

Lab Manual:  
Communications Principles  
  
Using the EMONA Communications board for NI ELVIS III



Lab 2: Modeling equations

List of Updates

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| --- | --- |
| **Date** | **Details** |
| 4/1/2018 | Completed final document |
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# Lab 2: Modeling equations

Mathematics is an important part of electronics and this is especially true for communications and telecommunications. As you’ll learn in this lab, the output of all communications systems can be described mathematically with an equation and these equations can be modeled with electronic circuit blocks.

Although the math that you’ll need for this manual is relatively light, there is some. Helpfully, the Emona Communications board can model communications equations to bring them to life.

## Learning Objectives

After completing this lab, you should be able to complete the following activities.

1. Contrast the addition of electrical signals in relation to the math of addition
2. Describe the effect of phase shifts on signals
3. Understand the relationship between math theory and its implementation with real electrical circuits

## Prerequisites

You should have completed Lab 1 and be familiar with the equipment, its use and the handling precautions for the equipment.

## Required Tools and Technology

|  |  |
| --- | --- |
| Platform: NI ELVIS III Instruments used in this lab:   * Oscilloscope-Time * Oscilloscope-FFT | * Install Instruments: [http://www.ni.com/documentation/en/ni-elvis-iii/latest/getting-started/installing-the-soft-front-panel/](http://www-preview.ni.com/documentation/en/ni-elvis-iii/1.0/getting-started/installing-the-soft-front-panel/) * Access instruments <https://measurementslive.ni.com> * View User Manual <http://www.ni.com/en-us/support/model.ni-elvis-iii.html> * View tutorials <https://www.youtube.com/playlist?list=PLvcPIuVaUMIWm8ziaSxv0gwtshBA2dh_M> |
| Hardware: Emona Communications Board Components used in this lab:   * Four BNC to 2mm banana-plug leads * Assorted 2mm banana-plug patch leads * Set of headphones or earbuds | * View User Manual <http://www.ni.com/en-us/support/model.emona-communications-board-for-ni-elvis-iii.html> |

## 

## Expected Deliverables

In this lab, you will collect the following deliverables:

* Calculations
* Data from measurements
* Observations

Your instructor may expect you complete a lab report. Refer to your instructor for specific requirements or templates.

## Section 1: Adding two signals together

**Powering up the ELVIS III + EMONA Communications Board**

|  |  |
| --- | --- |
| 1. | Ensure that the NI ELVIS III Application Board power button at the top left corner of the unit is OFF (not illuminated). |

|  |  |
| --- | --- |
| 2. | Carefully plug the Emona Communications board(ECB) into the NI ELVIS III ensuring that it is fully engaged both front and back. |

|  |  |
| --- | --- |
| 3. | Ensure that you have connected the NI ELVIS III to the PC using the USB cable and that the PC is turned on. |

|  |  |
| --- | --- |
| 4. | Turn on the Application *Board Power* button by pressing it once and confirm that it is illuminated. The LEDs on the ECB should also be illuminated. If they are not, then switch the unit off immediately and check for connection or insertion errors. |

|  |  |
| --- | --- |
| 5. | Open the Instrument Launcher software in your browser and select the required instruments. |

Table 1 Scope Configuration

|  |  |
| --- | --- |
| Channel Voltage Range | 2 V/div |
| Horizontal Timebase | 50us/div |
| Trigger | Analog Edge, Channel 1, Rising |
| Probe Attenuation | 1x |

In this part of the experiment, you’re going to use the Adder module to add two electrical signals together. Mathematically, you’ll be implementing the equation:

Adder module output = Signal A + Signal B

|  |  |
| --- | --- |
| 6. | Locate the Adder module on the board and set its soft *G* and *g* controls to about the middle of their travel. |

|  |  |
| --- | --- |
| 7. | Connect the set-up shown in Figure 1.  **Note:** Although not shown, insert the black plugs of the oscilloscope leads into a ground (*GND*) socket. |

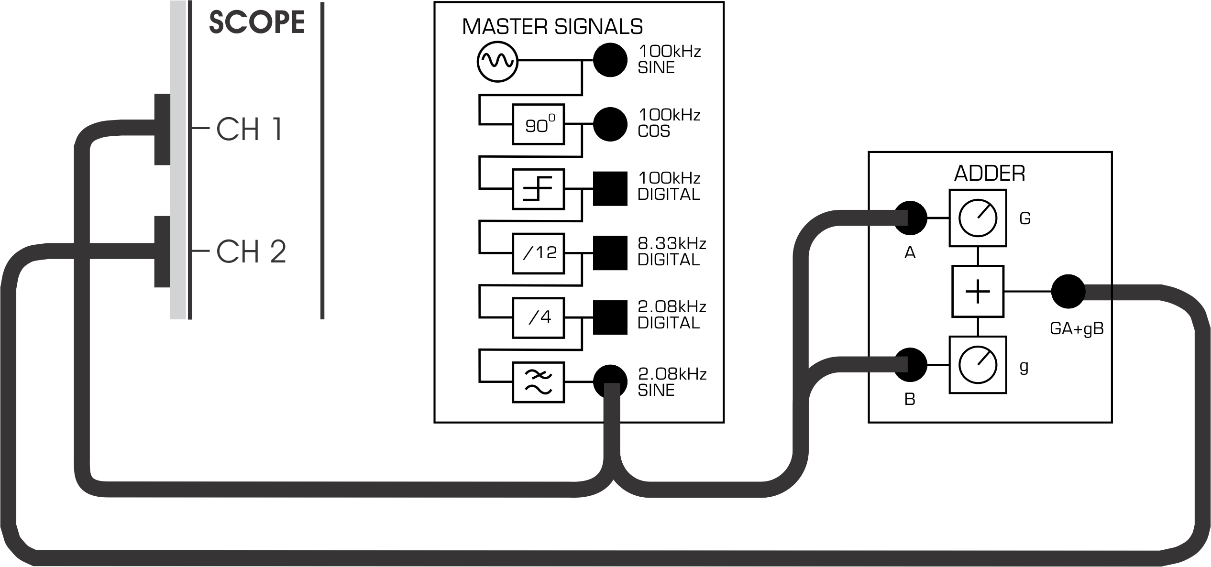


Figure 1: Patching for addition

This set-up can be represented by the block diagram in Figure 2.

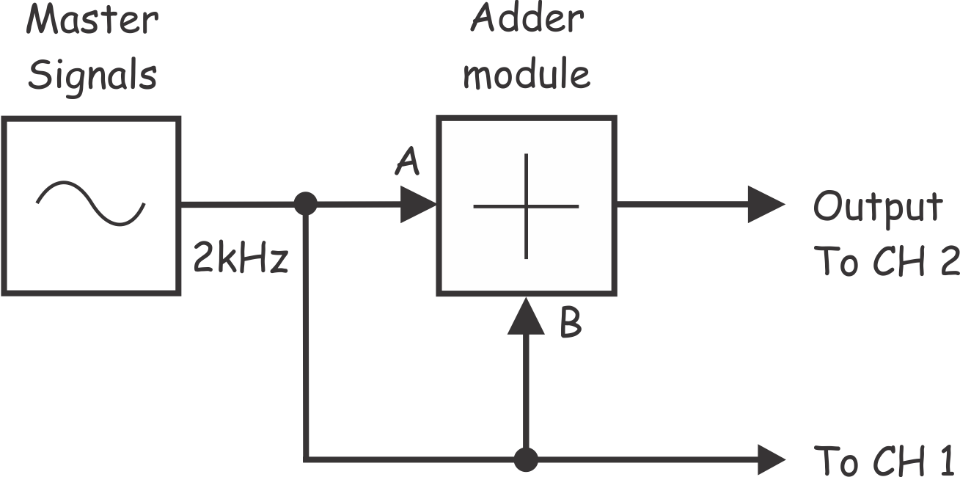


Figure 2: Block diagram for addition

|  |  |
| --- | --- |
| 8. | Adjust the scope’s *Timebase* control to view two or so cycles of the Master Signals module’s *2.08kHz SINE* output. |

|  |  |
| --- | --- |
| 9. | Measure the amplitude (peak-to-peak) of the Master Signals module’s *2.08kHz SINE* output. Record your measurement in Table 1 on the next page as the Input Voltage on the table. |

|  |  |
| --- | --- |
| 10. | Disconnect the lead to the Adder module’s *B* input. |

|  |  |
| --- | --- |
| 11. | Use scope’s Channel 2 to observe the Adder module’s output as well as its input. |

|  |  |
| --- | --- |
| 12. | Adjust the Adder module’s *G* control until its output voltage is the same size as its input voltage (measured in Step 9).  **Note:** This makes the gain (G) for the Adder module’s *A* input = 1. |

|  |  |
| --- | --- |
| 13. | Reconnect the lead to the Adder module’s *B* input. |

|  |  |
| --- | --- |
| 14. | Disconnect the lead to the Adder module’s *A* input. |

|  |  |
| --- | --- |
| 15. | Adjust the Adder module’s *g* control until its output voltage is the same size as its input voltage (measured in Step 9).  **Note:** This makes the gain (g) for the Adder module’s *B* input =1 and means that the Adder module’s two inputs should have the same gain. |

|  |  |
| --- | --- |
| 16. | Reconnect the lead to the Adder module’s *A* input. |

The set-up shown in Figures 1 and 2 is now ready to implement the equation:

Adder module output = Signal A + Signal B

Notice though that the Adder module’s two inputs are the same signal: a 4Vp-p 2.08kHz sinewave. So, for these inputs the equation becomes:

Adder module output = 4Vp-p (2kHz sine) + 4Vp-p (2kHz sine)

When the equation is solved, we get:

Adder module output = 8Vp-p (2kHz sine)

Let’s see if this is what happens in practice.

|  |  |
| --- | --- |
| 17. | Measure and record the amplitude of the Adder module’s output in Table 1 as the Output Voltage. |

|  |  |
| --- | --- |
| **Input Voltage** | **Output Voltage** |
|  |  |

Table 1

* 1. Is the Adder module’s measured output voltage **exactly** 8Vp-p as theoretically predicted?

|  |
| --- |
|  |
|  |
|  |

* 1. What are two reasons for this?

|  |
| --- |
|  |
|  |
|  |

## Section 2: Adding two phase shifted signals together

In the next part of the experiment, you’re going to add two electrical signals together but one of them will be phase shifted. Mathematically, you’ll be implementing the equation:

Adder module output = Signal A + Signal B (with phase shift)

|  |  |
| --- | --- |
| 1. | Set the Phase Shifter module’s *Phase Adjust* control about the middle of its travel. |

|  |  |
| --- | --- |
| 2. | Connect the set-up shown in Figure 3.  **Note:** Insert the black plugs of the oscilloscope leads into a ground (*GND*) socket. |

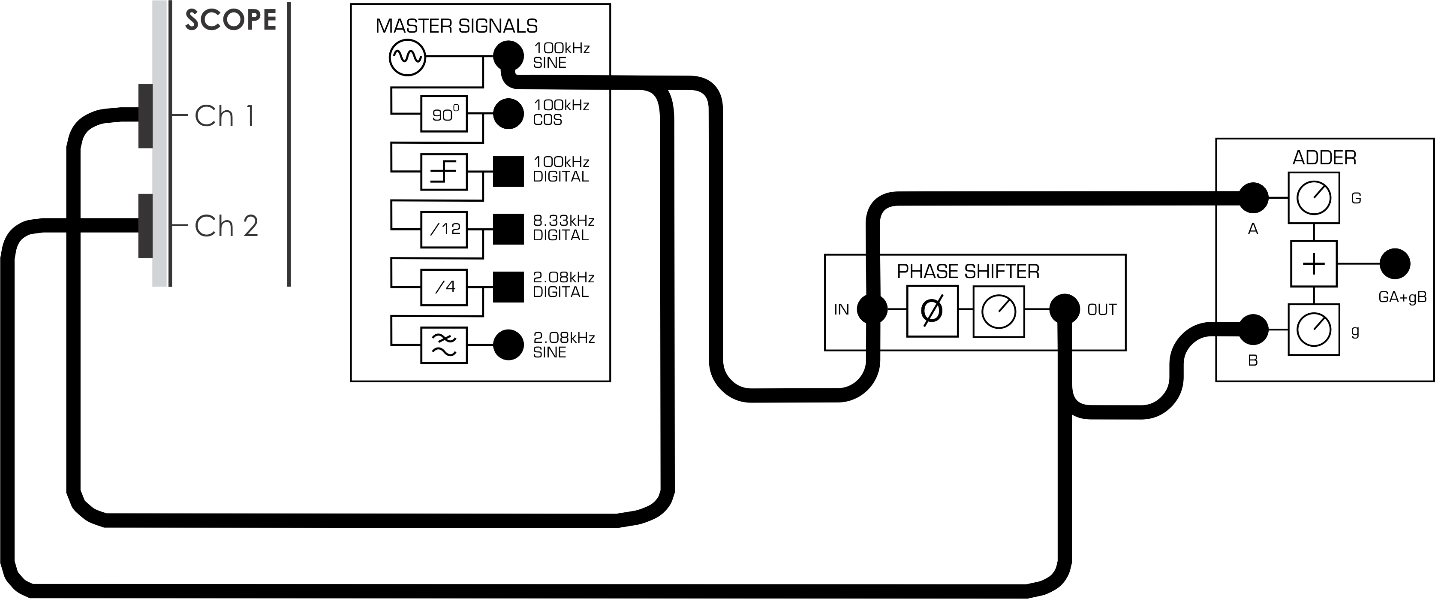


Figure 3: Patching for phase shifted addition

This set-up can be represented by the block diagram in Figure 4.

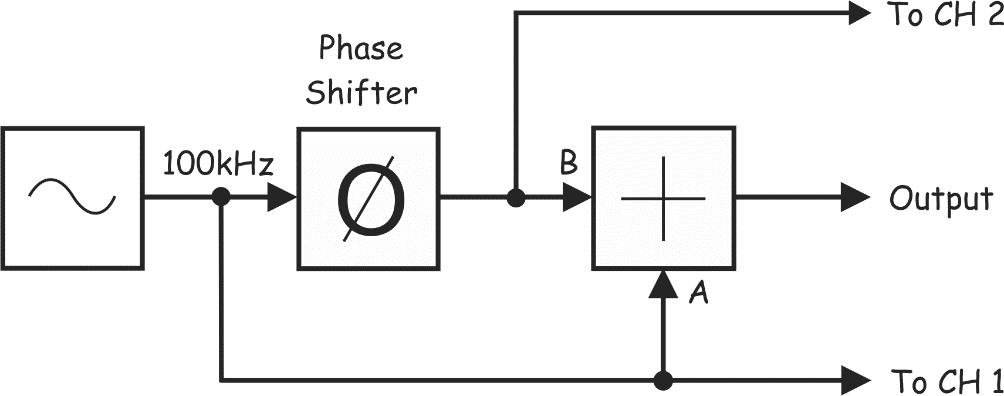


Figure 4: Block diagram for phase shifted addition

The set-up shown in Figures 3 and 4 is now ready to implement the equation:

Adder module output = Signal A + Signal B (with phase shift)

The Adder module’s two inputs are the same signal: a 4Vp-p 100kHz sinewave. So, with values the equation is:

Adder module output = 4Vp-p (100kHz sine) + 4Vp-p (100kHz sine with phase shift)

As the two signals have the same amplitude and frequency, if the phase shift is exactly 180° then their voltages at any point in the waveform is always exactly opposite. That is, when one sinewave is +1V, the other is -1V. When one is +3.75V, the other is -3.75V and so on. This means that, when the equation above is solved, we get:

Adder module output = 0Vp-p

Let’s see if this is what happens in practice.

|  |  |
| --- | --- |
| 3. | Adjust the Phase Shifter module’s *Phase Adjust* control until its input and output signals look like they’re about 180° out of phase with each other. |

|  |  |
| --- | --- |
| 4. | Disconnect the scope’s Channel 2 lead from the Phase Shifter module’s output and connect it to the Adder module’s output. |

|  |  |
| --- | --- |
| 5. | Adjust Channel 2’s S*cale* control to resize the signal on the display. |

|  |  |
| --- | --- |
| 6. | Measure the peak-to-peak amplitude of the Adder module’s output. Record your measurement in Table 2 below. |

|  |
| --- |
| **Output voltage** |
|  |

Table 2

2-1 What are two reasons for the output not being 0V as theoretically predicted?

|  |
| --- |
|  |
|  |
|  |

The following procedure can be used to adjust the Adder and Phase Shifter modules so that the Adder module has a *null* output. That is, an output that is close to zero volts.

|  |  |
| --- | --- |
| 7. | Vary the Phase Shifter module’s *Phase Adjust* control left and right a little and observe the effect on the Adder module’s output. |

|  |  |
| --- | --- |
| 8. | Make fine adjustments to the Phase Shifter module’s *Phase Adjust* control to obtain the smallest output voltage from the Adder module. |

2-2 What can be said about the phase shift between the signals on the Adder module’s two inputs now?

|  |
| --- |
|  |
|  |
|  |

|  |  |
| --- | --- |
| 9. | Vary the Adder module’s *g* control left and right a little and observe the effect on the Adder module’s output. |

|  |  |
| --- | --- |
| 10. | Make the necessary fine adjustments to the Adder module’s *g* control to obtain the smallest output voltage. |

2-3 What can be said about the gain of the Adder module’s two inputs now?

|  |
| --- |
|  |
|  |
|  |

You’ll probably find that you’ll not be able to null the Adder module’s output completely. Unfortunately, but as should be expected, real systems are never “perfect” and so they don’t behave exactly according to theory. As such, it’s important for you to learn to recognize these limitations, understand their origins and quantify them where necessary.