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Academic Guide to SBench 6 – Example 2

This example shows a simple way of creating a waveform using equations, making basic measurements on it and then applying waveform arithmetic. This example assumes that you have already installed the SBench 6 software. It would also be helpful to have reviewed the SBench 6 manual sections outlined in the “Using SBench 6 as a Learning Tool” note.

Using the Spectrum Control Center to Create a Demo Card

Open the Spectrum Control Center. The Spectrum Control center allows you to create a demo card based on any of Spectrums broad line of digitizer and arbitrary waveform generator products and see them operate, even without hardware. Once the control center is open, click on the ‘Add Democard’ button. Select and add an M4i.4451-x8 digitizer and an M4i.6631-x8 arbitrary waveform generator. As shown in Figure 1.

After adding the demo cards, click on the Quit bar.

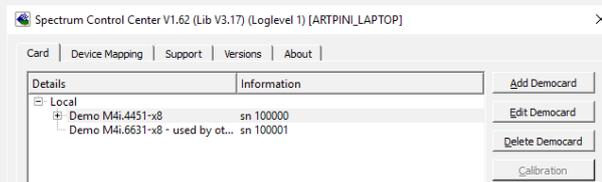


Figure 1: Add a software simulated demo card to the system using the control center

Starting SBench 6

Open SBench 6. The Welcome to SBench 6 screen, shown in Figure 2, shows the two demo cards that were loaded previously. Click on the M4i.6631-x8, this is a dual channel arbitrary function generator, a check mark should appear. Click on the Start SBench6 bar.

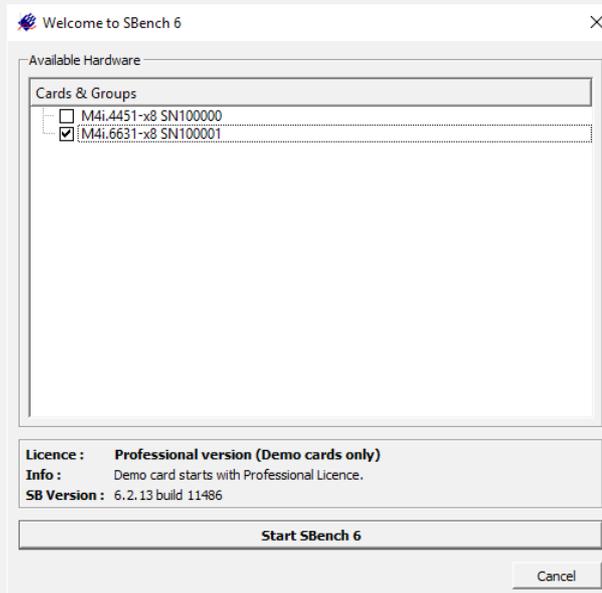


Figure 2: Card Selection in SBench 6

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SBench 6 will open as shown in Figure 3:

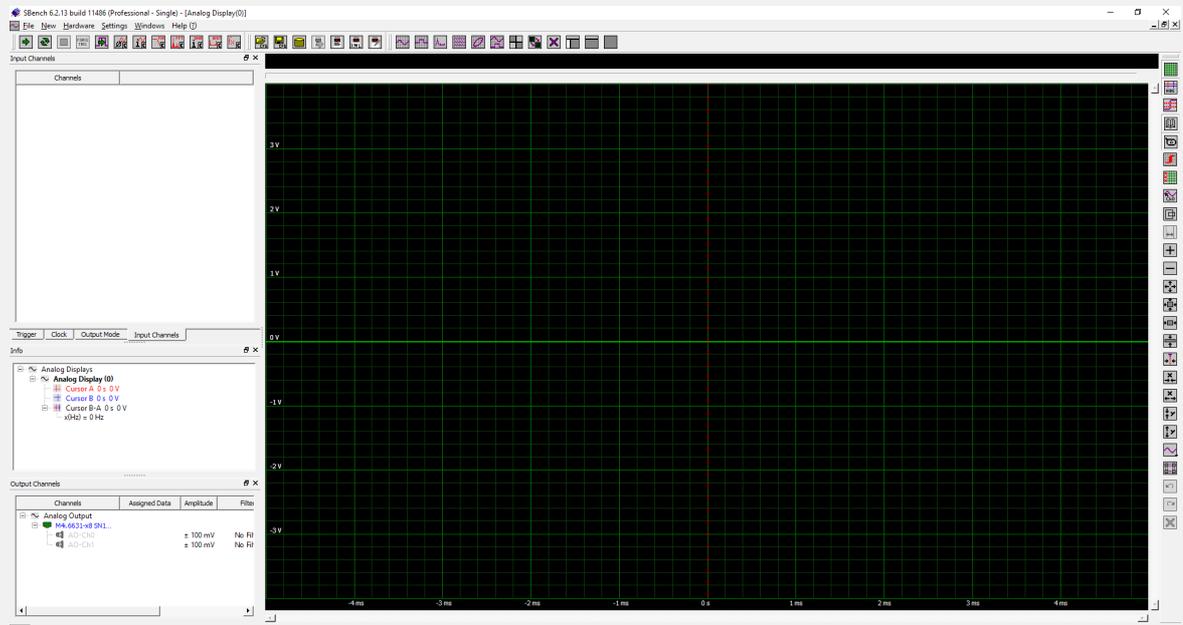


Figure 3: SBench 6 open screen

Creating a Waveform using equations with the Function Generator

Find the Function Generator icon on the Main Toolbar as shown in Figure 4. Click on the Function Generator icon, a pop up Function Generator window will appear.



Enter the equation into the Function box in the pop up:

$$\text{Sin}((x-8192)/100)/(x-8192)$$

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Note that the memory size (16 kS), amplitude range (1000mV) and sampling clock (1 MHz) can be set in this window. We are using the default settings. If you change them make sure that the settings are consistent with the equation that is entered.

After entering the equation click on the Start button, the waveform should appear in an analog display window and the Function waveform will be listed in the Input Channels tab in the Hardware and Channels pane on the top left. Right clicking on the waveform name produces a pop up with a range of operations that can be applied to the signal. We will return to this feature later.

This waveform will be the modulation signal for a double sideband suppressed carrier signal we will generate.

Click on the Function generator icon again. Enter the following equation:

$$\text{Sin}(2*\pi*x/100)$$

This will create a sinewave carrier waveform with a period of 100 sample clocks or 100µs (10 kHz frequency). This waveform will appear overlaid on the SINC function we created earlier as shown in Figure 5.

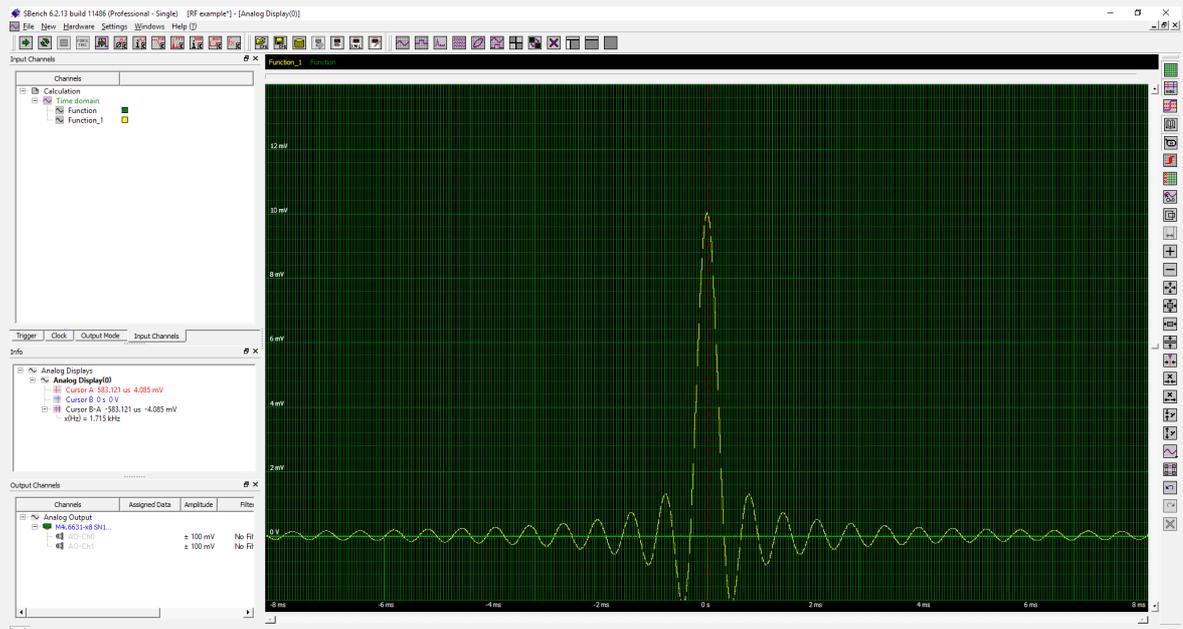


Figure 5: Two freshly generated waveforms overlaid in the display of SBench 6

Using Display Grids

Right click on the new waveform name in the Input Channels tab of the Hardware and Channel pane. Click on the selection “Remove from displays”, as shown in Figure 6. The carrier waveform will disappear from the analog display grid.

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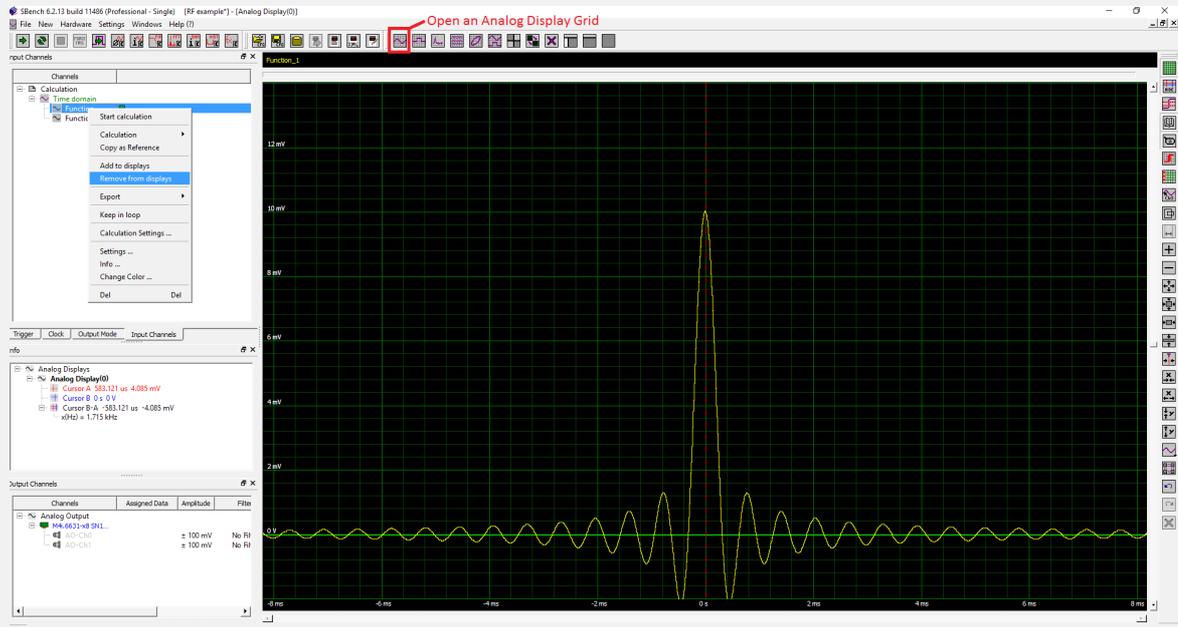


Figure 6: Remove waveform from display (left) and open a new analog display grid (top)

Right click on the same waveform a second time. Select “Settings”, a pop up will appear showing the waveform settings. This pop up allows you to customize the waveform by changing its name, color, and scaling. It also allows changing the units so if the signal were from a sensor you could rescale the data to read in vertical units appropriate for the measured quantity. Change the Name of the waveform to “Carrier”. Similarly, change the name of the first waveform to “Modulation”.

Note the highlighted icon on the Main Toolbar. This is the Analog Display icon, clicking on this icon will bring up another analog grid. Place your mouse cursor over the icon, a Tooltip will appear labelling the icon. Move the mouse cursor over the other icons and note their functions.

Click on the Analog Display icon another grid will appear over the existing one. Right click on the black bar under the Analog Display (1) title. Select “Add Channels”, on the resulting pop up select “Carrier”. The carrier waveform will fill the grid.

Move your mouse cursor over the main toolbar and find the Tile Displays icon. Click on that icon and the two analog displays will appear side by side. Investigate the other display controls in the main toolbar.

Using Signal Calculations to Create a Modulated Waveform

Right click on the Carrier waveform name in the Input Channels tab. Select Calculation, then Signal Calculations, and finally Analog Calculation. This sequence is shown in Figure 7 along with the resulting Calculation setup window.

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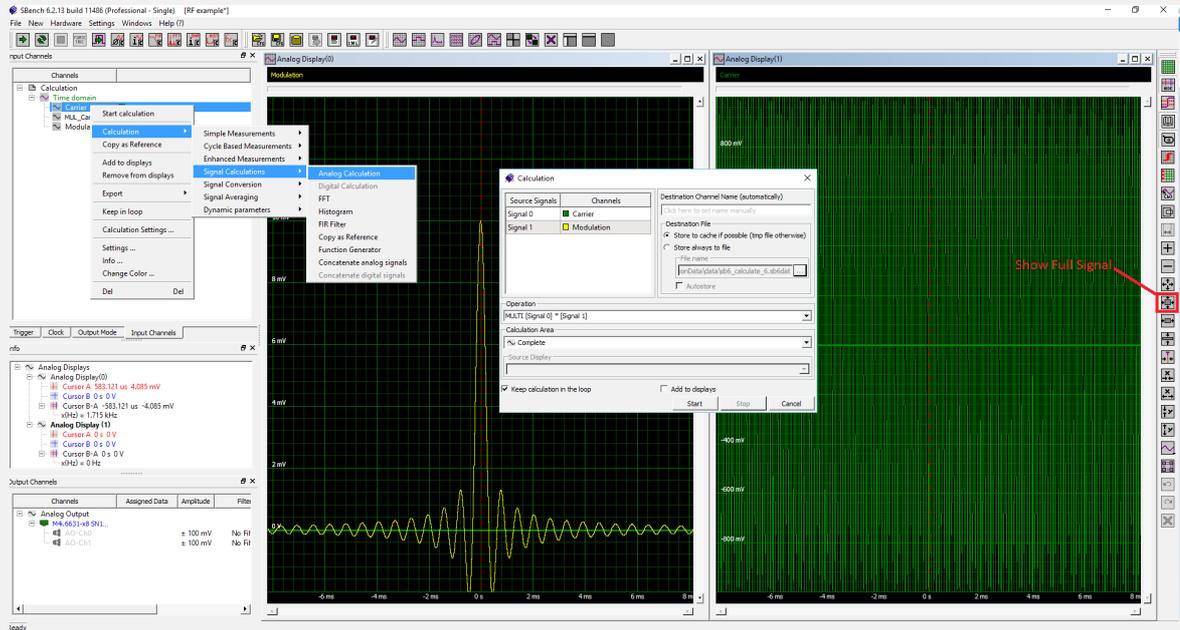


Figure 7: using an analog calculation to perform modulation on two generated waveforms

In the Calculation window set the operation to “Multi (Signal 0)* Signal (1)”. Double click on the Signal 1 box and select Modulation as the signal source. Uncheck the Add to Display box. Finally click on OK.

Create a new Analog Display grid and add the signal “Mul_Carrier_Modulation” to the new grid. You may have to click on the “Show Full Signal” icon located on the Display toolbar on the right side of the display as indicated in Figure 7. Click on the Tile Grids icon to arrange the grids.

Performing an FFT on the Modulated Carrier

Right click on the “Mul_Carrier_Modulation” signal name, select Calculation, Signal Calculation, and then FFT. When the FFT setting window appears click on OK, the FFT of the modulated carrier will be added to the displays. Use the Show Full Display tools to optimize the FFT display.

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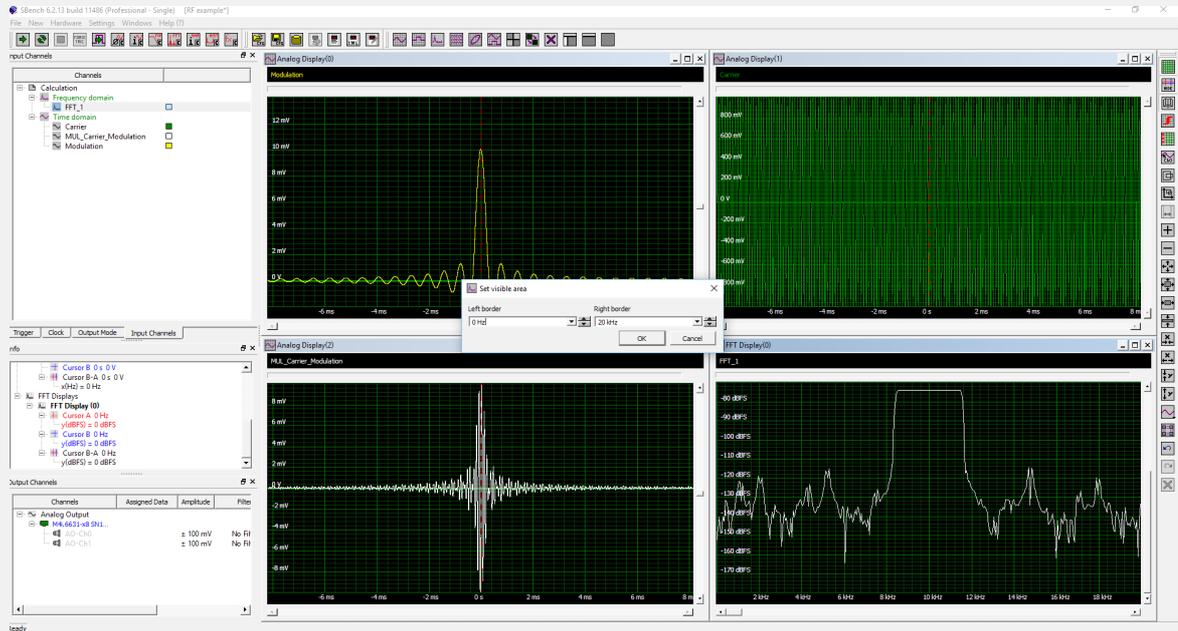


Figure 8: define the visible area of the FFT display

The FFT can be expanded horizontally by zooming but if we want to expand the lower frequency range it is easier to right click on the horizontal axis of the FFT display near the bottom border of the grid. A popup box will allow the left and right border limits to be changed as shown in Figure 8. Set the horizontal scale to show from 0 Hz to 20 kHz.

Measuring the Waveforms

The center frequency of the FFT is 10 kHz. This is related to the carrier frequency. Measure the carrier frequency by right clicking on the Carrier signal in the Input Channels tab, selecting sequentially: Calculation, Cycle Based Measurements, Frequency then click on OK in the Frequency setup pop up. The frequency readout will appear in the Info pane. Verify that the carrier frequency is 10 kHz.

The FFT spectrum of the modulated carrier has a rectangular shape that represents the upper and lower sidebands of the modulation about the carrier. The bandwidth of either of the sidebands is inversely proportional to the period of the SINC function. Use the cursors to measure the bandwidth of the Spectrum. Divide this number by two and then take its reciprocal. Then use cursors on the modulation signal to measure the period of the SINC function. Using zoom to expand the signals and its FFT makes placement of the cursors more accurate. This is illustrated in Figure 9:

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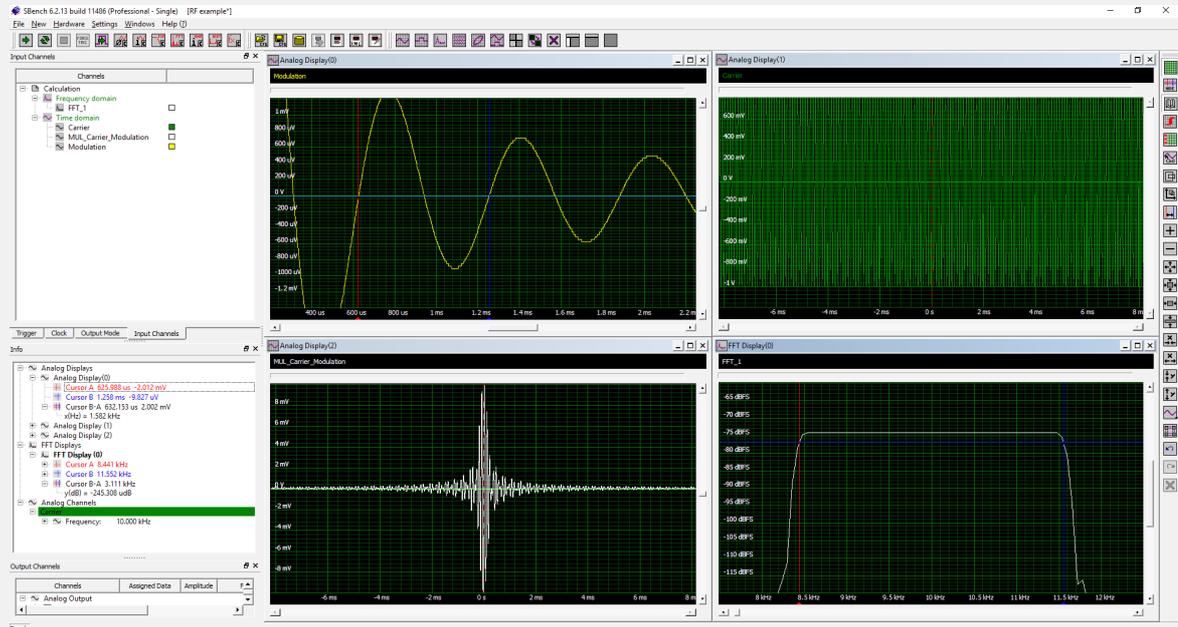


Figure 9: Performing measurements on the modulated signals FFT

The modulated carrier is a double sideband suppressed carrier (DSSC) signal. The bandwidth of both sidebands is 3.111 kHz. The bandwidth of a single sideband is half of that or 1.555 kHz. The measured period of the SINC function is 632 μ s which is a frequency of 1.58 kHz. The theoretical SINC period based on the equation is 628 μ s and its reciprocal is 1.591kHz. So the results are relatively good for manually placed cursor measurements.

Conclusion

We have created two waveforms using equations. Analog calculation was used to multiply these two waveforms to create a DSSC modulated waveform. Display tools were used to organize the waveform display. FFT analysis was applied to the modulated waveform and the signal bandwidth was measured. This was compared with the measured period of the SINC pulse and the carrier frequency all showing reasonable agreement with theoretical expectations. This is quite a bit of work but it was easy to investigate using SBench 6.