A Simple SystemView Example

This document introduces a new user to SystemView by Elanix. The user will be led through the design and analysis of a basic engineering example. Three other resources for the new user are:

1. An automated Demo available from within SystemView. The new user is encouraged to run this Demo either before or after reviewing this document. The Demo can be accessed by clicking on the following:
   
   Help (at the top menu bar), Demo

2. The USER GUIDE, Chapter 3: OVERVIEW OF SYSTEMVIEW

3. The USER GUIDE, Chapter 9: THE ANALYSIS WINDOW

   The USER GUIDE, is available from within SystemView by clicking on the following:
   
   Help (at the top menu bar), Help Navigator, SystemView User Guide

Example System

The task is to generate a clean sine wave that has a frequency of 1.070 MHz, add some noise to the sine wave, and then to filter the noisy signal to obtain a relatively clean sine wave. In the real world the 1.070 MHz sine wave (or 1070 kHz) could be the RF carrier of an AM radio station. The electrical noise could be from a mercury vapor street lamp, a nearby computer, or lightning. The filter could be inside a portable AM radio.

Definitions:

MHz MegaHertz or MegaCycles per second (1.0 MHz = 1.0 e6 Hertz)
kHz kiloHertz or kiloCycles per second (1.0 kHz = 1.0 e3 Hertz)
RF radio frequency
AM amplitude modulation

Nyquist's sampling theorem -- http://www.its.bldrdoc.gov/fs-1037/dir-025/_3621.htm

System Sample Rate

Before a simulation is run, SystemView requires that its Sample Rate be set to a value that is appropriate for the frequencies present in the system. Although a simulation may be designed in the System Window first, and then the Sample Rate can be set, it is usually best to set the Sample Rate first, especially if filters are used. The Sample Rate is set by left-clicking on the Define System Time (stopwatch icon) top-right button in the toolbar, and setting some parameters (Figure 1). Usually only one or two of the six parameters needs to be changed. Clicking on the Update or OK button will automatically calculate the remaining four parameters.

Nyquist's sampling theorem would have us set the Sample Rate to at least twice the highest frequency in the simulation. In this example the highest frequency is 1,070 kHz, so the Sample Rate needs to be higher than 2,140,000 samples/second. SystemView users typically use sample rates that are 3 to 5 times higher than the highest frequency in the simulation. In some cases, sample rates are used that are 20 (or more) times higher than the highest frequency. SystemView will always produce an accurate answer no matter what Sample Rate is used, however, as the Sample Rate is increased, the resulting plots will look smoother, and less like connected straight lines. Initially, the Sample Rate in this system will be set to 25.0 e6 samples/second, which is about 23 times higher than 1.070 MHz. Setting the number of samples (No. of Samples) to 128 produces a display in the Analysis Window of about 5 cycles of a sine wave. As shown in Figure 1, please use the default number of samples (128), enter the Sample Rate (25.e+6), click Update, and then click OK.
Figure 1. The System Time Specification window -- accessed by using the stopwatch symbol at the top toolbar.

**Entering the Design in the System Window**

You can create the example task, the system in Figure 2, by doing the following:

4. Use the mouse to drag a **Source** onto the screen from the token reservoir at the left side of the screen.

5. Left-double-click the **Source** token (0) with the mouse to get the menu in Figure 3.

6. Select **Sinusoid**, then **Parameters**, and change the **Frequency (Hz)** from 10 to 1070e3. See Figure 4. Click **OK**, and then **OK** again. The default values for **Amplitude (v)** and **Phase (deg)** are used, as shown in Figure 4.

Note 1. An alternate way of setting token parameters: Right-mouse-click the token to get a menu, select **Edit Parameters**.

Note 2. If you make a mistake, you can **Undo** an action by clicking on the top menu bar: **Edit, Undo xxxxxx**. You can also remove a token from the screen by dragging it back into the appropriate reservoir on the left side of the screen.

Note 3. If you make a mistake and want to cancel an operation, click on the red button (Cancel Operation) on the top toolbar. Think of the red cancel button as the stop button on a VCR (video cassette recorder).

![Figure 2. A system that filters a noisy signal.](image-url)
**Sinks**

Adding a Sink to a system allows the plot of a signal to be displayed in the Analysis Window. There are several ways to add a Sink to a system. This is probably the most convenient way: On the keyboard, hold both the Ctrl and Alt keys down, position the mouse cursor to a location on the screen, then right-click the mouse. The most common type of Sink (Analysis Sink) will appear on the screen. It may be moved to a different location by left-mouse clicking on the token and dragging it to the desired place.

**Connecting the Source to the Sink**

There are several ways to interconnect tokens in SystemView. One easy way is: Position the mouse cursor to the right-hand edge of the Source token until an up-arrowhead (↑) appears, then left-mouse-click and drag the mouse (and the connecting line) over to the Sink (token 1). When the mouse is released, you will have a choice of selecting one of the two outputs of the Sinusoid Source token (Figure 6). Use the default output, 0: Sine, and then select OK. The system is ready to run now.

**Running the Simulation**

Four conditions are necessary to run a SystemView simulation.

a) There must be a Source that has its parameters set.

b) There must be a Sink that has been defined.

c) The Source must eventually be connected to a Sink, usually with a few other tokens in between them.

d) The System Time has to be set.

The system in Figure 5 meets these requirements. To run the system, click on the green triangle on the top toolbar. Think of the green Run System button as the play button on a VCR. While the simulation is running, the blue flood bar at the bottom of the screen will be active. (Note: With only 128 samples, the blue flood bar will just be a blip.)
Viewing the Simulation Results

The results contained in a Sink may be viewed by clicking the Analysis Window button that is located to the right of the stopwatch button at the top toolbar. If the plot of the sink is not visible, you will find it minimized at the bottom of the screen. Click on the left or center button (Restore, or Maximize, Close) to view the plot (Figure 7).

You can view the actual, time vs amplitude, sample points of the plot by left-mouse-clicking on the 5th button from the left (Connected Points) on the top toolbar (Figure 8).
Labeling Sinks

The plot is automatically labeled Sink 1. To make the plot label more meaningful, do the following:

7. Go back to the System Window (Click on the right-hand button on the top toolbar).
8. Double click on the Sink (token 1) to get Figure 9.
9. Rename the Custom Sink Name from Sink 1 to Sine input so it looks like Figure 10, and then click OK. (Actually, any text that you may prefer can be used.)

Run the system, by clicking on the green triangle on the top toolbar. View the new plot by clicking the Analysis Window button that is located to the right of the stopwatch button at the top toolbar. You will see the previous plot on the screen. To refresh the screen with the new plot that contains the new label, left-mouse-click on the flashing blue button at the left side of the top toolbar (Load New Sink Data).

Notepads

Adding notepads can help document your project in the System Window. To add a notepad that says "Sine input", do the following:

10. Go back to the System Window (right-hand button on the top toolbar).
11. Left-mouse-click on the New Note Pad button located near the center of the top toolbar.
12. Left-mouse-click on the notepad and drag it to a convenient place on the screen, and enter the text as shown in Figure 11a (Sine input). The 8 tabs that surround the notepad may be used to resize it. (It may be necessary to click on the notepad to see the 8 tabs.)

Here is a shortcut for copying the parameters of a token into a notepad:

13. On the top menu, 5th choice from the left, left-mouse-click on NotePads to get a sub-menu. Select Copy Token Parameters to NotePad… then click on the Source (token 0).
14. Left-mouse-click on the notepad and drag it to a convenient place on the screen (Figure 11b).
Adding Noise to the Example:

15. Make sure that you are in the System Window.

16. Left-mouse-click and drag another Source (token 2) from the reservoir on the left and place as shown in Figure 11. Double-click the Source token (2) with the mouse, select Noise/PN to get the menu in Figure 12. Select Gauss Noise, then Parameters, and change the Std Deviation (v) from 1 to 0.3 (or 300.e-3) to get the window shown in Figure 13. Click OK, and OK again. As shown in Figure 13 the default value for Mean (v) is used, also the default setting of Std Deviation is used.

17. Left-mouse-click and drag an Adder (token 3) from the reservoir on the left and place as shown in Figure 11.

18. Add a Sink (token 4) to the right of the Adder by holding both the Ctrl and Alt keys down, position the mouse cursor to a location on the screen, then right-click the mouse.

19. Connect each of the two Sources to the Adder. When questioned about which of the two Sinusoid outputs to use, select 0: Sine, and select OK.

20. Connect the Adder to the new sink (token 4).

21. Run the system (green triangle).

22. Select the Analysis Window.

23. Refresh the screen by clicking on the flashing blue button. Sink 4 will be minimized at the bottom of the screen. If Sink 4 is covered up by the first plot (Sine input), reduce the size of the first plot by clicking on the center (Restore) button in the top-right corner. Click on Sink 4's left or center button (Restore, or Maximize, Close) to view the plot. The sine wave plus noise plot will look similar to Figure 14. Each time the simulation is run the noise will be different because the noise is random.

![Figure 11.](image1)

![Figure 12.](image2)

![Figure 13.](image3)

![Figure 14. Sine wave plus noise.](image4)
Viewing two or more plots at a Time
If the plots of each of the two sinks are not visible, you will find them in their minimized form at the bottom of the screen. Click on the 8th button from the right on the top toolbar, Open All Windows, to view the plots (Figure 15 or Figure 16). The two green buttons on the toolbar (button 8, from the left, Tile Vertical and button 9, from the left, Tile Horizontal), may be used to change the view between Figures 15 and Figure 16.

In the next section you will learn how to use the Sink Calculator.

![Figure 15](image1.png) In this view, the Sine input is on the top, the Sine input plus noise is on the bottom.

![Figure 16](image2.png) Same as Figure 15, but the windows are arranged side-by-side.

The Sink Calculator
At this point in our system simulation we have 2 separate plots that represent the 2 sinks in the system. Now we will use the information in the 2 original plots to create other plots. This can be done by using the Sink Calculator at the bottom, left of the Analysis Window. It looks like a square-root of alpha symbol.

Overlaying Plots using the Sink Calculator
24. Make sure that you are in the Analysis Window and click on the Sink Calculator. It will look like Figure 17.
25. Select the default conditions: Operators, Overlay Plots, and then select both windows (w0, w1) at the top-right of the SystemView Sink Calculator window. To select both items, left-mouse-click on the w0 line and then drag the mouse down to the w1 line, highlighting both lines. The highlighted window will look like Figure 18. Click OK to get the window in Figure 19.
26. To rearrange the 3 windows so that they don't overlap, click the Tile Horizontal button on the toolbar (Figure 20).
Figure 17.

Figure 18.

Figure 19. The 1st two plots overlapped in a 3rd window.

Figure 20. The 3 windows using *Tile Horizontal.*
Adding a Filter

27. Make sure that you are in the System Window.
28. Left-mouse-click and drag an Operator token (green) from the reservoir on the left and place as shown at the bottom of Figure 21. Connect the adder token to the Operator token. (Connecting tokens -- see top of page 3.) Double-click the Operator token (5) with the mouse, to get the menu in Figure 22.

Select Linear SyS Filters, then Parameters, to get the menu in Figure 23.

29. In Figure 23, select the 2nd button down on the right, Analog… to get the window shown in Figure 24. The purpose of this filter is to reduce the electrical noise that may interfere with the reception on a portable AM radio.

While many different types of filters could be used, here is one example. Set the filter parameters to the following:

Filter Type: Butterworth (default)
No. of Poles / BP Filter Order: 3 (default)
Filter Pass-Band: Bandpass (select)
Low Cutoff (Hz): 500e+3 (select) (500 kHz = 500e+3 = 0.5e+6)
High Cutoff (Hz): 1.7e+6 (select) (1700 kHz = 1700e+3 = 1.7e+6)

(Continued on the next page.)
30. Click on Finish, to get the window in Figure 25, that shows the Impulse Response of the filter.
31. Click on the Bode Plot button to get the window in Figure 26. The Bode Plot shows that this filter has a near zero loss in the 530 kHz to 1600 kHz frequency band that AM radio stations use, but on either side of the passband the filter has increasing loss to help reject the unwanted noise. (In Figure 26, the Phase plot has been disabled, and Show Points have been turned off.)
32. Click Close, and then click OK, and OK again to confirm the filter design.
33. Add a Sink (token 6) to the right of the Filter by holding both the Ctrl and Alt keys down, position the mouse cursor to a location on the screen, then right-click the mouse. Connect the filter (token 5) to the sink (Figure 21). Now the example system is complete.
34. Run the system by clicking on the green triangle on the top toolbar.
35. Go to the Analysis Window and click on the flashing blue Load New Sink Data button.
36. To get the view in Figure 27, close the overlay plot window and open the new Sink 6 window by using the Open All Windows button, in the top toolbar. In Figure 27, the Sine input is at the top, the noisy Sine wave is in the middle, and the filtered result is at the bottom (use Tile Horizontal). The filtered result is much cleaner than the Sine+noise signal, but not perfect like the original Sine input. Also, the filtered result is delayed in time because of the action of the filter.
Power Spectrum
Up to now all the plots have been of signals in the time domain -- amplitude vs time. Important additional information is shown when signals are viewed in the frequency domain -- amplitude vs frequency. To view the power spectrum of the Sine+noise signal do the following:

37. Make sure that you are in the Analysis Window and click on the Sink Calculator at the bottom of the screen. It will look like Figure 28.
38. Select: Spectrum, Power Spectrum (dBm in 50 ohms) and then select Sine input (w0) at the top-right of the SystemView Sink Calculator window. The highlighted window will look like Figure 29. Click OK to get the plot in Figure 30.
39. To rearrange the 4 windows so that they don't overlap, click the Tile Horizontal button on the toolbar.

The power spectrum in Figure 30 shows a peak near 1 070 kHz as expected, but the spectrum is rather crude looking because only 128 samples were used when the simulation was run. Now go back to the System Window and modify the Define System Time to have 32768 samples instead of 128. You can use the Set Power of 2 button to increment the number of samples. Click OK. Go to the System Window, run the system by clicking on the green triangle on the top toolbar. Then go to the Analysis Window and click on the flashing blue Load New Sink Data button. When the system is run and the plots are refreshed, you will get the spectrum in Figure 31.

FFT Bin Splitting
The spectrum in Figure 31 is a vast improvement on Figure 30, but it is still not as good as possible. Initially the sample rate was set to 25.0 e6 samples/second, using 32768 samples, and that produced a frequency resolution of 762.939453125 Hz. Since this frequency resolution is not a nice "round number", a phenomenon called FFT bin splitting causes a single frequency to share frequency bins, resulting in a relatively wide line on the plot. Using all "power of two numbers" will eliminate the bin splitting. In this example do the following:

40. Go to the System Window, Define System Time and modify the Freq. Res. (Hz) to be 500 Hz instead of 762.939453125 Hz.
41. Click the Update button, this will cause the sample rate to change from 25.0 e6 samples/sec to 16.384 e6 samples/sec. Click OK.
42. When the system is run and the plots are refreshed, you will get the spectrum in Figure 32.

In step 1 above, if the Freq. Res. (Hz) is set to 1000 Hz instead of 500 Hz, the sample rate will change to 32.768 e+6 samples/sec (still using 32768 samples). This produces the plot in Figure 33.

In any plot you can zoom in to see an area of interest in greater detail by using the mouse to left-click-and-drag a rectangular area and then release the mouse (Figure 34). You can undo the zoom by clicking on the Rescale button on the top toolbar, 3rd button from the left.

Also, in any plot, the mouse cursor can be used to display the frequency and amplitude of a particular sample. This x vs y display is at the top-right corner of the Analysis Window. For example, in Figure 31 where bin splitting is occurring, the mouse will read the following:

\[ x \text{ (Frequency)} = 1.06964… \text{e6 Hz} \quad y \text{ (Amplitude)} = 6.57137… \text{dBm} \]

In Figure 32, without bin splitting, the mouse reads:

\[ x \text{ (Frequency)} = 1.07000… \text{e6 Hz} \quad y \text{ (Amplitude)} = 9.99999… \text{dBm} \]

Now that the reader is acquainted with some of the fundamental capabilities of SystemView, he has at his command the power to express creativity and genuine innovation.
Figure 28.

Figure 30. Power spectrum using 128 samples, at 25.0 e6 samples/sec.
Figure 31. Power spectrum using 32768 samples, at 25.0 e6 samples/sec.

Figure 32. Power spectrum using 32768 samples, at 16.384 e6 samples/sec.

Figure 33. Power spectrum using 32768 samples, at 32.768 e6 samples/sec.
Figure 34. Power spectrum using 32768 samples, at 32.768 e6 samples/sec (zoomed).

Note: Back at the bottom of page 7, there is a description of overlaying plots using the Sink Calculator. Here is an alternate way of overlaying plots:

Make sure that you are in the Analysis Window with two or more open plot windows.

Leftmouse-click-and-hold somewhere in the gray border surrounding one of the plots. The arrow-cursor will be replaced by a hand-with-plot cursor. (It may take several attempts to locate a valid location in the gray area.)

Drag the hand-with-plot cursor on top of another plot, then release the mouse. The result will be a new window containing the two original plots.

The End

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