Lab number:

*1*

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ELE213: Singal processing

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1. **Introduction**

The purpose of this experiment was to learn how to use LabVIEW to generate and manipulate sine wave signals, and to understand the effects of sampling, frequency, phase, and amplitude on the signals. The experiment also aimed to demonstrate the concepts of linear signal processing, and to compare the theoretical and practical results. Perhaps to also teach this student graphical programing

1. **Theory and Methods**

***<Theory>***

* A sine wave is a periodic function that can be expressed as

where

is the amplitude,

is the frequency,

is the time, and

is the phase.

* Sampling is the process of converting a continuous signal into a discrete sequence of values, by taking measurements at regular intervals. The sampling frequency

is the number of samples taken per second. The sampling theorem states that a signal can be reconstructed from its samples if the sampling frequency is at least twice the highest frequency component of the signal

* The distance between the samples measured in time is the inverse of the sampling frequency
* The number of samples in one period of the sine signal is the ratio of the sampling frequency and the signal frequency
* The phase of a sine wave is the angle that determines the initial value of the function at

. The phase can be changed by adding or subtracting a constant to the argument of the sine function

The phase shift

affects the position of the peaks and troughs of the sine wave, but not its shape or amplitude.

* The amplitude of a sine wave is the maximum value that the function can reach. The amplitude can be changed by multiplying the sine function by a constant

The amplitude scaling

affects the height and depth of the sine wave, but not its shape or frequency.

***<Methods>***

* Create a blank project in LabVIEW and save it as "lab 1.lvproj".
* Create a new VI and save it as “ov1 oscillator.vi”. This VI will generate a sine wave signal with user-defined parameters.
* In the front panel, place the following controls and indicators: Samples, Amplitude, Frequency, Sampling Frequency, Phase, Reset Phase, XY-Display, and Signal Out. Adjust their properties and formats as instructed in the assignment pdf.
* In the block diagram, place the following function blocks: Sine Wave, Reciprocal, Multiply, For Loop, Bundle, and Unbundle. Connect them with wires as shown in Fig. 5 of the assignment pdf. Change the Signal Out terminal to an indicator.
* Edit the icon and terminal map of the VI to create a meaningful symbol for the VI, as shown in Fig. 12 of the assignment pdf.
* Create another new VI and save it as “Lab 1.vi”. This VI will use the ov1 oscillator.vi as a sub-VI and perform some signal manipulation and display.
* In the front panel, place the following controls and indicators: Double Frequency, Stop, and XY-Graph. Adjust their properties and formats as instructed in the assignment pdf.
* In the block diagram, place the following function blocks: ov1 oscillator.vi, Expression Node, Wait, Build Array, Cluster Constant, While Loop, and Case Structure. Connect them with wires as shown in Fig. 13 of the assignment pdf.

1. **Experiment Results**

Some of the experiment results and explanations are:

* For the first part of the experiment, the input values were: Samples: 50, Sampling Frequency: 10000Hz, Frequency: 400Hz, Double Frequency: off, Phase: 0, Reset Phase: on. The output graph is shown below:
* The purpose of the amplitude control is to change the height and depth of the sine wave, as shown by the different values of the y-axis. When the amplitude is 1, the sine wave ranges from -1 to 1. When the amplitude is 0.5, the sine wave ranges from -0.5 to 0.5.
* The distance between the samples measured in time is

seconds, or 0.1 milliseconds. This can be observed by the values of the x-axis in the graph, which increase by 0.1 ms for each sample.

* The number of samples in one period of the sine signal is

. This can be observed by counting the number of samples from one peak to the next peak in the graph, which is 25.

* The purpose of the phase control is to change the position of the peaks and troughs of the sine wave, as shown by the different values of the x-axis at which the sine wave reaches its maximum or minimum. When the phase is 0, the sine wave starts at 0. When the phase is

, the sine wave starts at -1. When the phase is

, the sine wave starts at 1.

* When the frequency is changed to 9600Hz, the distance between the samples measured in time remains the same (0.1ms), but the number of samples in one period of the sine signal changes to

. This means that the signal frequency is too high for the sampling frequency, and the sampling theorem is violated. As a result, the signal cannot be reconstructed from the samples, and the graph shows a distorted waveform that does not resemble a sine wave. The frequency and phase of the signal in the graph are not the same as the input values, and cannot be determined accurately. This is called aliasing, and it occurs when the signal frequency is higher than half of the sampling frequency (

).

* When the frequency is changed to 10400Hz, the same problem of aliasing occurs, but with a different distorted waveform. The frequency and phase of the signal in the graph are still not the same as the input values, and cannot be determined accurately.
* When the frequency is adjusted around 400Hz, the graph shows a clear sine wave that matches the input values. The frequency and phase of the signal in the graph are the same as the input values, and can be determined by the number of samples in one period and the position of the peaks and troughs. The graph also shows the effect of changing the frequency on the shape and period of the sine wave. When the frequency is higher, the sine wave becomes narrower and has more cycles in a given time. When the frequency is lower, the sine wave becomes wider and has fewer cycles in a given time.
* The function of the Reset Phase control is to reset the phase of the sine wave to 0 every time it is pressed. This can be observed by the sudden jump of the sine wave to 0 in the graph when the Reset Phase button is pressed.
* For the second part of the experiment, the input values were: Samples: 100, Sampling Frequency: 10000Hz, Double Frequency: on, Reset Phase: on, Amplitude: 1, Phase: 0. The output graph is shown below:
* The graph shows two signals, one in blue and one in red. The blue signal is the original sine wave generated by the ov1 oscillator.vi sub-VI. The red signal is the manipulated signal obtained by applying the expression

to the blue signal, where

is the value of the blue signal and

is the value of the red signal. The Double Frequency control determines whether the frequency of the blue signal is doubled or not before applying the expression. When the Double Frequency control is on, the frequency of the blue signal is 800Hz, and when it is off, the frequency of the blue signal is 400Hz.

* The relationship between the two signals can be shown mathematically as follows:
  + When the Double Frequency control is off, the blue signal can be expressed as

, where

is the time. The red signal can be obtained is doubled or not before applying the expression. When the Double Frequency control is on, the frequency of the blue signal is 800Hz, and when it is off, the frequency of the blue signal is 400Hz.

The relationship between the two signals can be observed by comparing their graphs. The red signal is a distorted version of the blue signal, with a shape that resembles a parabola rather than a sine wave. This is because the expression

is a quadratic function, which produces a parabolic curve. The red signal is also shifted down by 1 unit, as indicated by the “-1” in the expression.

When the amplitude is changed to 0.5V, the height and depth of both signals are halved, as shown by the different values of the y-axis. This is because the amplitude control multiplies the value of the signal by a constant, which affects the range of the signal but not its shape or frequency.

In conclusion, the experiment results show that the LabVIEW program can generate and manipulate sine wave signals according to the students parameters, and the output graphs match the theoretical predictions. The experiment also demonstrates the effects of sampling, frequency, phase, and amplitude on the signals, and the phenomenon of aliasing when the signal frequency is too high for the sampling frequency. The experiment results also show that the signal manipulation

is a non-linear operation that changes the shape of the signal and produces a new signal with a parabolic curve. The experiment results provide a practical understanding of the concepts and skills learned in the lab exercise.

1. **References**

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