Summary

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Introduction

Objectives:

To describe the workings of the operational amplifier and to show the differences between the inverting and non-inverting amplifier.

Background

Understanding the workings of the operational amplifier will enable the design of circuits to be carried out effectively. Knowing the functionality and components of the op amp will enable the the user/designer to understand their uses and limitations. He will be able use them effectively without blowing them up, for example.

Theory

Basic Concepts: Theory of both op amps

A study of the differences between the theoretical and measured gain of the inverting and non-inverting amplifier. To take note of the effect of an increase in the input voltage for inverting and non-inverting amplifiers. To look into the effect of adding a diode to the inverting amplifier circuit.

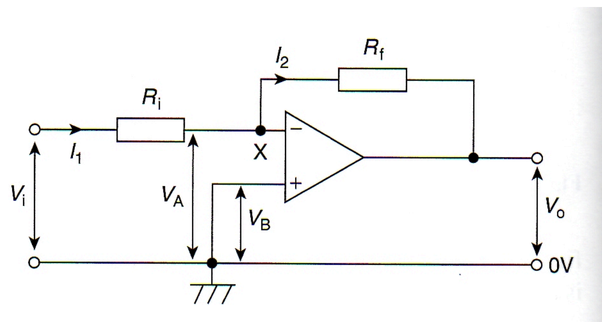
An operational amplifiers purpose is to amplify a weak signal and this is called Gain.
The closed-loop gain A is given by:

$$A = \frac{V_o}{V_i} = \frac{-R_f}{Ri}$$

This shows that the gain of the amplifier depends only on the two resistors.
For example, if:

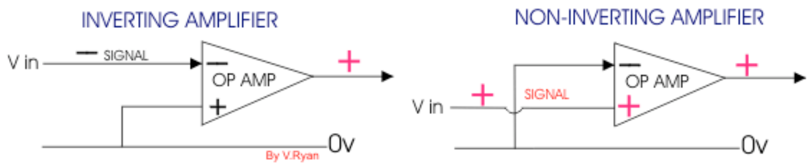
$$A = \frac{-R_f}{R_i} = \frac{-100\times10^3}{10\times10^3} = -10$$

Thus the input of 100mV will cause an output change of 1V (reference Bird p.292)



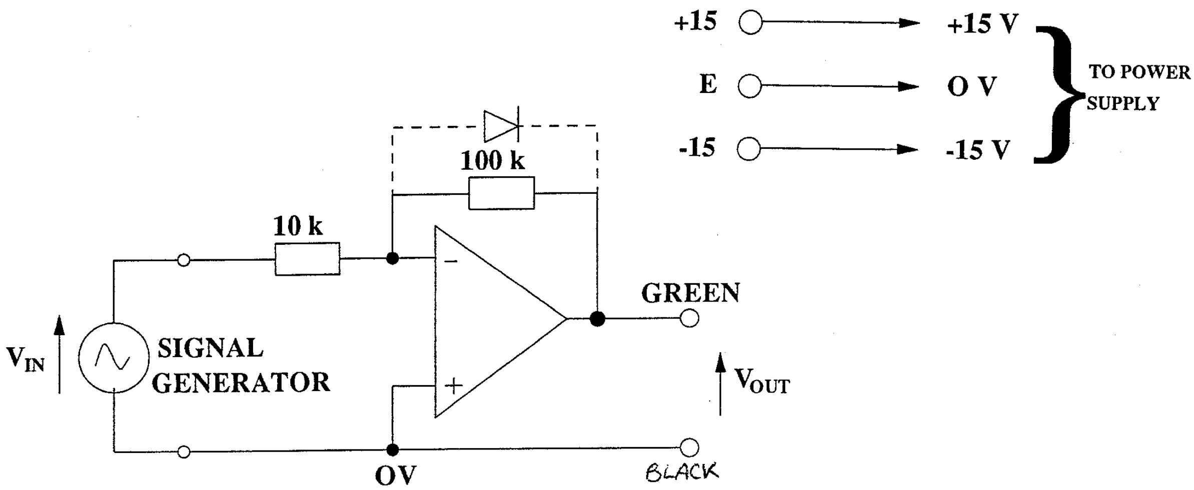
If there is a gain of 10, for instance, if 1.0V is put in then the output will be 10.0V.
R_F=Feedback risistance

Differences between inverting and non-inverting amplifiers.



Reference (file:///Users/defunktlemon/Desktop/Non-inverting%20and%20Inverting%20Operational%20Amplifiers.html)

- For an *inverting amplifier* the polarity of a signal is reversed at the output. A negative input becomes a positive output. Voltage is applied to the inverting (-) terminal, and voltage out is therefore in anti-phase with the input. The waves will be out of phase.



- For a *non-inverting amplifier* a signal applied keeps its polarity at the output. A positive input remains a positive output. Feedback goes into the negative terminal to keep control.

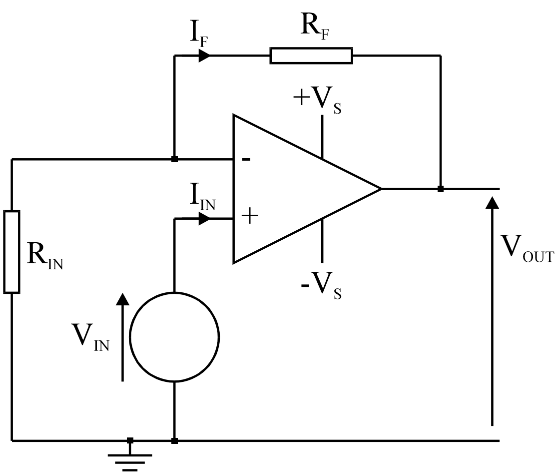


Figure 2 (a)

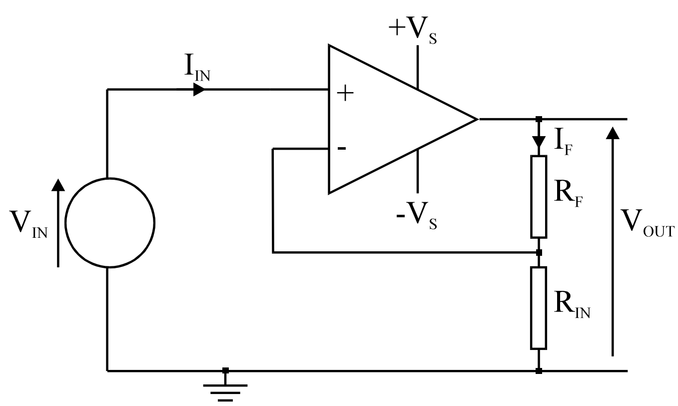


Figure 2 (b)

$$\text{Gain} = \frac{V_{OUT}}{V_{IN}} = \frac{R_{IN} + R_F}{R_{IN}} = 1 + \frac{R_F}{R_{IN}} \qquad (\text{Eqn } 3)$$

Symbols Used: definitions and units e.g. I: current, amps(A)

Experiments

Apparatus:

Scope Tektronix TDS 1002 allows signal voltages to be viewed as two-dimensional graphs of one or more electrical potential differences (vertical axis) plotted as a function of time or of some other voltage (horizontal axis).
Function generator TTi R5 is used to generate electrical waveforms.
Tti EB2025T Triple Output PSU is a bench power supply for applications requiring stable and controllable sources of DC voltage.

Procedure: *Inverting Amplifier*.

Voltage Gain:

- A theoretical value for the voltage gain of the amplifier was calculated using Equation 2.
- The oscilloscope was used to measure V_{IN} and V_{OUT} and determine the measured gain of the amplifier, using Equation 1 and peak to peak values of V_{IN} and V_{OUT}.
- The measured and theoretical gains were compared.
- Phase shift between V_{IN} and V_{OUT} were noted.

Effect of increase of V_{IN}:

- Peak to peak value of V_{IN} and V_{OUT} were noted as V_{IN} was gradually increased.
- Waveform was sketched, and magnitudes labelled.

Addition of Diode:

- Waveform was sketched, and magnitudes labelled. An increased scale on the oscilloscope showed detail of effect of diode in reverse bias.

Procedure: *Non-inverting Amplifier*.

Voltage Gain:

- A theoretical value for the voltage gain of the amplifier was calculated using Equation 2.
- The oscilloscope was used to measure V_{IN} and V_{OUT} and determine the measured gain of the amplifier, using Equation 1 and peak to peak values of V_{IN} and V_{OUT}.
- The measured and theoretical gains were compared.
- Phase shift between V_{IN} and V_{OUT} were noted.

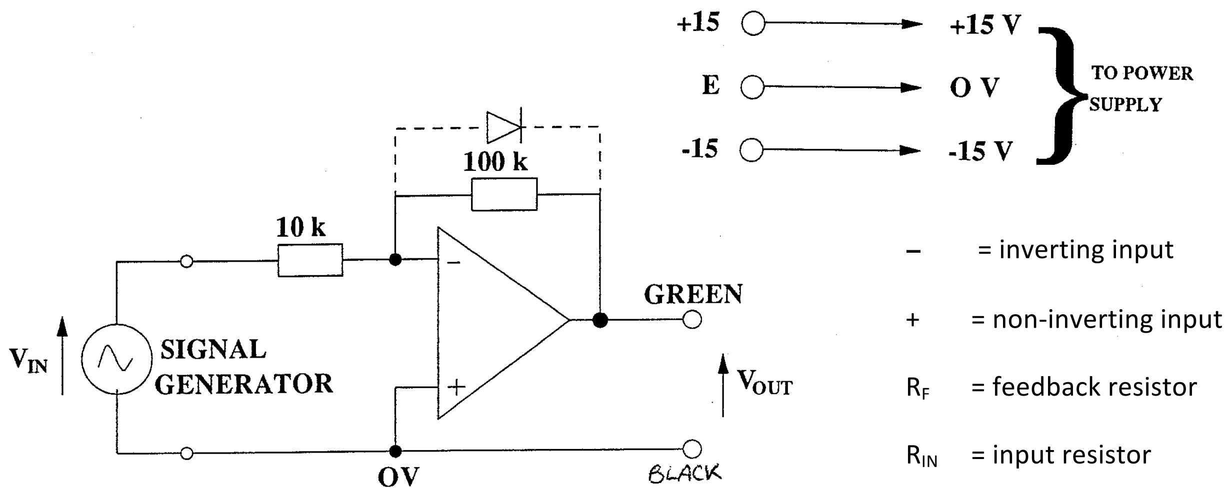
Effect of increase of V_{IN}:

- Peak to peak value of V_{IN} and V_{OUT} were noted as V_{IN} was gradually increased.

- Waveform was sketched, and magnitudes labelled.

Results

Inverting Amplifier.



<u>Circuit connection:</u>

The diode was disconnected initially and the power supply was set to 15V. The signal generator was set to give 2.0V peak-to-peak at a frequency of 1.0kHz.

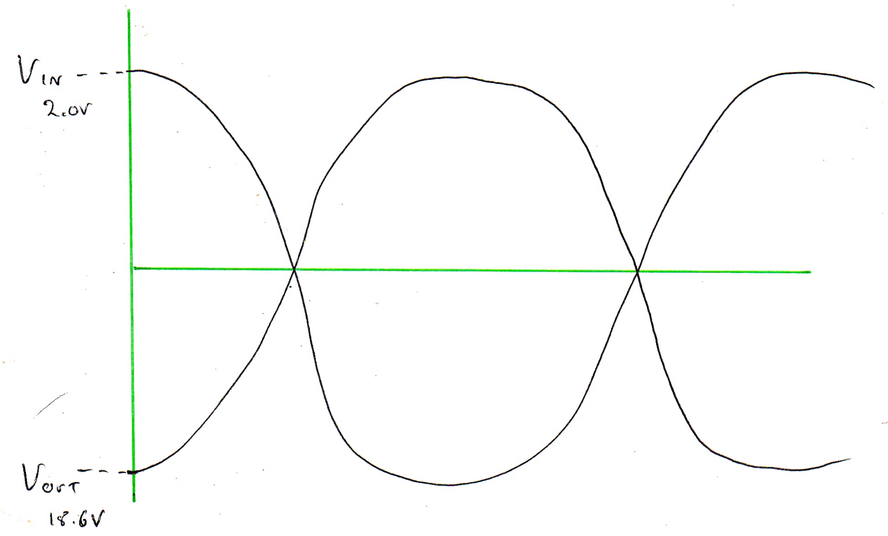
<u>Voltage Gain:</u>

$$\text{Eqn 2, } Gain = -\frac{R_F}{R_{IN}} = -\frac{100k\Omega}{10k\Omega} = 10$$

$$V_{IN} = 2.0V, \; V_{OUT} = 18.6V$$

$$Gain = \frac{V_{OUT}}{V_{IN}} = \frac{18.6V}{2.0V} = 9.3$$

<u>Voltage gain graph – Inverting amplifier</u>



CH1 = V_{OUT}
1.00V
m=250μs

CH2 = V_{IN}
5.00V
m=250μs

- The theoretical gain is 0.7 higher than the measured gain. This could be due to a discrepancy in the resistors, a manufacturers margin of error or due to the quality of the components. It may also be attributed to human error when reading values from the scope.
- The waves were seen to be in anti-phase, 180 degrees difference. Neither of the waves, therefore, leads nor lags the other.

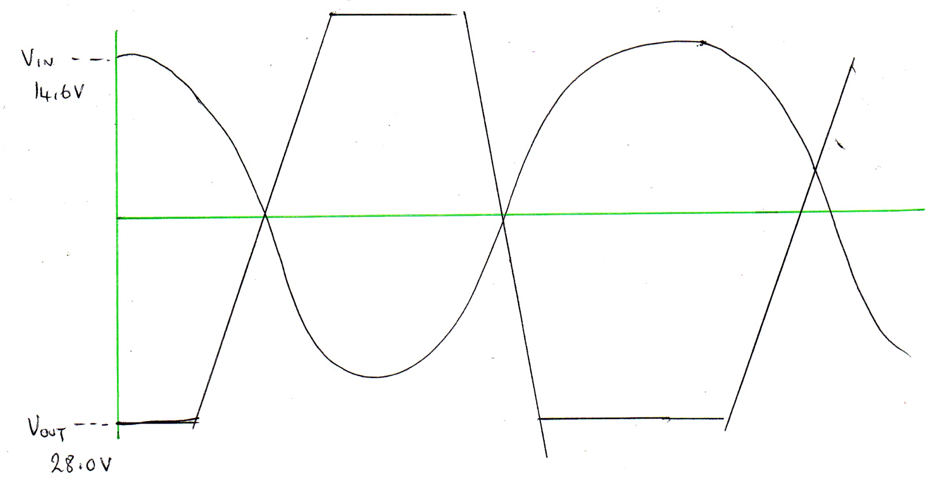
$$I_{IN} = \frac{V_{IN}}{R_{IN}}, \quad \mathrm{I}_F = \frac{0 - V_{OUT}}{R_F}$$

$$\textbf{and: } I_{ZN} = I_F \quad \therefore \quad V_{OUT} = -\frac{R_F}{R_{IN}} V_{IN}$$

<u>Effects of increase of V_{IN}</u>

V_{OUT} = 28.0V
V_{IN} = 14.6V

<u>Effect of increase of V_{IN} graph – Inverting amplifier</u>

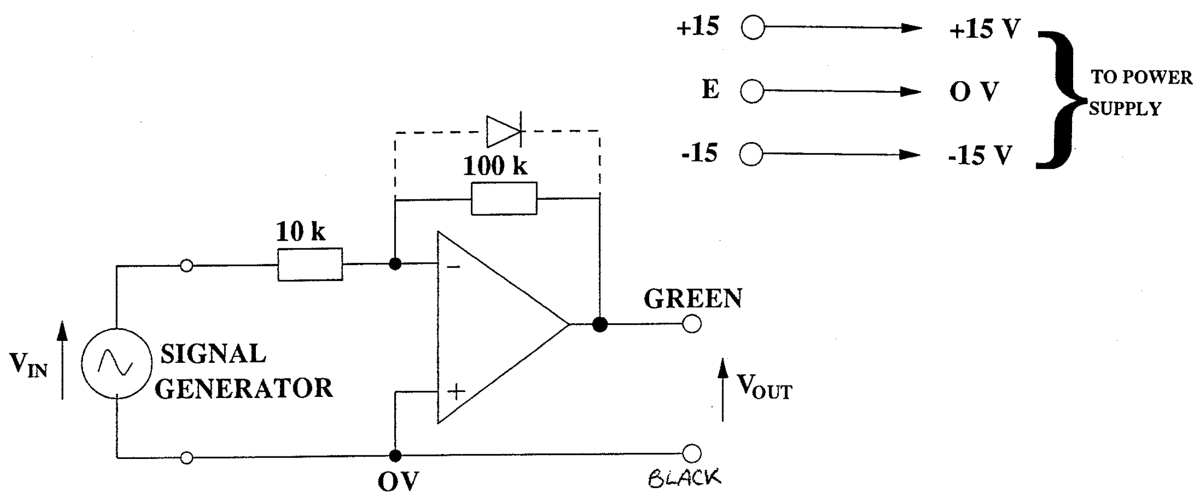


CH1 = V_{OUT}	CH2 = V_{IN}
5.00V	1.00V
m=250µs	m=250µs
28.0V peak-to-peak	2.92V peak-to-peak

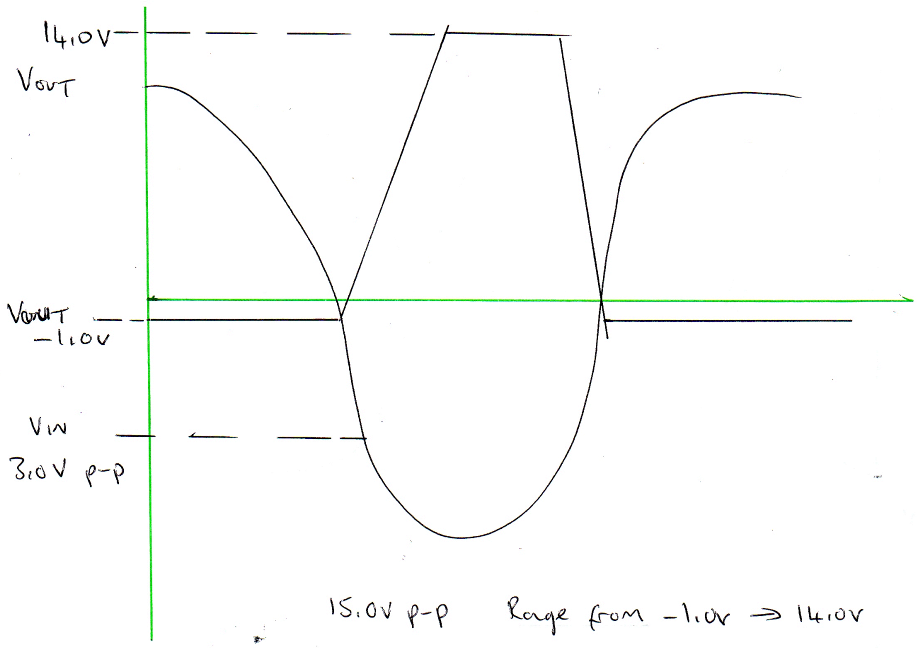
Range of voltage is ±2.92V
V_{OUT} value levels off at 28.0V as it can' get any higher voltage than the power supply is offering.

Diode Addition

As the diode starts to draw the current the voltage across R_F drops. When the diode is 0.7V, it is now opened and drawing all the current and voltage.
R_F has no voltage, therefore, and the signal bottoms out.



Addition of diode graph – Inverting amplifier



CH1 = V_{OUT}	CH2 = V_{IN}
5.00V	1.00V
m=250μs	m=250μs
15.0V peak-to peak	3.0V peak-to-peak

Results

Non-inverting Amplifier.

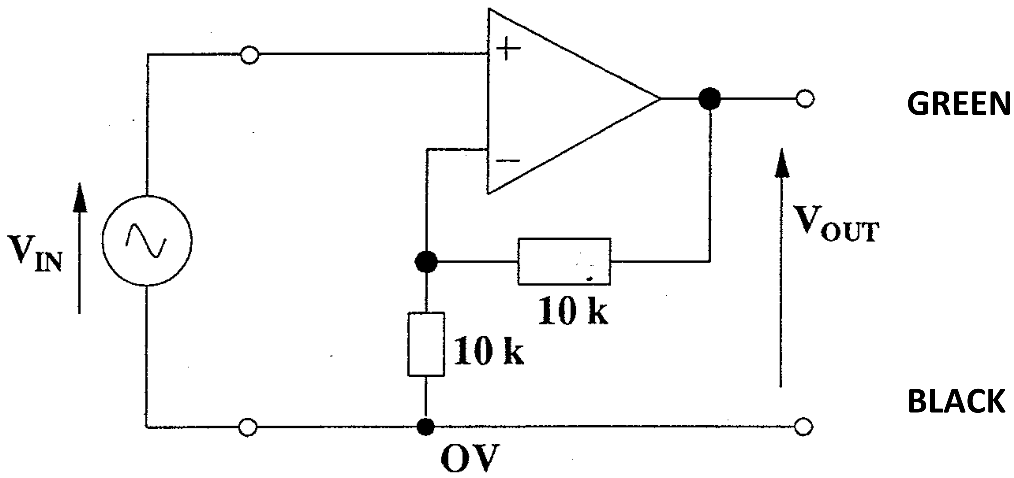


Fig.1: Inverting Amplifier

Circuit connection:

The power supply was set to 15V. The signal generator was set to give 2.0V peak-to-peak at a frequency of 1.0kHz.

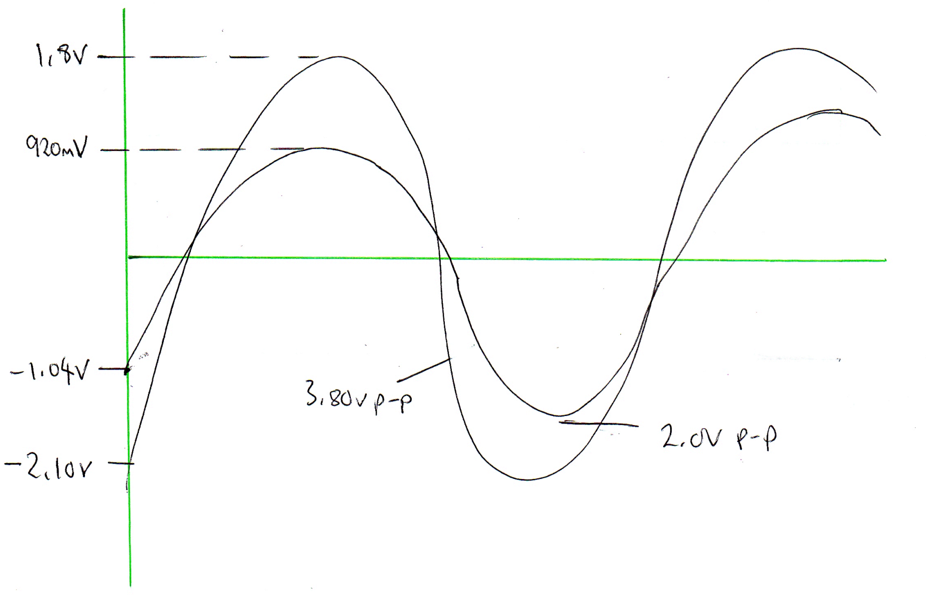
Voltage Gain:

$$\text{Theoretical gain} = 1 + \frac{R_F}{R_{IN}} = 1 + \frac{10k\Omega}{10k\Omega} = 2.0$$

$$\text{Measured gain} = \frac{V_{OUT}}{V_{IN}} - \frac{R_{IN} + R_F}{R_{IN}} = \frac{3.80V}{2.0V} = 1.9$$

- The theoretical gain is 0.1 higher than the measured gain. This could be due to a discrepancy in the resistors, a manufacturers margin of error or due to the quality of the components. It may also be attributed to human error when reading values from the scope.
- There is no phase shift on these waves = Non-inverting amplifier

Voltage gain graph – Non-inverting amplifier



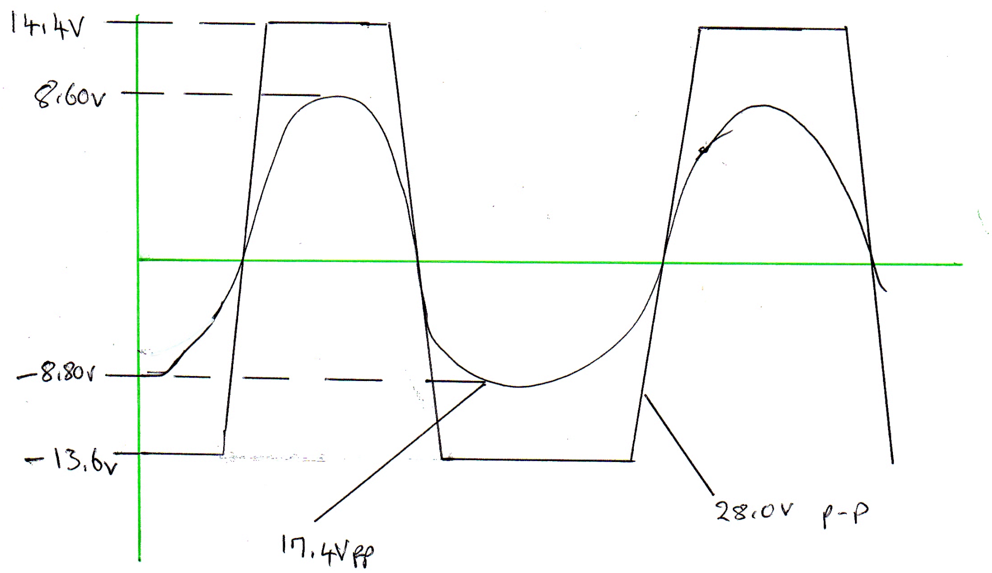
CH1 = V_{OUT}
1.00V
m=250μs
3.8V peak-to peak

CH2 = V_{in}
1.00V
m=250μs
2.0V peak-to peak

Effects of increase of V_{IN}

The waveform max's out due to a limit of voltage supply of 30.0V peak – peak.

Effect of increase of V_{IN} graph – Non-inverting amplifier



CH1 = V_{OUT}	CH1 = V_{OUT}
5.00V	1.00V
m=250µs	m=250µs
28.0V peak-to peak	17.4V peak-to peak

Error analysis

In this section I'm asked to analyse the uncertainties in the processed results based on the estimated accuracy of each of the measured quantities from which they were derived. Which was the largest source of error?

I'm a bit lost with this section. Can anyone tell me what is required exactly? Are we talking about the discrepancy between the theoretical value and actual value?

The inverting and non-inverting amplifiers had estimates and measured values. The inverting was the largest discrepancy of 0.7.

So is this what I wrote earlier?:

- The theoretical gain is 0.7 higher than the measured gain. This could be due to a discrepancy in the resistors, a manufacturers margin of error or due to the quality of the components. It may also be attributed to human error when reading values from the scope.

Discussion of results

Comparison with theory

Discussion

Conclusions

References

Appendices