Macau University of Science and Technology
CE102
Analog Circuit

Integral and Derivative Circuit Report

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06-12-2020

Objective

To learn how to construct integration and differentiation circuits using an op-amp.

To study the feature and performance of integration and differentiation cir- cuits.

Device Required

Capacitors/Resistors

Operational Amplifier LM741

SS1798 DC Supply

Breadboard

EE1651 Function Generator

Tektronix TDS210 Digital Oscilloscope

Prelab Questions

1.Analyze the circuit in Fig. 5.1, predict the variation of the amplitude and phase angle of the output when the frequency of input signal changes.

Actually, the Op-amp Integrator is an operational amplifier circuit that performs the mathematical operation of Integration, that is we can cause the output to respond to changes in the input voltage over time as the op-amp integrator produces an output voltage which is proportional to the integral of the input voltage.

In other words the magnitude of the output signal is determined by the length of time a voltage is present at its input as the current through the feedback loop charges or discharges the capacitor as the required negative feedback occurs through the capacitor.

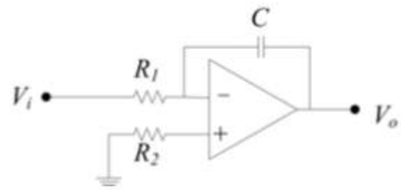

Figure 5.1: Double-End Input Summing Amplifier

the circuit has virtual short and virtual open

so I=$\frac{V_i}{R}$=0, V_i=0;

We assume that the current flowing through the capacitor is i_c

$\frac{0-V_i}{R_1}$=i_c=$C_2\frac{dV_c}{dt}$=$C_2\frac{dV_o}{dt}$

V_o=V_c-$\frac{1}{R_1C_2}\int_0^t V_i$(t)dt

we predict that there is a phase shift of $\frac{\pi}{2}$ between V_i and V_o

2.Analyze the circuit in Fig. 5.2, predict the variation of the amplitude and phase angle of the output when the frequency of input signal changes.

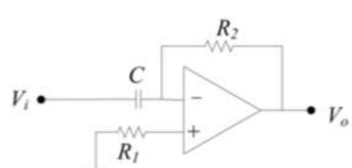

Figure 5.2: Double-End Input Summing Amplifier

The input signal to the differentiator is applied to the capacitor. The capacitor blocks any DC content so there is no current flow to the amplifier summing point. The capacitor only allows

AC type input voltage changes to pass through and whose frequency is dependant on the rate of change of the input signal.

the circuit still has virtual short and virtual open

so I=$\frac{V_i}{R}$=0, V_i=0;

V_o=-$R_2 C_1 \frac{dV_i(t)}{dt}$

we predict that there is a phase shift of $\frac{\pi}{2}$ between V_i and V_o

Procedures

Circuit Set up

Without applying the DC power, we connect the circuit on the breadboard. Carefully check all connection to make sure there is no short-circuit in whole circuit. As much as possible, make sure that the devices are not too tightly connected, and as much as posible let LM741 performed at the middle position on breadboard. Pay attention to connect Vcc power correctly.

Integration Circuit

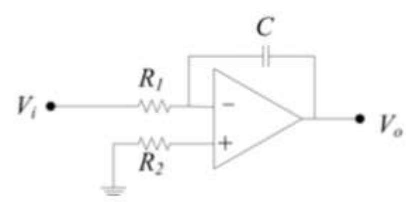

Figure 5.1: Double-End Input Summing Amplifier

1. Connect the circuit in Fig. 5.1 with R_1 = R_2 = 20 KΩ, C = 100 nF. Connect the power

supplies Vcc-=-10V and Vcc+=+10V to LM741.

2. Produce a 100 Hz, Vpeak = 1 V sinusoidal signal as V_i. Use the two channels of the oscilloscope to monitor V_i and V_o

Record the two waveforms and include them in your final lab report.

What is the phase shift between V_i and V_o? Which signal is leading? V_i or V_o?

After we measured when we adjust to 100Hz, we found that V_i is leading

we read that the time Increment is 2.7ms

T=$\frac{1}{frequency}$, T=0.001s

We can calculate the phase shift from the ratio of period to angle.

$\frac{0.001}{0.0027}=\frac{360°}{shift}$

phase shift is 97.297°
3.Vary the frequency of the input V_i (40 Hz-300 Hz), observe the change of the phase shift and amplitude of the two signals.

when the input frequency becomes lower (40Hz), how does the phase shift between V_i and V_o change? how does the amplitude of V_o change?

we read that the time Increment is 7.6ms

T=$\frac{1}{frequency}$, T=0.025s

We can calculate the phase shift from the ratio of period to angle.

$\frac{0.025}{0.0076}=\frac{360°}{shift}$

phase shift is 109.44^{circ}
when the input frequency becomes higher (300Hz), how does the phase shift between V_i and V_o change? how does the amplitude of V_o change? we read that the time Increment is 1ms

T=$\frac{1}{frequency}$, T=$\frac{1}{300}$s

We can calculate the phase shift from the ratio of period to angle.

$\frac{0.00333}{0.001} = \frac{360°}{shift}$

phase shift is 108°

Differentiation circuit

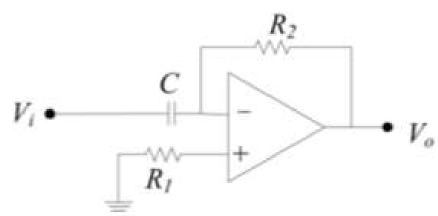

Figure 5.2: Double-End Input Summing Amplifier

1. Connect the circuit in Fig. 5.1 with $R_1 = R_2 = 10$ KΩ, C = 100 nF. Connect the power supplies Vcc-=-10V and Vcc+=+10V to LM741.

2. Produce a 100 Hz, Vpeak = 1 V sinusoidal signal as Vi. Use the two channels of the oscilloscope to monitor V_i and V_o

Record the two waveforms and include them in your final lab report. What is the phase shift between V_i and V_o? Which signal is leading? V_i or V_o?

we read that the time Increment is 2.5ms

T=$\frac{1}{frequency}$, T=0.001s

We can calculate the phase shift from the ratio of period to angle.

$\frac{0.001}{0.0025} = \frac{360°}{shift}$

phase shift is 90°

Then Experimentally, it was found that the greater the applied input frequency, the greater the V_o is.

3. Vary the frequency of the input V_i (40 Hz-300 Hz), observe the change of the phase shift and amplitude of the two signals.

when the input frequency becomes lower (40Hz), how does the phase shift between V_i and V_o change? how does the amplitude of V_o change?

we read that the time Increment is 6ms

T=$\frac{1}{frequency}$, T=0.025s

We can calculate the phase shift from the ratio of period to angle.

$\frac{0.025}{0.006}=\frac{360°}{shift}$

phase shift is 86.4°
when the input frequency becomes higher (300Hz), how does the phase shift between V_i and V_o change? how does the amplitude of V_o change?

we read that the time Increment is 0.8ms

T=$\frac{1}{frequency}$, T=0.00333s

We can calculate the phase shift from the ratio of period to angle.

$\frac{0.00333}{0.0008}=\frac{360°}{shift}$

phase shift is 86.4°

Then Experimentally, it was found that the greater the applied input frequency, the greater the V_o is.

problems during experiment

In the process of the experiment, while observing the oscilloscope screen, we happened to notice that the signal image began to coarsen, accompanied by violent jitter. After examination, we found that this was caused by a bad circuit contact.

summary

This experiment gave us a deep understanding of how to use op-amp to build integral and differential circuits, and in general, after four experiments, we did learn a lot. Starting from building BJT circuits with breadboard in the first class, to doing some experiments with amplification operators in the second and third class, we learned how to do error analysis, organize experimental data and analyze them step by step. Even though we made some empirical mistakes, we learned from our mistakes and slowly started to pay attention to the details of the experiments.

In the end, we would like to thank Professor Li sincerely for his guidance and instruction in learning and experimentation.