



## Echoview Tutorial: Introduction to the Formula Operator

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## Overview

This tutorial is optimized for Echoview 13 and provides an introduction to the formula operator, a virtual variable in Echoview.

This tutorial is not intended as a comprehensive user manual.

Further information on Echoview tools and topics can be found in the latest version of the Echoview help file. This can be viewed online and is installed with Echoview. Press F1 when using Echoview to open the help file and read context-sensitive information.

Throughout this tutorial further reading is referred to the Echoview help file or other Echoview training materials: <https://echoview.com/support/tutorials/>

## Prerequisites

This tutorial assumes you have Echoview installed, and the following skills and knowledge:

- Familiarity with the basic operation of Echoview. We strongly recommend that you complete the "Getting Started" tutorial before beginning this tutorial.
- Familiarity with a supported Microsoft Windows™ operating system. For more information refer to the Echoview Help file page: Computer requirements.
- A basic understanding of echosounding techniques and hydroacoustic surveying. For more information, see texts such as *Fisheries Acoustics* (Simmonds and MacLennan, 2008, Chapman and Hall, London).

## Echoview modules

This tutorial requires a license with the Essentials and Advanced Operators modules.

If you do not yet have access to Echoview licenses with these modules, please contact [info@echoview.com](mailto:info@echoview.com) to request an evaluation license.

## Contacting Echoview

For assistance with this tutorial please contact [support@echoview.com](mailto:support@echoview.com).

## Troubleshooting

The files for a tutorial are typically located in C:\Echoview Software\Tutorials\. The file path may be different if you chose to install the tutorials elsewhere on your system. If the files are not in this folder, use Windows Explorer to search for them. If they are not loaded on your machine, download and reinstall the tutorial from [www.echoview.com](http://www.echoview.com) or from the Echoview USB drive.

If you receive a message saying that the version of Echoview you are running cannot read the file you have opened, you may be running an old version of Echoview. You can download the latest version of Echoview from [www.echoview.com](http://www.echoview.com).

## Topic 1: Formula operator overview

Echoview provides more than 120 operators, referred to as virtual variables, which are designed for data manipulations, including data comparisons, noise removal, quality control, data classification, and more. Operators are created and managed in the Dataflow window in Echoview.

When you have an interesting data processing idea but there is no operator in Echoview to perform the required calculations, you may be able to use the Formula operator to implement your customized mathematical and logical expressions.

Echoview derives raw variables from echosounder and sonar data files. The data in these variables is displayed in echograms as a matrix of pings and samples.

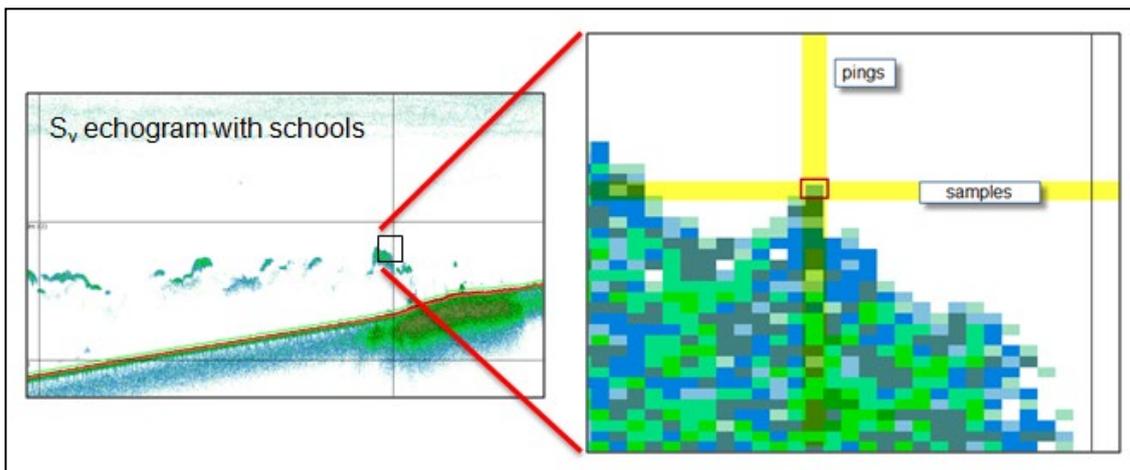


Figure 1. AutoOpen.EV - Sv echogram pings and samples.

The Formula operator can apply mathematical/logical functions to pings and samples from nominated input operands.

### Formula operator functions

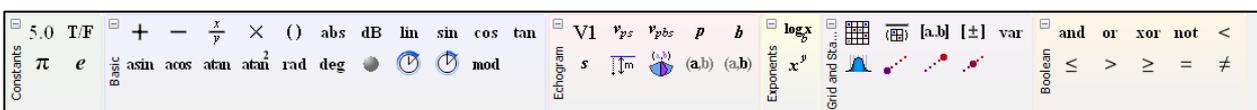


Figure 2. Available Formula operator elements in the Elements toolbar. New Echoview releases can introduce new elements.

Toolbar Symbol	Math Symbol	Name	Contains this many elements	Properties	Description
5.0	a number	Number	0	The value itself	Contains a single real number which is set as a property.
T/F	T/F	Boolean	1	boolean value	Specifies a boolean value of True or False.
$\pi$	$\pi$	Pi	0	The value itself	Contains a single real number for Pi.
$e$	$e$	e	0	The value itself	Contains a single real number for $e$ .

Figure 3. The Formula elements page in the Echoview help file. Each group of elements is described in detail.

## From processing intent to a Formula operator expression: a data processing idea

De Robertis, A., McKelvey, D. R., and Ressler, P. H. 2010. **Development and application of an empirical multifrequency method for backscatter classification.** Can. J. Fish. Aquat. Sci. 67:1459-1474.

**Abstract:** We evaluated the feasibility of identifying major acoustic scatters in North Pacific ecosystems based on empirical measurements of relative frequency response. Acoustic measurements in areas where trawl catches were dominated by single taxa indicated that it might be possible to discern among key groups of scatterers such as fish with gas-filled swimbladders, euphausiids, myctophids, and jellyfish. To establish if walleye pollock (*Theragra chalcogramma*), a key species in the ecosystem, can be separated reliably from other groups under prevailing conditions, we developed a method based on the normal deviate (or Z score) to identify backscatter consistent with the pollock relative frequency response. We evaluated the performance of the method by comparing it with the traditional method of species identification (i.e., directed trawl catches and subjective interpretation of echograms) during five large-scale acoustic surveys of the eastern Bering Sea. Pollock abundance estimates employing the multifrequency method were highly correlated with those using the traditional method, which indicates that the multifrequency method performs well in this situation. In this environment, multifrequency methods will allow more inferences to be drawn when direct sampling of organisms is limited and will also complement existing abundance surveys by improving species classification and providing information about key non-target species.

### How are Echoview's operators used?

This paper's Echoview dataflow uses the Formula operator at several points. The Formula operator is used in the Autopollock computations group and the Autokrill group, as shown in the dataflow screenshot in Figure 6.

The Formula operator is used to calculate a normal deviate analysis for three frequencies ( $n = 3$ ) where  $i$  is the frequency pair and  $j$  is the backscatter (species) class. Estimated values for  $\mu$  and  $\sigma$  are used.

The Formula operators implement these equations in relation to the Pollock and Krill frequency response.

$$Z_{i,j} = \frac{X_{i,j} - \mu_{i,j}}{\sigma_{i,j}}$$

$$Z_{avg,j} = \frac{\sum_{i=1}^n |Z_{i,j}|}{n}$$

Figure 4. Normal deviate equations

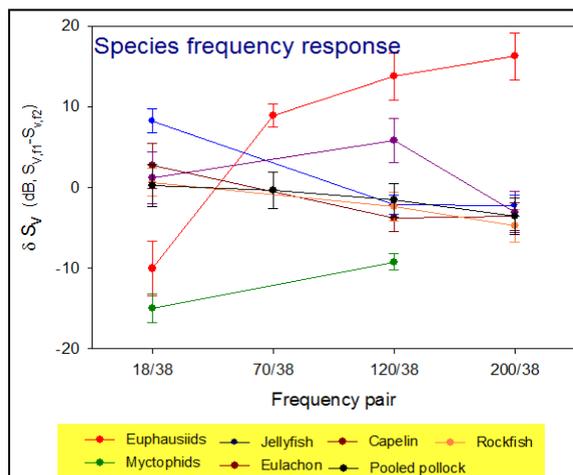


Figure 5. Species frequency-pair-response data.

### The Dataflow window

A Formula virtual variable is often part of a larger dataflow of virtual variables.

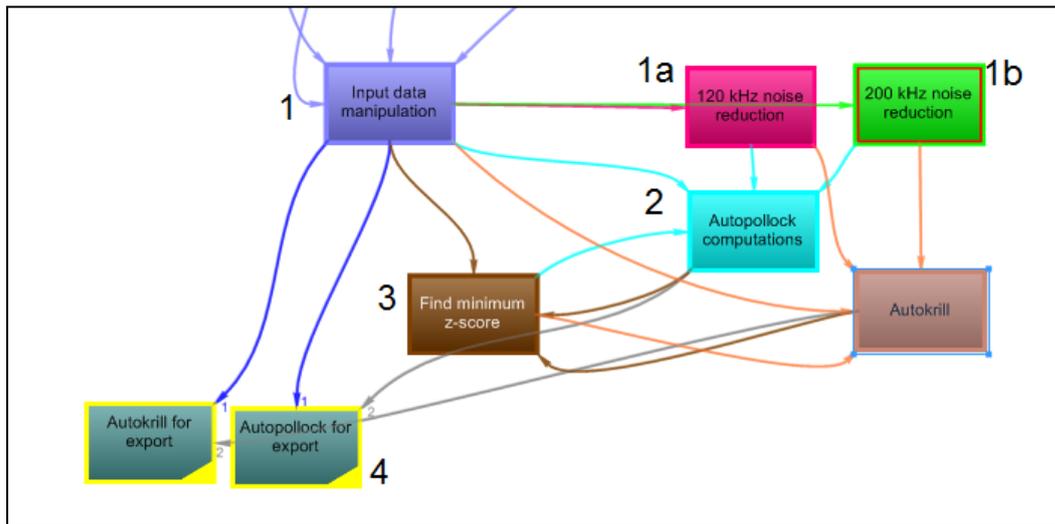


Figure 6. Dataflow showing the collapsed operator groups for the z-score related multifrequency analysis method in De Robertis et al (2010). The numbers indicate the analysis stages for the Autopollock calculations.

The (numbered) dataflow stages contain grouped operators. The following table provides more information about the stages related to Pollock analysis.

Stage	Aim	Echoview Operators
1	Prepare initial data.	Resample, Mask, Match ping times
1a, 1b	Frequency-related noise removal.	Resample, Minus, Match ping times, Plus, Linear minus, Type conversion, Mask
2	Pollock-related normal deviate analysis.	Formula, Select, Mask
3	Find minimum z-score.	Minimum, Match ping times, Resample.
4	Configure data for Pollock related analysis export	Mask

## Topic 2: Normal deviate Formula operator example

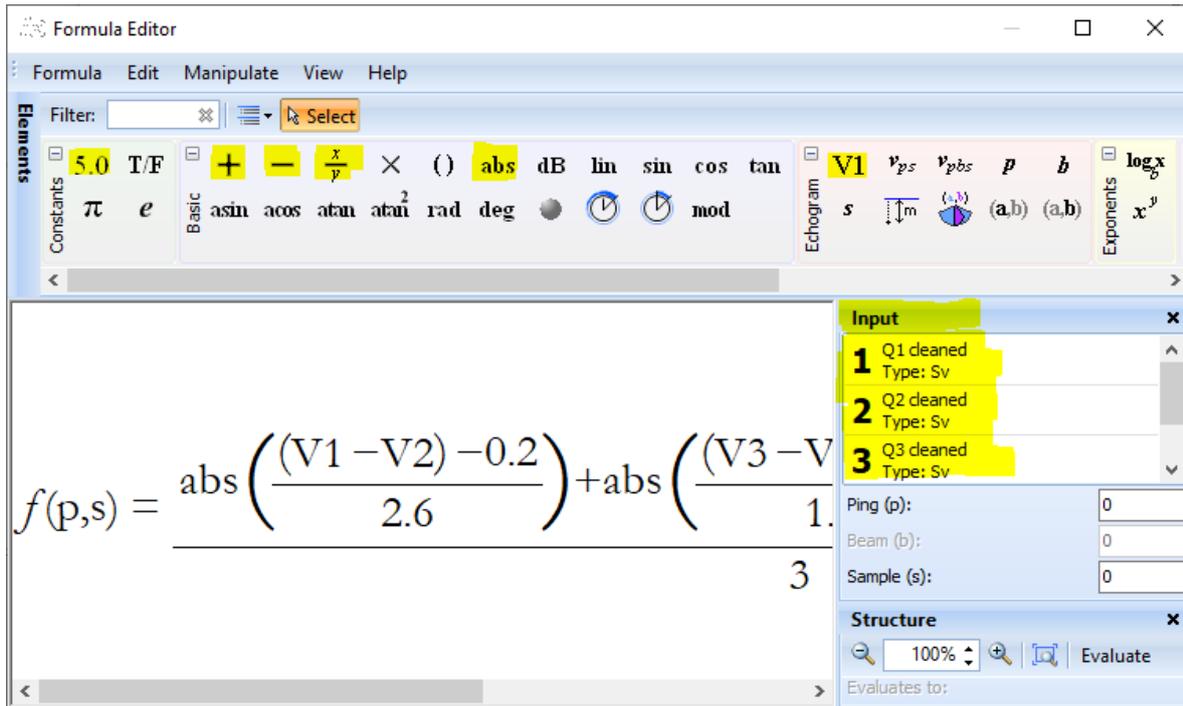


Figure 7. The Formula editor window shows part of a  $Z_{avg,j}$  expression using z-scores, as detailed in De Robertis et al. 2010. Formula elements that are used are highlighted on the Elements toolbar and are 5.0, +, -, x/y, abs and V1.

1. Start Echoview by selecting it from the **Start** menu or by double-clicking the Echoview shortcut on your desktop.
2. Open the file "C:\Echoview Software\Tutorials\IntroToTheFormulaOperator\Formula example.EV". You can view available Sv Q\* echograms for the three frequencies: 38, 120, 200 kHz.

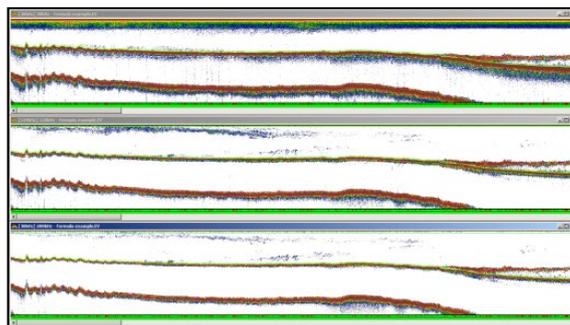


Figure 8. Sv echograms in the EV File "Formula example.EV".

3. Click Dataflow window and select the **Formula example** View tab.

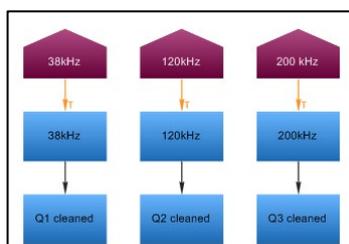


Figure 9. Formula example View of the Dataflow window.

4. On the **Formula example** View place the mouse pointer on the white background, right-click and on the Shortcut menu select **New, Variable**
5. On the New Variable dialog box under **New virtual variable, Name** type "Formula example", then select **Formula** from the list and click OK.
6. Click the Operands page. Use the **Add New Operand** button to add operands until you have three operands. Use the Operand list arrow to select the **Q1 cleaned**, **Q2 cleaned** and **Q3 cleaned** variables as Operand 1, 2 and 3 respectively.  
These input operands are the output of the Processed data operator. Exclusion lines and other analysis settings have been applied to "clean" the data.

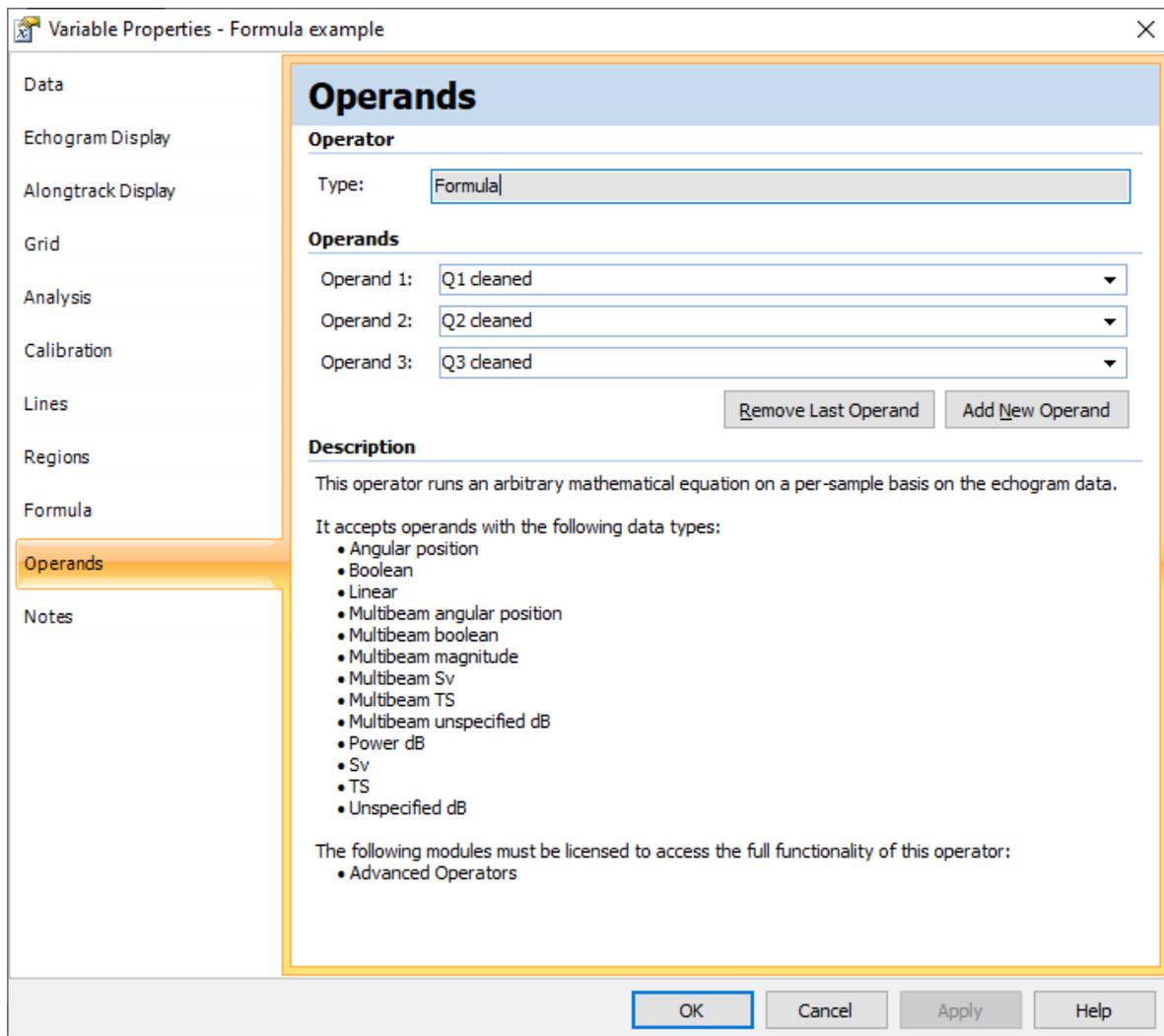


Figure 10. Variable Properties showing Operand tab and input operands.

7. Click the **Formula** page, then click the **Edit Formula** button.

The Formula expression space is the green box to the left of  $f(p, s) =$ . Available Formula elements are shown on the Elements toolbar. **Note:** The Input and Structure dialog box title bars can be dragged to other positions.

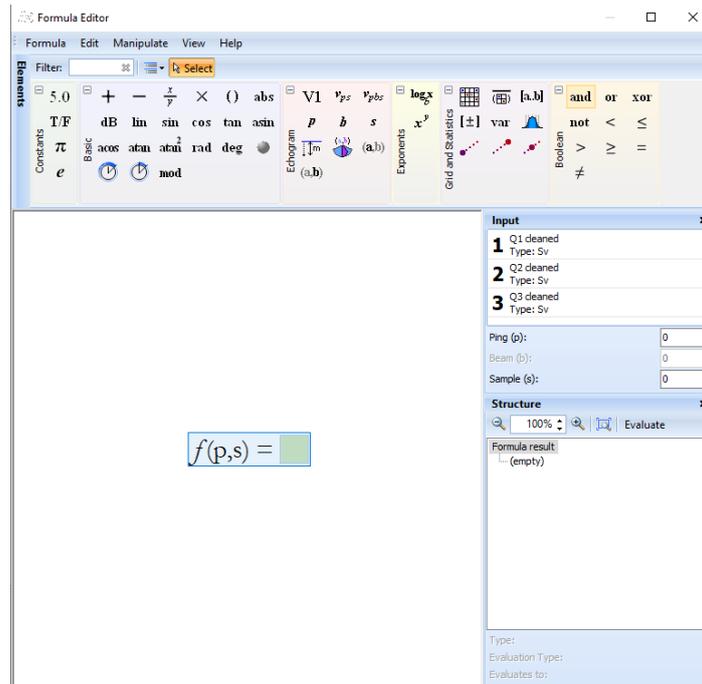


Figure 11. Formula Editor window with the default expression.

The Formula Elements on the toolbar are used to create an expression. Click an element and place it in the green expression space with a mouse click. The rest of the expression is created with similar actions. The expression space is sensitive to the mouse pointer. The expression space changes color and highlights boundaries to show where you may place the next Formula element.

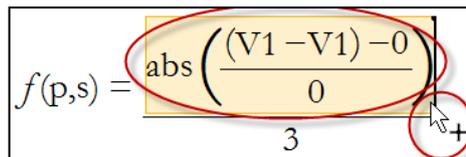


Figure 12. Creating the initial Formula expression. The (circled) Mouse tooltip shows that the Plus element is active, The colored expression space shows that you can put the Plus to the right of the numerator. You can also copy and paste the term within the larger red circle.

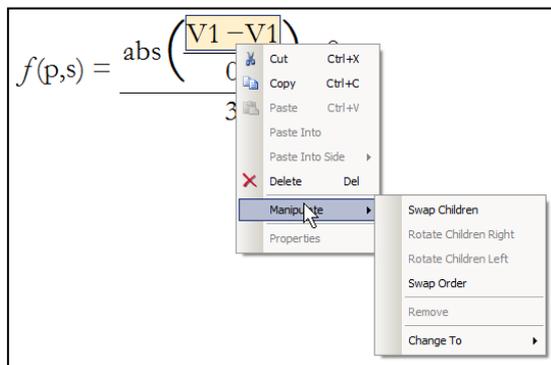


Figure 13. Context-sensitive Shortcut menu with useful actions for Formula elements.

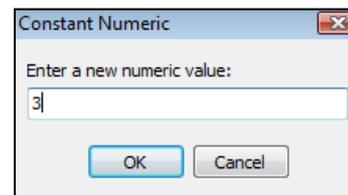


Figure 14. Shortcut menu, Properties dialog box of a numeric constant.

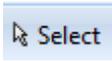
In the following steps you will learn how to create an expression for a normal deviate analysis for three frequencies and given values for  $\mu$  and  $\sigma$  for each frequency pair:

$$Z_{avg,j} = \frac{\sum_{i=1}^n |Z_{i,j}|}{n}$$

In the Formula editor this translates to:

$$Z_{avg,j} = \frac{\left| \frac{(V1-V2)-0.2}{2.6} \right| + \left| \frac{(V3-V2)-1.2}{1.8} \right| + \left| \frac{(V3-V1)-1.9}{2.5} \right|}{3}$$

The initial section of the expression is created using elements in the following order. **Red text** indicates the element that is selected (with a click) on the **Element** toolbar. If you make a mistake use **Edit** menu, **Undo** **Edit**.

**Tip:** To simplify the placement of new elements, click the  button after the placement of each Formula element.

8. Click  $\frac{x}{y}$  on the Element toolbar. Place to the right of  $f(p, s)$ .
9. Place **abs** at the x-position.  
Place **5.0** at the y-position.  
Use the **Properties** of the 5.0 element to set the value to 3. This is found in the Shortcut menu, as shown in Figure 14.

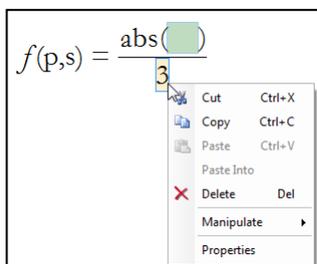
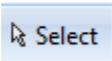


Figure 15. Progress after step 9.

10. Inside abs(), place  $\frac{x}{y}$   
At x-position of the abs term place ( )  
To the right of ( ) place -
11. In the right bracket of abs, place **5.0**  
In the left bracket of abs, place **V1**  
Next to V1 place -  
Next to V1 minus, place **V1**  
At the y-position of abs, place **5.0**

$$f(p,s) = \frac{\text{abs}\left(\frac{(V1 - V1) - 0}{0}\right)}{3}$$

Figure 16. Progress after step 11.

12. Click the Select button . Highlight the abs( ) part of the expression, right-click and select **Copy** as shown in Figure 18.
13. Place **+** to the right of the abs( ) term as shown in Figure 17.
14. On the empty ( ) to the right, right-click and select **Paste Into Side, Right side** as shown in Figure 19.  
Repeat steps 13, 14 once more, so that there are three abs( ) terms.

15. Use an Element's Properties to set each V1 element to the correct operand number and each Constant element to a numerical value as shown in Figure 20.

$$f(p,s) = \frac{\text{abs}((V1-V1)-0)}{3} +$$

Figure 17. Placement of plus sign in the numerator

$$f(p,s) = \frac{\text{abs}((V1-V1)-0)}{3} +$$

Figure 18. Shortcut menu, Copy for a repeated part of the expression

$$f(p,s) = \frac{\text{abs}((V1-V1)-0)}{3} +$$

Figure 19. Shortcut menu, Paste Into Side, Right Side.

$$f(p,s) = \frac{\text{abs}\left(\frac{(V1-V2)-0.2}{2.6}\right) + \text{abs}\left(\frac{(V3-V2)-1.2}{1.8}\right) + \text{abs}\left(\frac{(V3-V1)-1.9}{2.5}\right)}{3}$$

Figure 20. Final Formula expression.

16. When you have finished editing the Formula expression, close the Formula Editor window, and click **OK** on the Variable Properties dialog box.

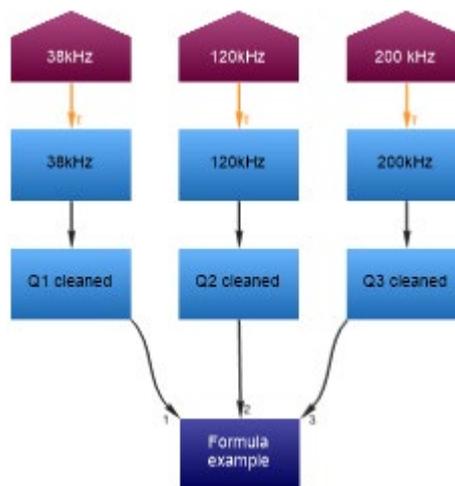
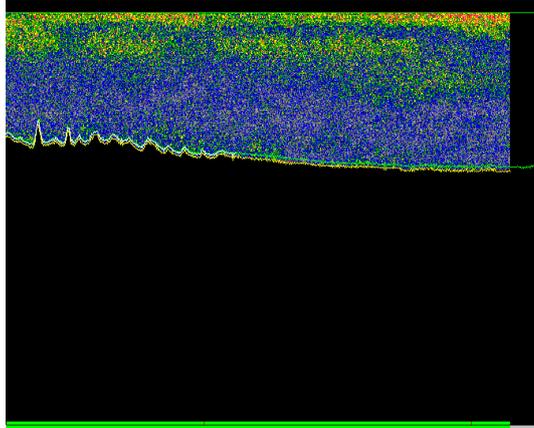


Figure 21. New virtual variable called Formula example in the Dataflow window.

17. Double click the **Formula example** virtual variable object to view the echogram.

18. On the echogram, use the Shortcut menu and select **Variable Properties**. On the **Echogram Display** page, set the following:  
Color display minimum = 0  
Color display range = 12  
Click **OK**.  
The echogram displays the result of the normal deviate expression created by the Formula operator.



*Figure 22. Echogram of the Formula example virtual variable*

19. When you have finished this tutorial, save your EV file and close Echoview.

## Further information

A Formula virtual variable is often part of a wider dataflow of virtual variables. The wide variety of Echoview operators facilitate the implementation of advanced processing methods and complex analyses.

Refer to the Echoview Help file for further useful information about virtual variables and operators.

- Formula operator Help file materials. At any time, you can press F1 in Echoview to launch the Echoview Help file.

Particular topics include: About the Formula operator, Creating a formula, About the Formula editor window, The formula elements, Example of a mathematical expression and Example of a multiple variable expression using logical operators.

- Parts of a formula expression that are copied can be pasted into the expression of other Formula variables.
- The multi-threaded Code operator, allows you to apply a Python® script from a Python file to specified operands. The supported Python NumPy and SciPy modules offer a wide range of open-source scientific computing and numerical integration capabilities. The Code operator is available under a licensed Advanced Operators module. For further information refer to About the Code operator and Using the Code operator pages in the Help file.