Lab report operational amplifier application essay sample

Introduction

Operational amplifiers (“ op-amp”) are high gain electronic voltage amplifiers, which are the significant building blocks for most electronic circuits. In addition to this, they are still the most widely used microelectronic devices nowadays, being used in vast applications for industrial and individual users. The aim of this experiment is to demonstrate how the operational amplifier operates and show its imperfections via constructing various kind of circuit such as non-inverting/inverting amplifier circuits, filter circuits, differentiator and integrator circuits.

In this report, we will go through two experiments, which are the fundamental circuits of operational amplifiers: non-inverting and inverting amplifier circuits, to analyze the difference between ideal and real op-amps. For the following section, the relevant theory will be introduced, and then the detail and results of the experiments will be discussed before proceeding to conclusion.

Theory

Figure 1 : The op amp and its ideal attributes

As the Figure1 shown, operational amplifier has two inputs labeled (+) and (-) with positive and negative power supply, and a single output. It is primarily a high gain differential amplifier which amplifies the difference of voltages between two inputs. The output voltage of the amplifier Vout is given by the following formula:

Vout = A (V+ – V-) ————— (1)

Where A is the open loop voltages gain of the amplifier, which typically is very large about 105 at low frequency. V+ and V- are the non-inverting and inverting input voltage respectively. From the equation, output voltage is entirely governed by the difference between the two input voltages. However for real op-amps inputs do draw a small amount of current and the output voltage is affected by the output current drawn. For the analysis, both inverting and non-inverting amplifiers are applying negative feedback. It cause the V- to increase, hence voltages of the two input terminals will be much closed together. And the input draw current is assumed to be zero. Therefore Kirchhoff’s first (current) Law and Kirchhoff’s second (voltage) Law could be applied.

Experiment

The main apparatus for this experiment are the test board with ±15V power supply, Kenwood CS4125 oscilloscope, Hameg DVMs, and the input signal function generator is Hameg HM80030-2. Inverting amplifier:

Vout=-RFR1Vin

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Figure 2 : Inverting Amplifier

Constructing the circuit of an inverting amplifier as shown in figure 2 on the test board. In order to make an amplifier with a gain of -10, setting R1 = 2. 7 kΩ and RF = 27 kΩ. Applying a Hameg signal generator, a 1KHz sine wave was supply into the amplifier input, the amplitude should be adjusted to low values to prevent waveform distortion occur. Moreover, connecting the input and output of amplifier to X-Y channels of the Oscilloscope, to check the waveform and verify the amplification.

If both inputs are held at a common zero, the offset voltage will not be zero as ideally owing to a small amount of bias currents and internal imbalances of a real amplifier. Setting the oscilloscope to X-Y mode, a graph like Figure 3 will be display in the screen.

The output offset voltage which is the sum of two independent variables, one is Input offset voltage (Vin off), the other one is input bias current (Iin bias). The equation of the Vout off is given below: Vout off= Vin off1+RFR1+Iin bias RF —————— (2)

For the experimental purpose, the values of R1 and RF should be varied to form simultaneous equations, as a result, Vin off and Iin bias could be derived separately. When applying R1 = 2. 7kΩ and RF = 27kΩ , the value of offset voltages obtained was 8mV; furthermore, the value of Vout off increased to 10mV while R1 = 0. 1kΩ and RF = 1kΩ. Hence the simultaneous equation could be solved:

8×10-3= Vin off1+27k 2. 7k+Iin bias 27k Vin off = 0. 916 mV 10×10-3= Vin off1+1k0. 1k+Iin bias 27k Iin bias = -76. 92 nA

Figure 3 : X-Y mode trace of Vout against Vin

With the respect to Figure 3, the values of Vmax and Vmin acquired from experiment are +13. 5V and -14V, therefore the real output voltage range is from -14V to +13. 5V when ±15V supply rails are being used. Additionally, two horizontal lines reveal that maximum and minimum output voltages will less than the supply rail voltages due to the energy losses in the internal resistors.

Figure 4 Measurement of the output impedance

Measure the output impedance of the inverting amplifier by setting input voltage to ground, and injecting a load current to output side by adding a signal generator which drives a 10 kHz sine wave via a 220Ω resistor. Compare the difference between V out and V load shown in figure 4 by applying the oscilloscope, so that the output impedance could be derived by following equation Output impedance= V outIout ————– (3)

where Iout=(V load- V out)220 ————– (4)

As the result, the value of output impedance obtained from experiment is 1. 03Ω, which is quite small but still not equal to zero as ideal situation. In addition to this, V out will rise when the frequency of the signal is increasing; Meanwhile, the closed loop output impedance will tend to zero. Because the deviation between the V out and V load is getting smaller.

Non-inverting amplifier:

Vout= 1+RFR1Vin

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Figure 5: Non-inverting amplifier

Converting the circuit in to non-inverting amplifier and using the same values of RF and R1 . Moreover, applying the signal to the positive input of op-amps, thus a positive gain can be acquired. Much more interesting, the output offset voltage and output impedance will stay the same as values obtained from inverting amplifier. The reason is the resistors for both circuits are consistent.

Discussion

From the investigation of the experiments, the gain of non-ideal amplifiers is finite and it could be affected by the changing in frequency and existence of input offset voltages. Experiments have shown that there is error input voltage due to the non-zero bias currents flowing in the input terminals. Also they have proved that the maximum gain of real op-amps is finite and limited by maximum and minimum supply voltages.

During the experiment, it is vital to be aware of the error that may occur. Generally, errors can be divided into two categories which are the systematic errors and random errors. Unfortunately, systematic errors are unavoidable because of the existing error in the equipment used in the experiments. For instance, hameg DVMs can accurate about 0. 1% for DC voltages and 0. 2% for resistance; the accuracy of AC signals is around 1% while the frequency is within range from 40Hz to 20kHz. However, the random error could be minimized to the best extent by taking several measurements and using the average values.

Conclusion

The results acquired from the experiments reveal the properties of both inverting and non-inverting amplifiers, and describe the differences between real and ideal op-amp. Further, the phase relationships of input and output voltage for the inverting amplifier are 180 degrees out of phase; as opposed to this, they are in phase with each other for non-inverting amplifier. In the practical circuit design, there are many crucial factors should be considered to avoid exceeding the op-amp specification, and to enable op-amp works as ideally as possible in the real circuits.

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