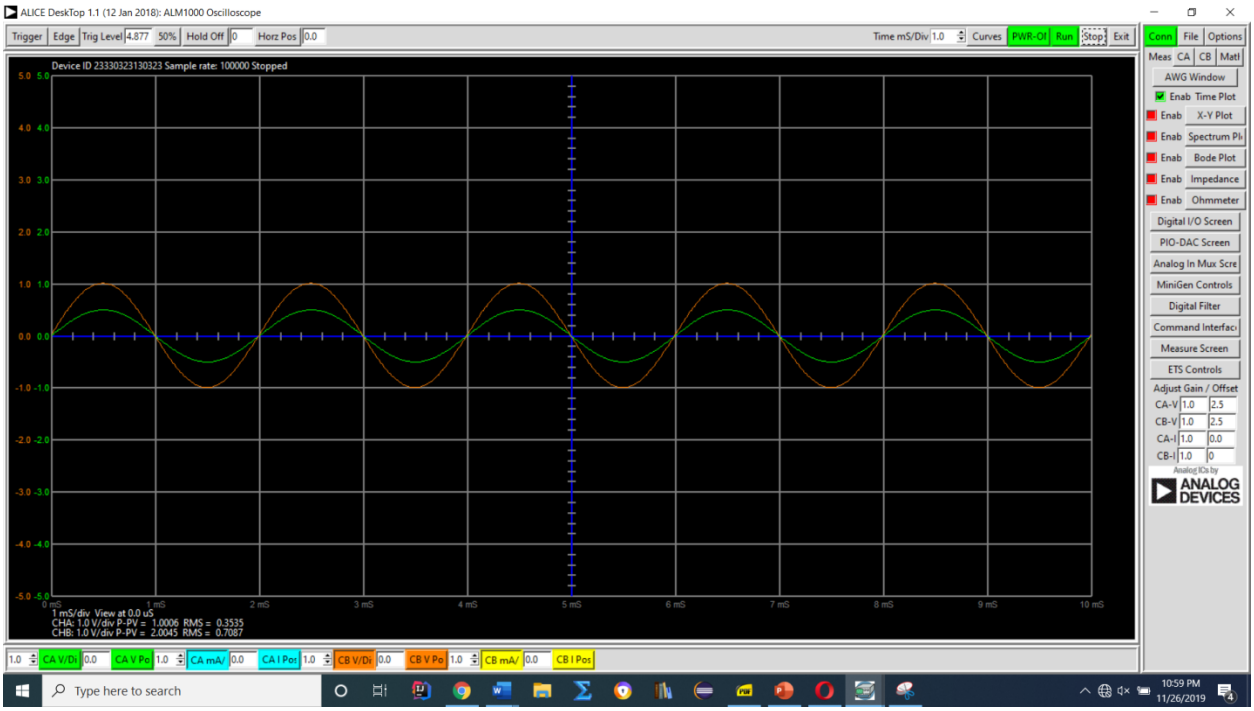
Rf=1000

Gain=1+1000/470=3.12

Obtained voltage gain=CH B/CH A=3.0886/0.9893= 3.122

Case 2:

SINE



Calculations:

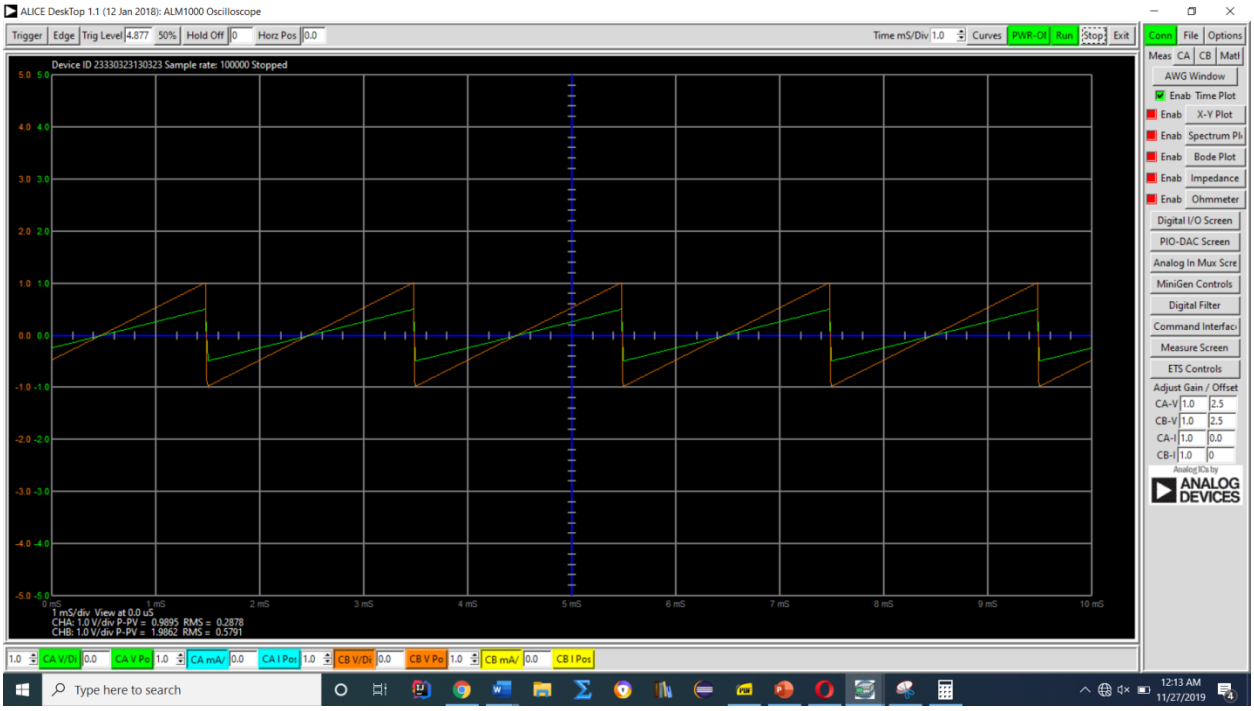
R1=1000

Rf=1000

Gain=1+1000/1000=1+1=2

Obtained gain=CHB/CHA =2.0045/1.0006=2

SAWTOOTH



Calculations:

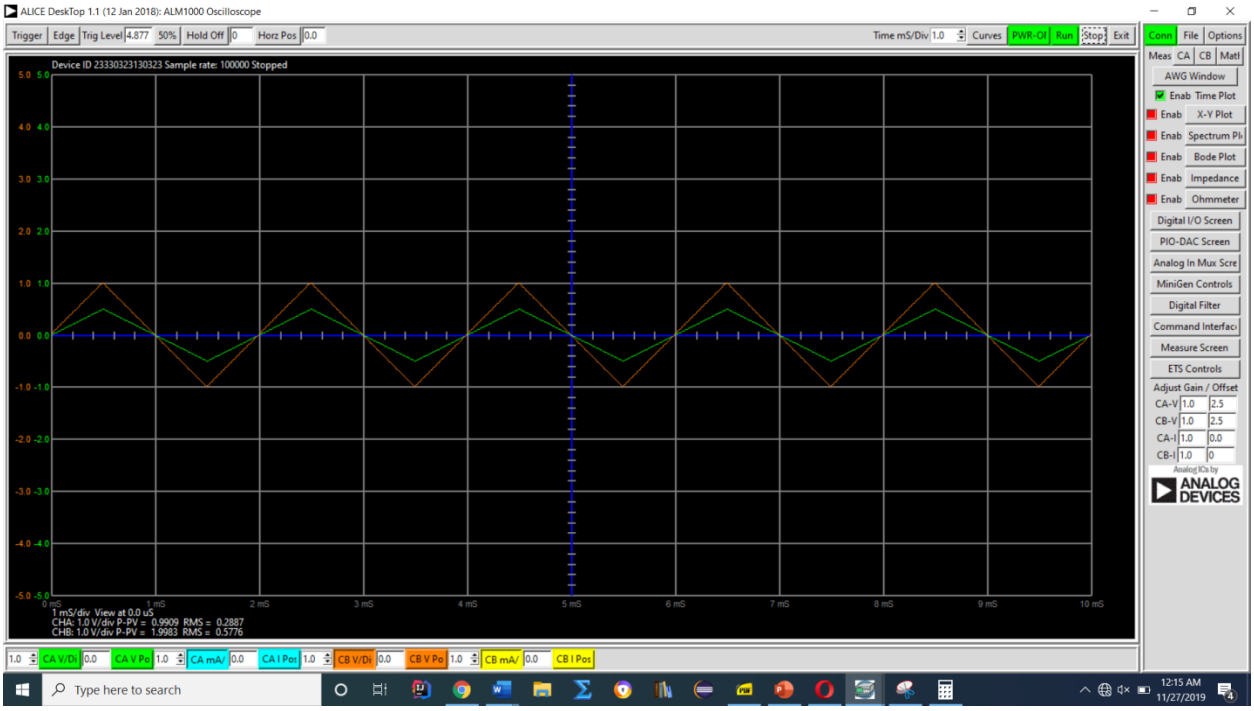
R1=1000

Rf=1000

Gain=1+1000/1000=1+1=2

Obtained gain=CHB/CHA =1.9862/0.9895=2.007

TRIANGLE



Calculations:

R1=1000

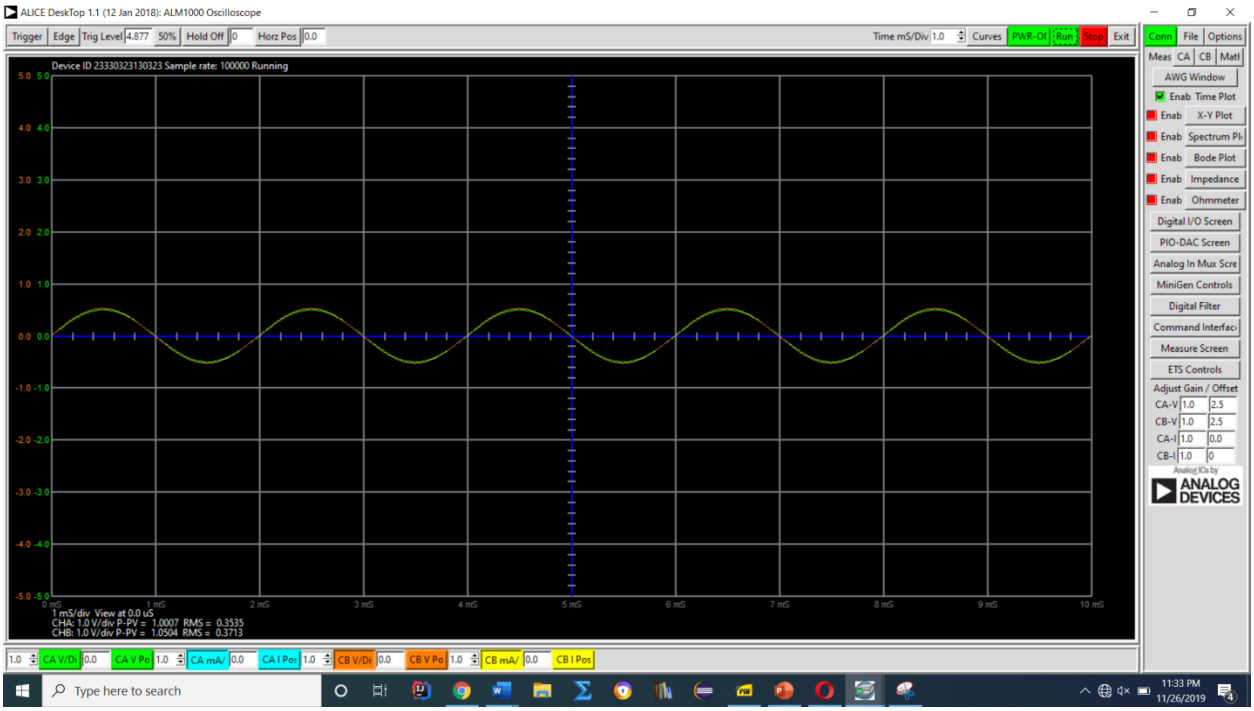
Rf=1000

Gain=1+1000/1000=1+1=2

Obtained gain=CHB/CHA =1.9983/0.9909=2.01

Case 3:

SINE



Calculations:

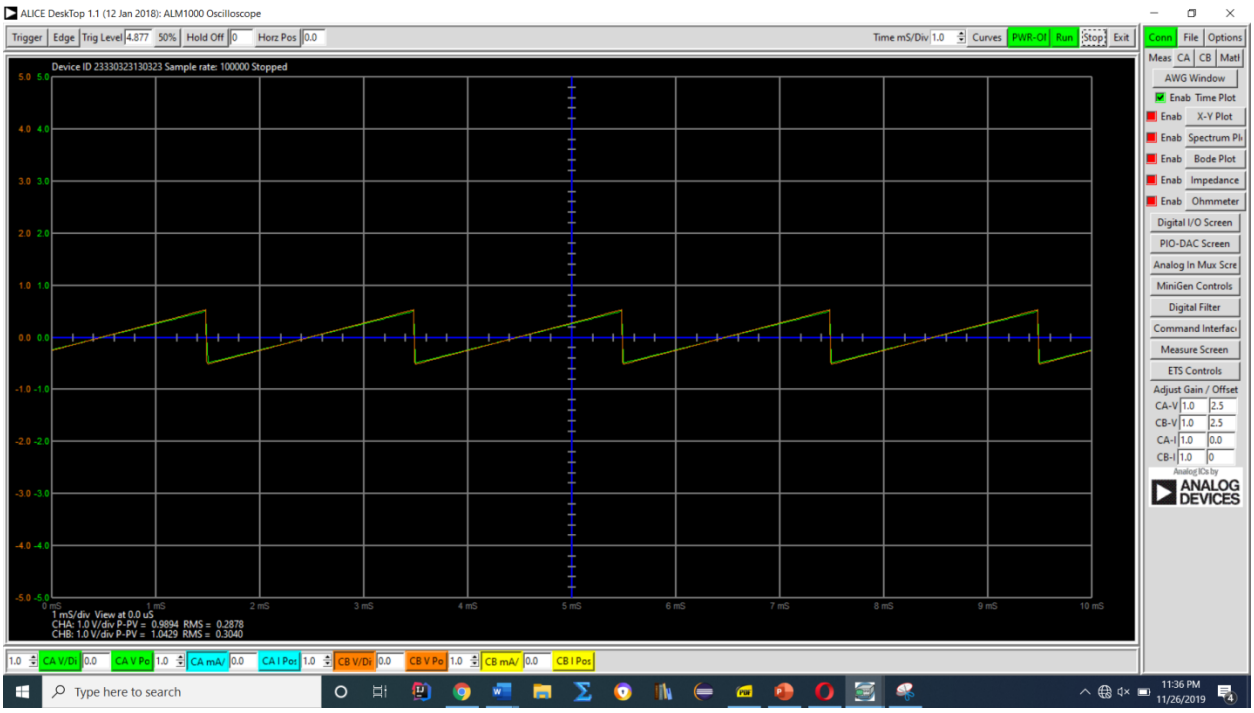
R1=20000

Rf=1000

Gain = 1+Rf/R1 = 1+1000/20000 = 1.05

Obtained Gain = CHB/CHA = 1.0504

SAWTOOTH



Calculations:

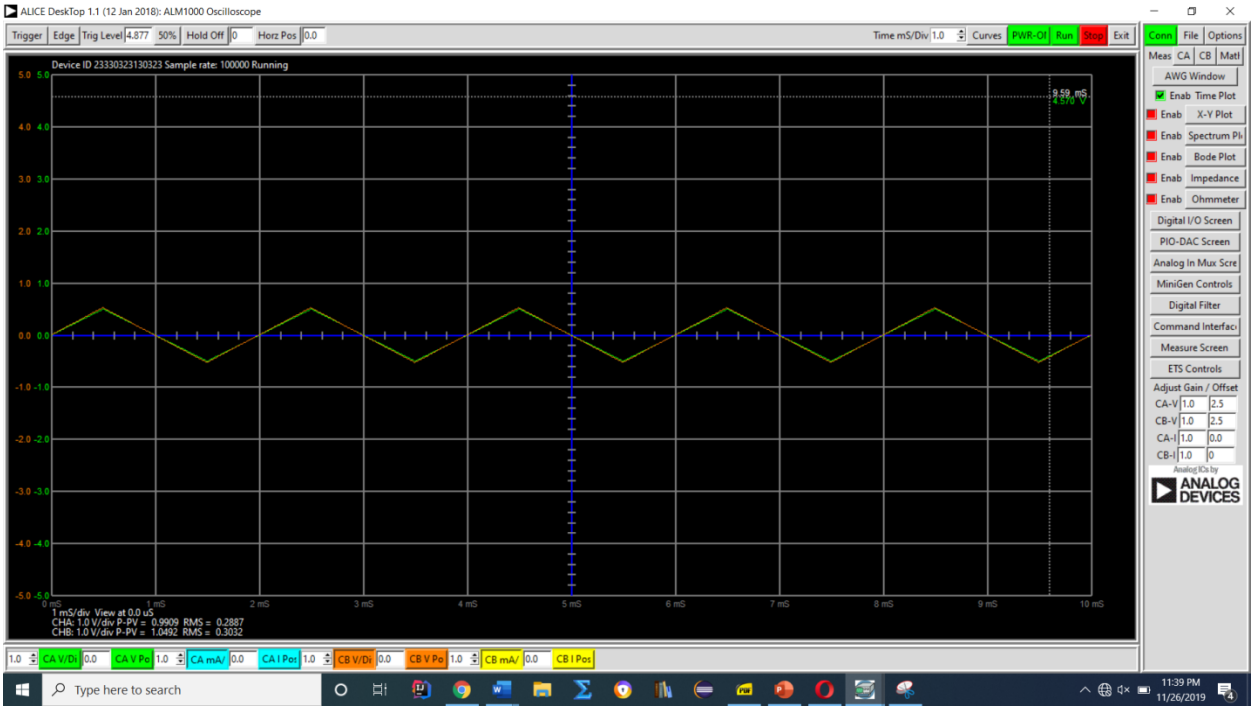
R1=20000

Rf=1000

Gain = 1+Rf/R1 = 1+1000/20000 = 1.05

Obtained Gain = CHB/CHA = 1.0429/0.9894 =1.05

TRIANGLE



Calculations:

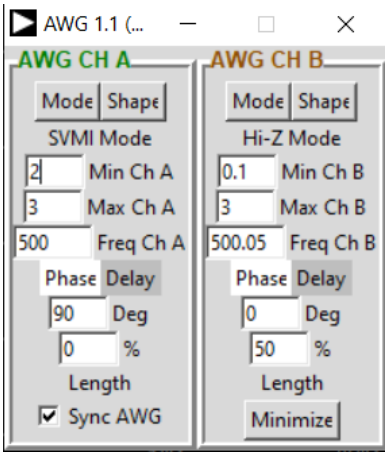
R1=20000

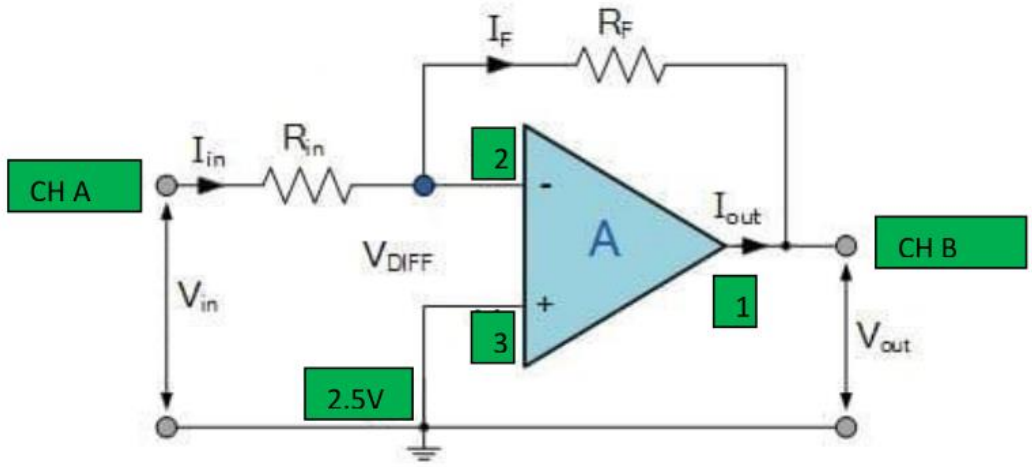
Rf=1000

Gain=1+Rf/R1=1+1000/20000=1.05

Obtained Gain = CHB/CHA = 1.042/0.9909 = 1.05

Challenge 2 : Inverting





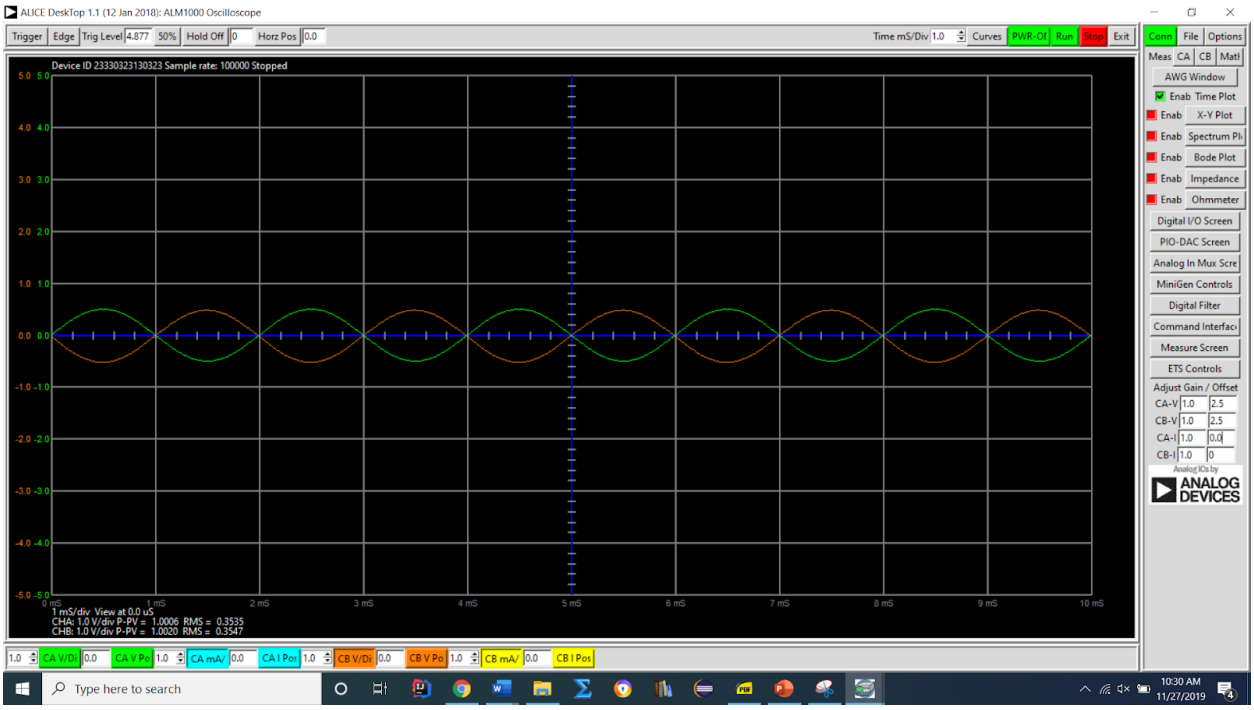
Procedure:

1. Connect the circuit according to the diagram above.
2. In order to get the gain in a inverting amplifier, we use $A=R_f/R_{in}$.
3. Taking different values of Rin, use the above formula to calculate gain(A).
4. Record the values in a table, shown as the P-P value in CA and CB.
5. Check if the ratio of obtained channel B voltage to channel A voltage is equal to the calculated gain
6. Check if channel B is equal to calculated gain*Vin

Rf	Rin	Calculated gain = $1+\frac{R_f}{R1}$	Channel A	Channel B	Voltage gain= (ChB/ChA)	Vout=A*Vin Where A is gain
1000	470	2.12	0.9909	2.1145	2.12	2.1145=2.1146*0.9909
1000	1000	1	1.006	1.002	1	1.002=1*1.006
1000	20000	0.05	1.0008	0.0504	0.05	0.0504=0.05*1.0008

Case 1:

SINE



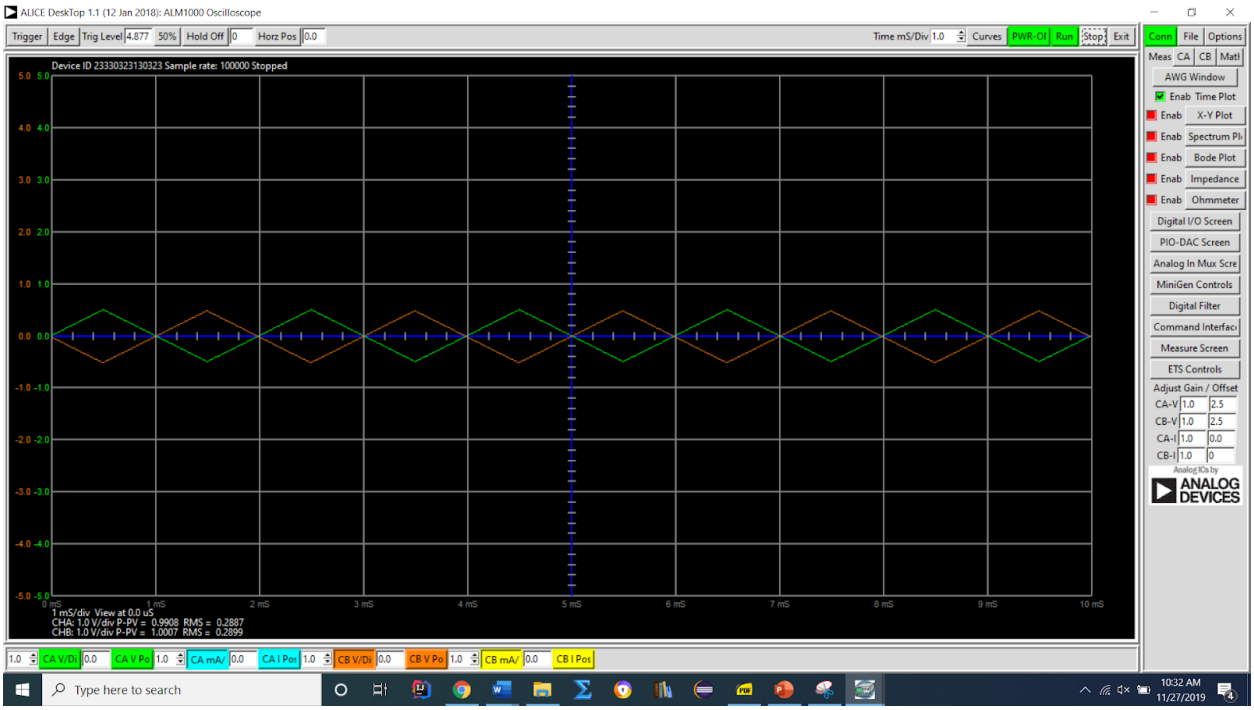
R1=1000

Rf=1000

Gain=-Rf/R1=1

Obtained Gain = CHB/CHA = 1.002/1.006 = 1.00

TRIANGLE



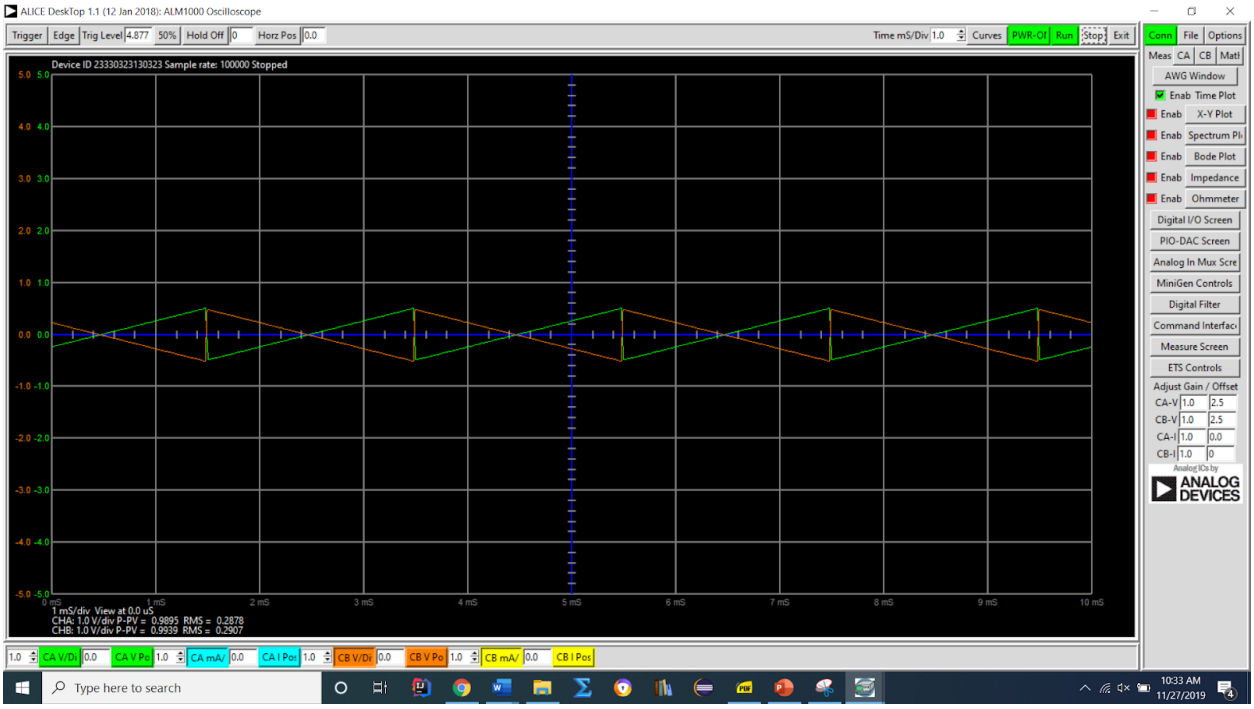
R1 = 1000

Rf = 1000

Gain = -Rf/R1=1

Obtained gain=CHB/CHA=1.007/0.9908=1.01

SAWTOOTH



Calculations:

R1=1000

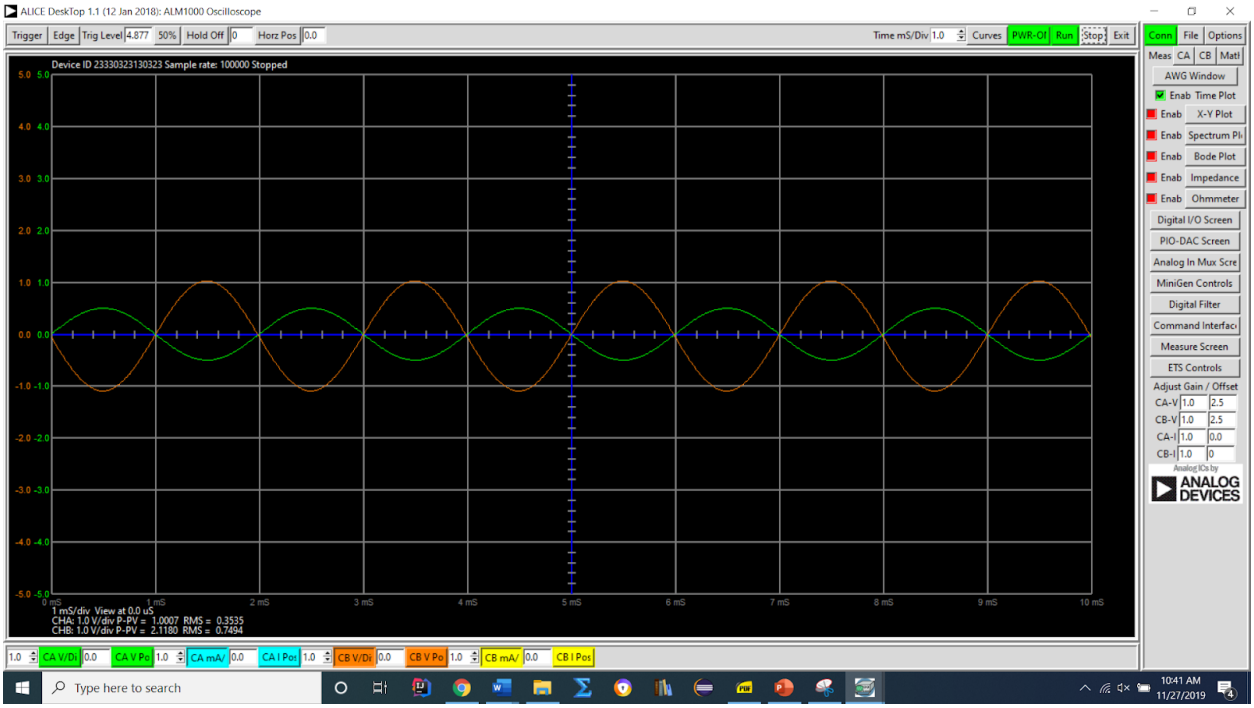
Rf=1000

Gain= -Rf/R1=1

Obtained gain=CHB/CHA=0.9939/0.9895=1.00

CASE 2:

SINE



Calculations:

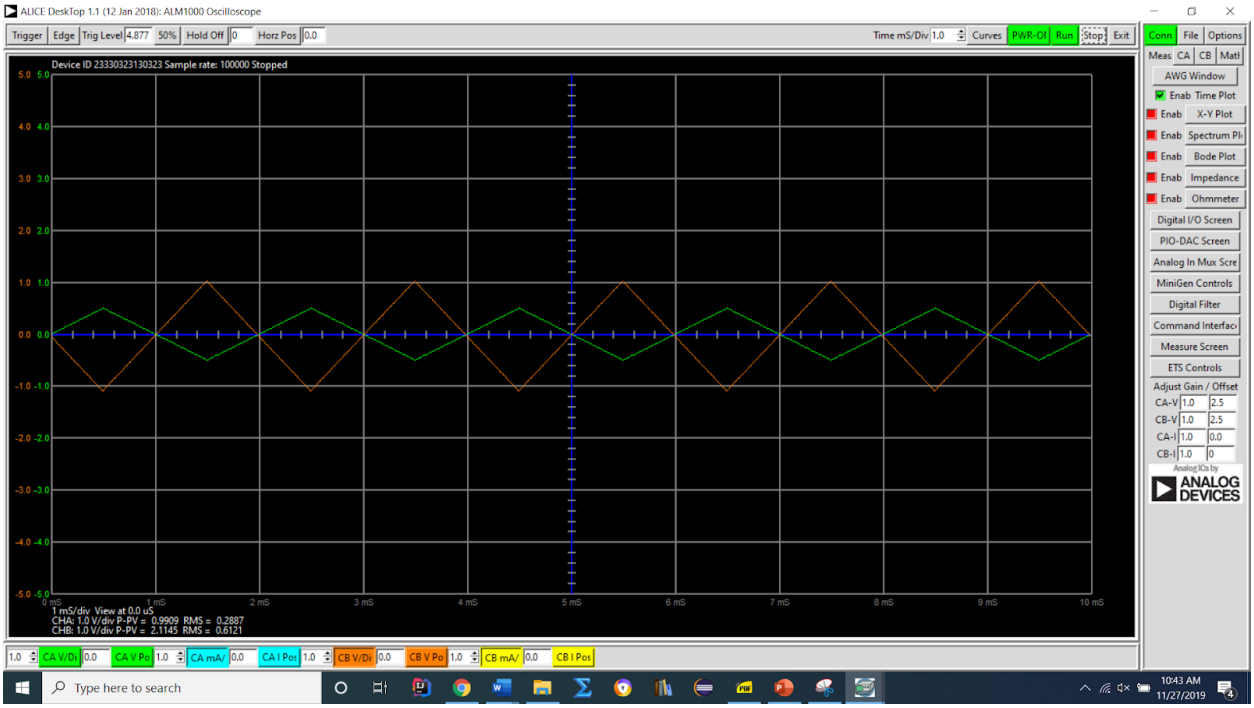
R1 = 470

Rf= 1000

Gain = 1000/470 = 2.12

Obtained Gain = 2.118/1.00 = 2.12

TRIANGLE



Calculations:

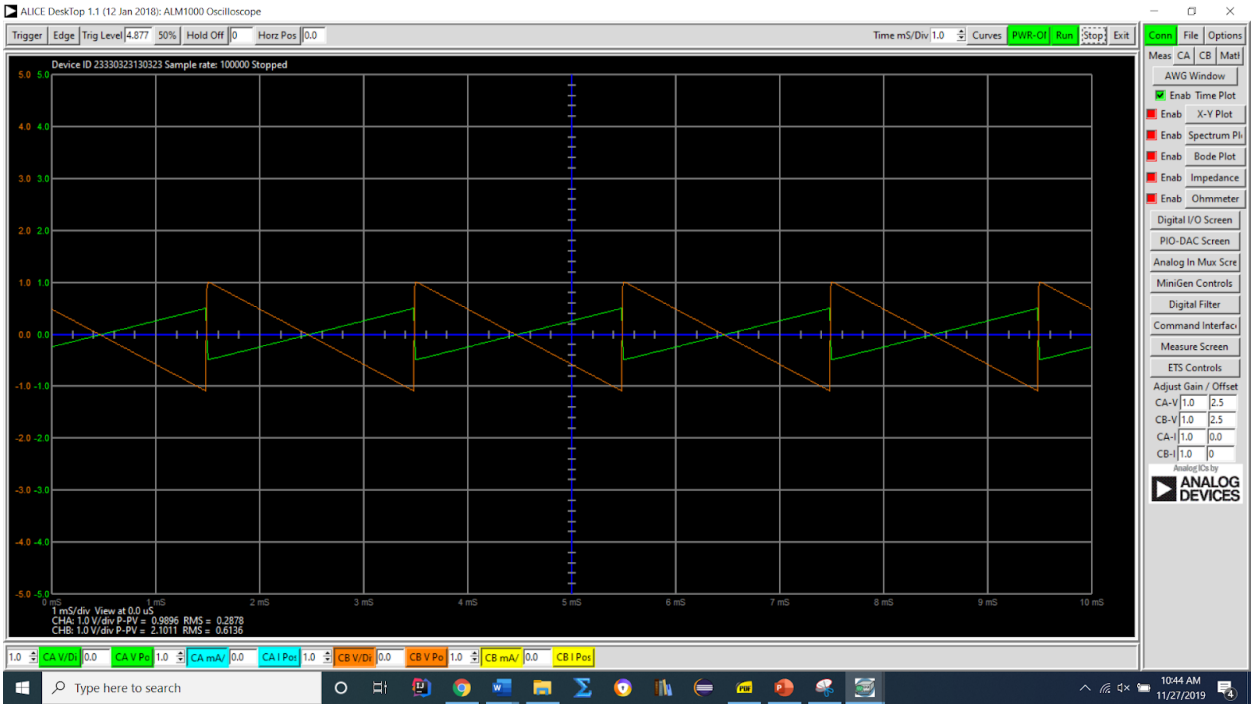
R1 = 470

Rf = 1000

Gain = 1000/470 = 2.12

Obtained Gain = 2.1145/0.9909 = 2.13

SAWTOOTH



Calculations:

R1 = 470

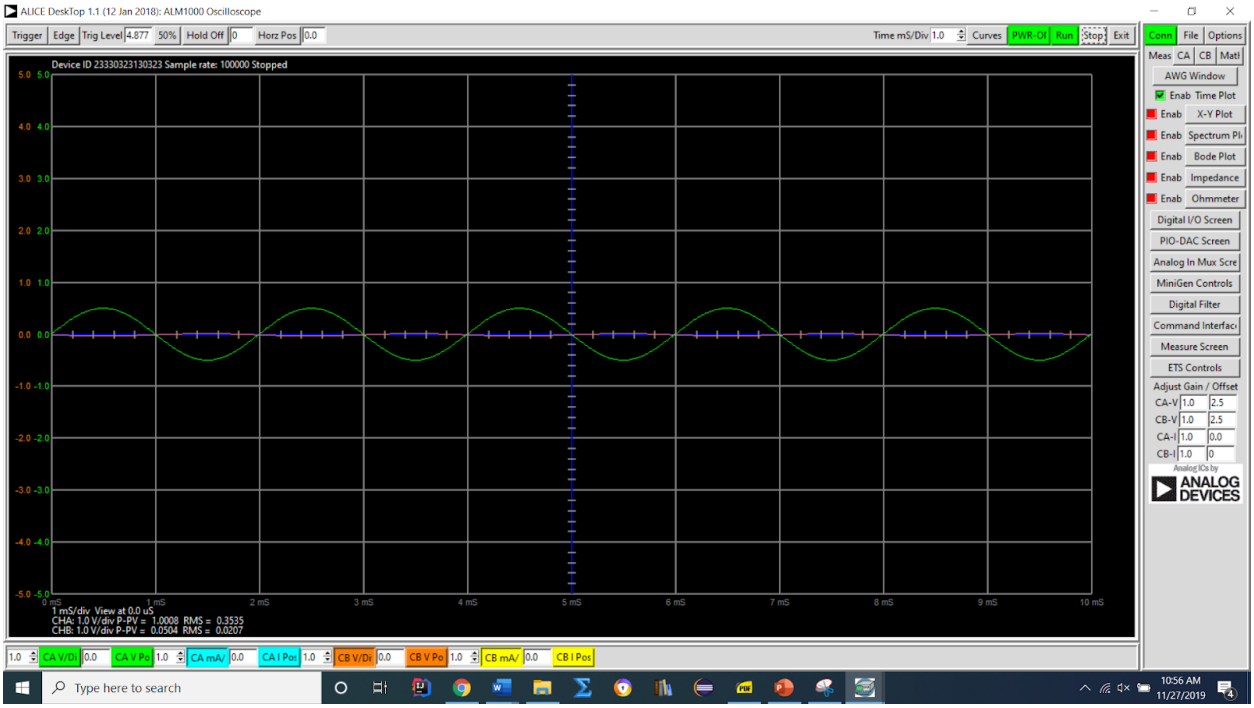
Rf = 1000

Gain = 1000/470 = 2.12

Obtained Gain = 2.1011/0.9896 = 2.12

CASE 3:

SINE



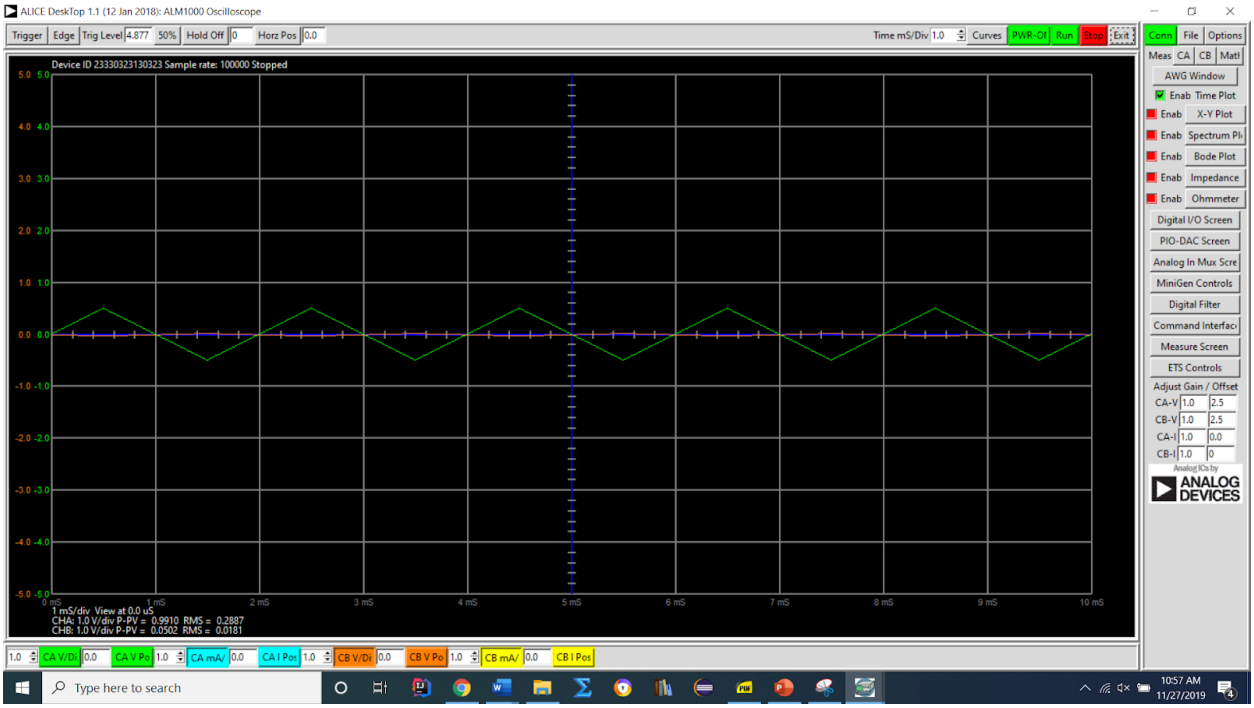
R1 = 20000

Rf = 1000

Gain = 1000/20000 = 0.05

Obtained gain = 0.0504/1.0008 = 0.05

TRIANGLE



Calculations:

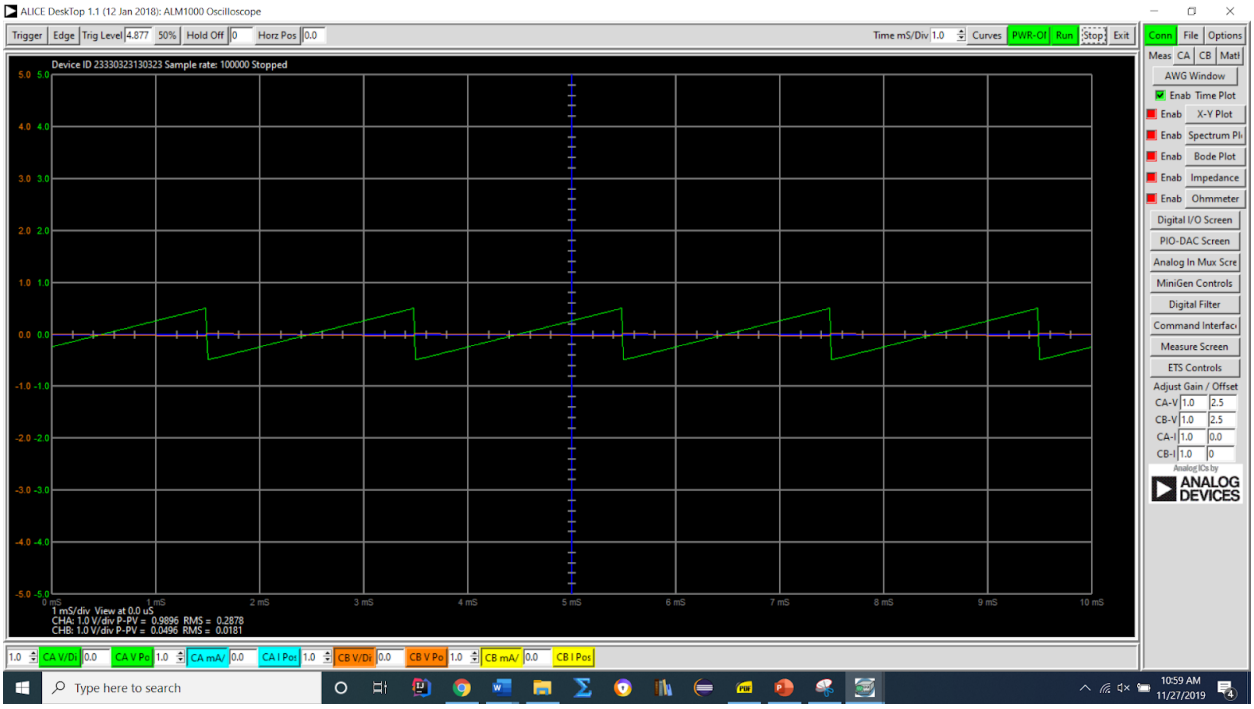
R1 = 20000

RF = 1000

Gain = 1000/20000 = 0.05

Obtained Gain = 0.0502/0.9910 = 0.05

SAWTOOTH



Calculations:

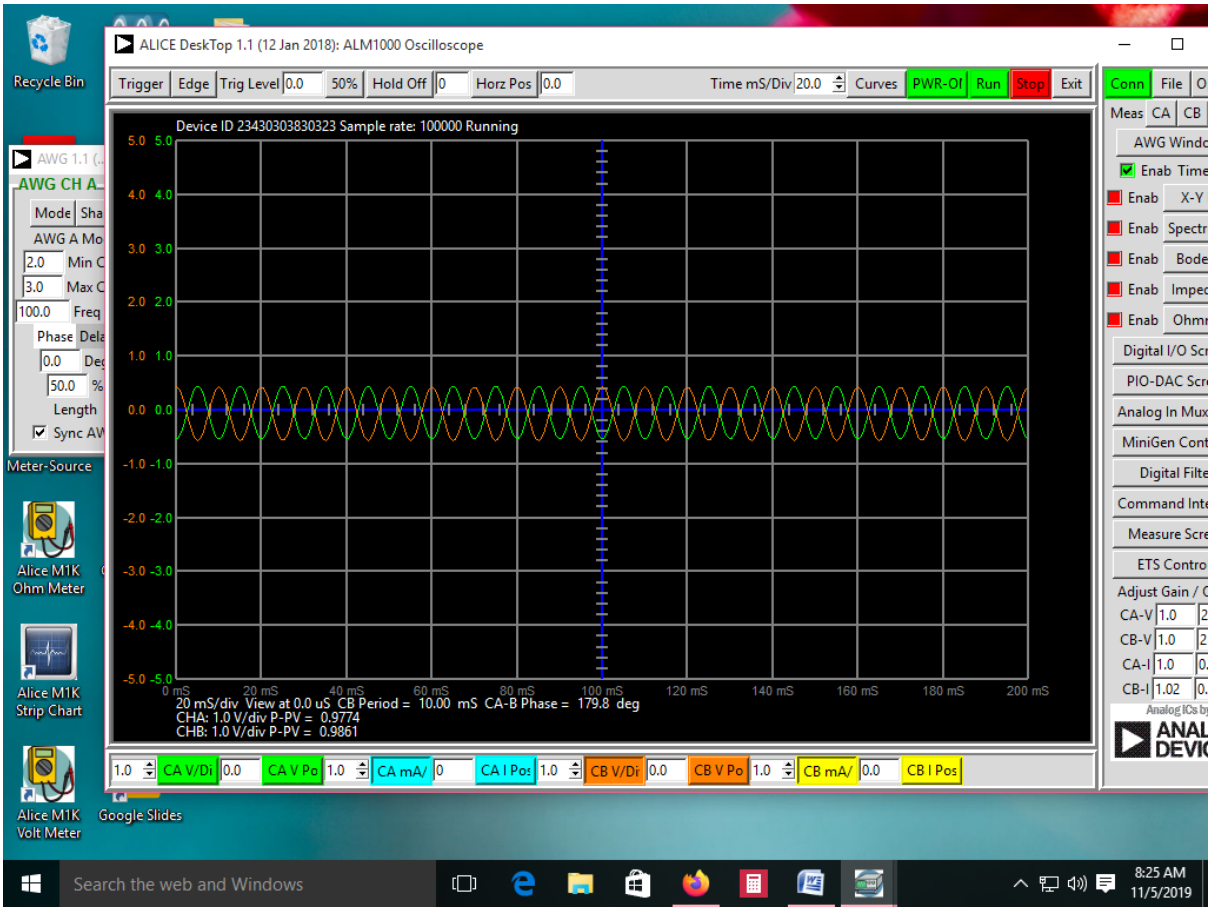
R1 = 20000

RF = 1000

Gain = 1000/20000 = 0.05

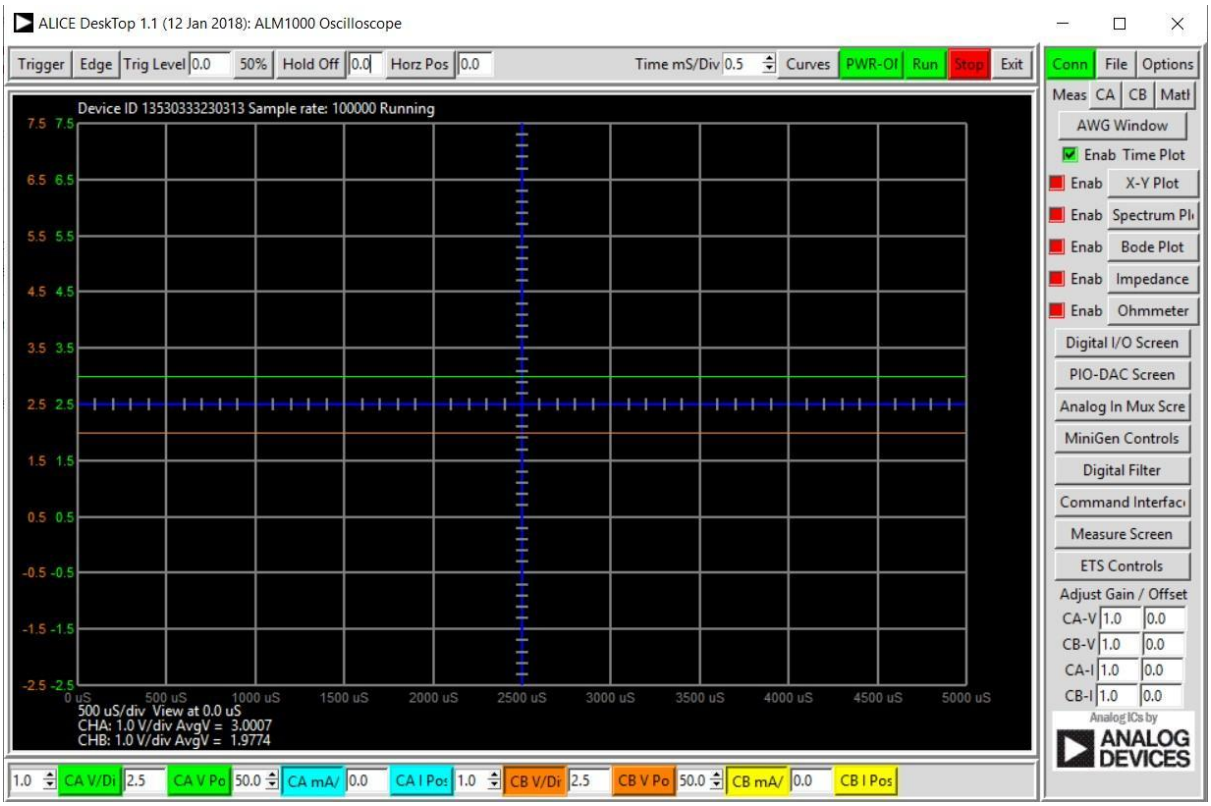
Obtained Gain = 0.0496/0.9896 = 0.05

Inference



The given wave form is of an inverting op-amp since the waves have a phase difference of 180 degrees. Since the both the amplitudes of the sine waves are equal and the ratio of Channel A : Channel B is almost 1, the gain is 1.

When CA-V is changed to 2.0V and 3.0V, waves similar to the ones above are observed but the graphs have been shifted up by 2.5V. When the shape is changed to DC, the sine waves change to a constant straight line parallel to the x-axis.


ALICE DeskTop 1.1 (12 Jan 2018): ALM1000 Oscilloscope
Trigger
Edge
Trig Level
Hold Off
Horz Pos
Time mS/Div
Curves
PWR-Of
Run
Stop
Exit
Conn
File
Options
Meas
CA
CB
Matl
AWG Window
Enab Time Plot
Enab X-Y Plot
Enab Spectrum Pl
Enab Bode Plot
Enab Impedance
Enab Ohmmeter
Digital I/O Screen
PIO-DAC Screen
Analog In Mux Scre
MiniGen Controls
Digital Filter
Command Interfac
Measure Screen
ETS Controls
Adjust Gain / Offset
CA-V
CB-V
CA-I
CB-I
Analog ICs by
ANALOG DEVICES
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CHA: 1.0 V/div AvgV = 3.0007
CHB: 1.0 V/div AvgV = 1.9774
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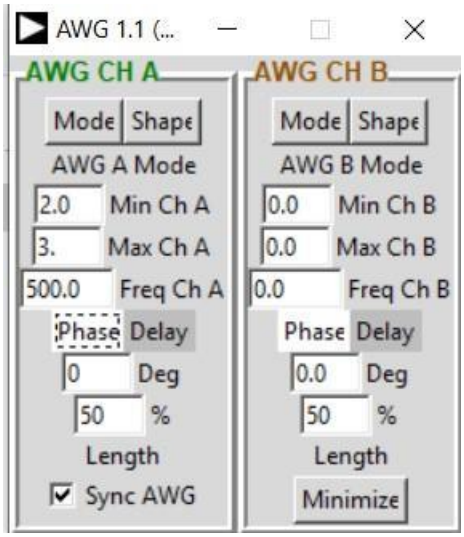
CA V Po
CA mA/
CA I Pos
CB V/Di
CB V Po
CB mA/
CB I Pos


AWG 1.1 (...
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Reference:
https://www.daenotes.com/electronics/devices-circuits/inverting-and-non-inverting-amplifiers
https://electronicsforu.com/resources/learn-electronics/inverting-non-inverting-amplifier-basics
https://circuitdigest.com/tutorial/non-inverting-operational-amplifier
https://circuitdigest.com/tutorial/inverting-operational-amplifier-op-amp

Acknowledgment:
We would like to thank Dr. Sowmya V. and Mr Vinod for their contribution to this project.