

# Correlation and Convolution Toolkit

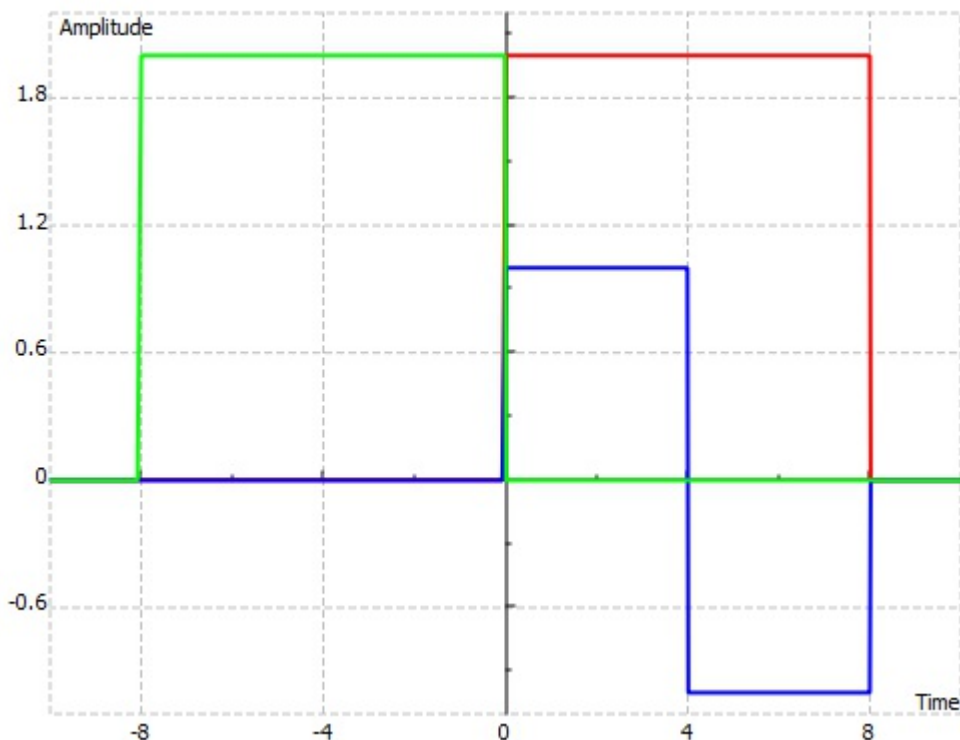
## Description

Convolution, correlation, and covariance are very common operations in DSP. Convolution is used to determine the output of linear time-invariant system defined by its impulse response. It can be also used to multiply polynomials given by vector of polynomial coefficients. Correlation is used to test measure of similarity between signals. In probability theory and statistics, covariance is a measure of the joint variability of two signals. In the following example we illustrate how to perform aforementioned operations on signals using MatDeck.

## Waveform generation

In order to demonstrate use of Correlation and Convolution Toolkit we define two test signals which give illustrative results. First of all, we generate independent variable  $t$ . The first signal denoted as  $x$  is a rectangle of length  $2T$ , and amplitude  $A$ . The second signal, denoted as  $y$ , is a signal composed of two rectangles of opposite sign. We plot both signals  $x$  and  $y$  in the same graph.

```
t:=ynodes(z , -10 , 10 , 1000)
T1:=4
A1:=2
x:=A1 · rectangle(t-T1 , T1)
y:=rectangle(t-2 , 2) - rectangle(t-6 , 2)
xg:=join mat cols(t , x)
yg:=join mat cols(t , y)
```

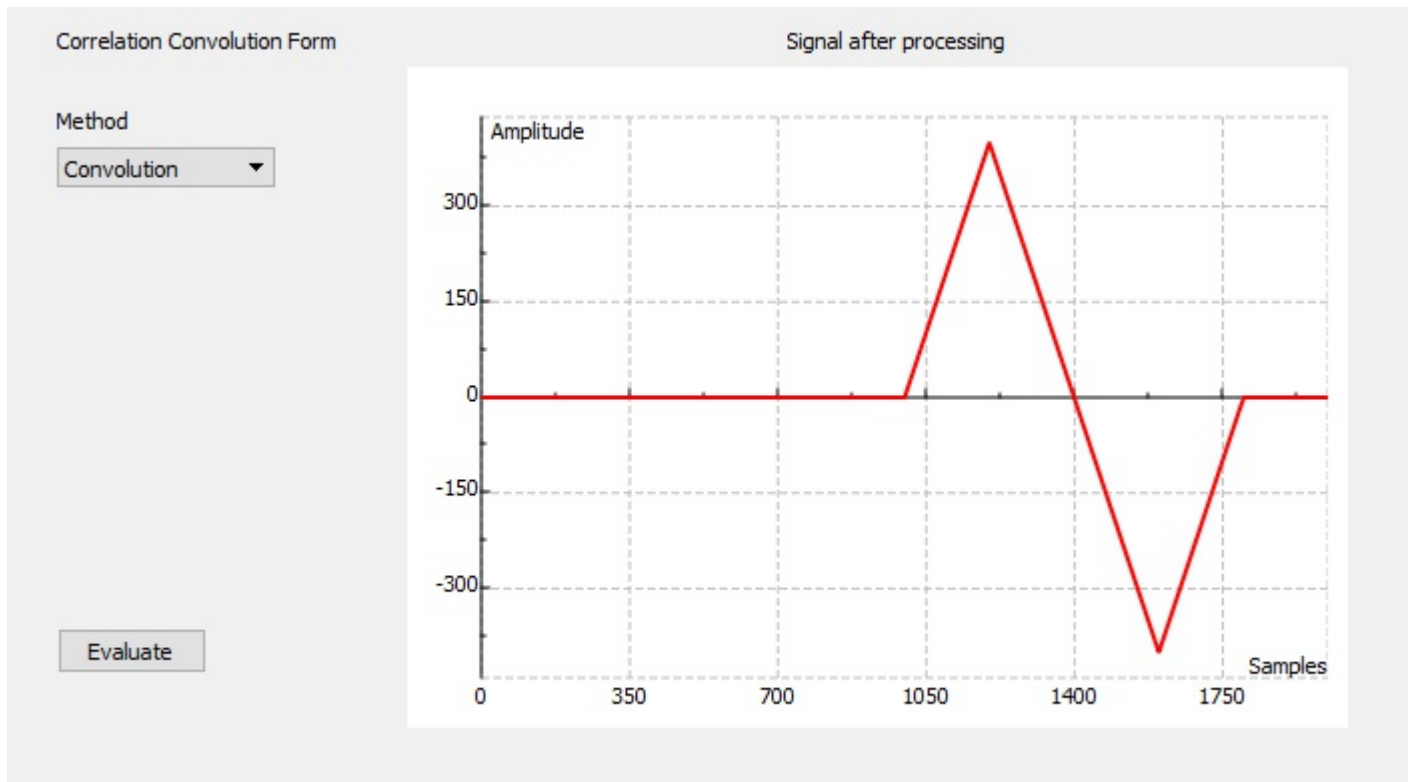


## Convolution

Here we determine the convolution of the two signals determined above. Convolution is denoted as  $h=x*y$ , and in MatDeck we can use the convenient toolkit form `corrconvform()`.

```
f1 := corrconvform(0 , "FormCCC1")
```

```
h1 := corrconvresult(f1 , x , y)
```



## Cross-Correlation

Next, we determine the cross-correlation of the two signals determined above. The cross-correlation is also determined by using the same form `corrconvform()`.

```
f2 := corrconvform(0 , "FormCCC2")
```

```
g1 := corrconvresult(f2 , x , y)
```

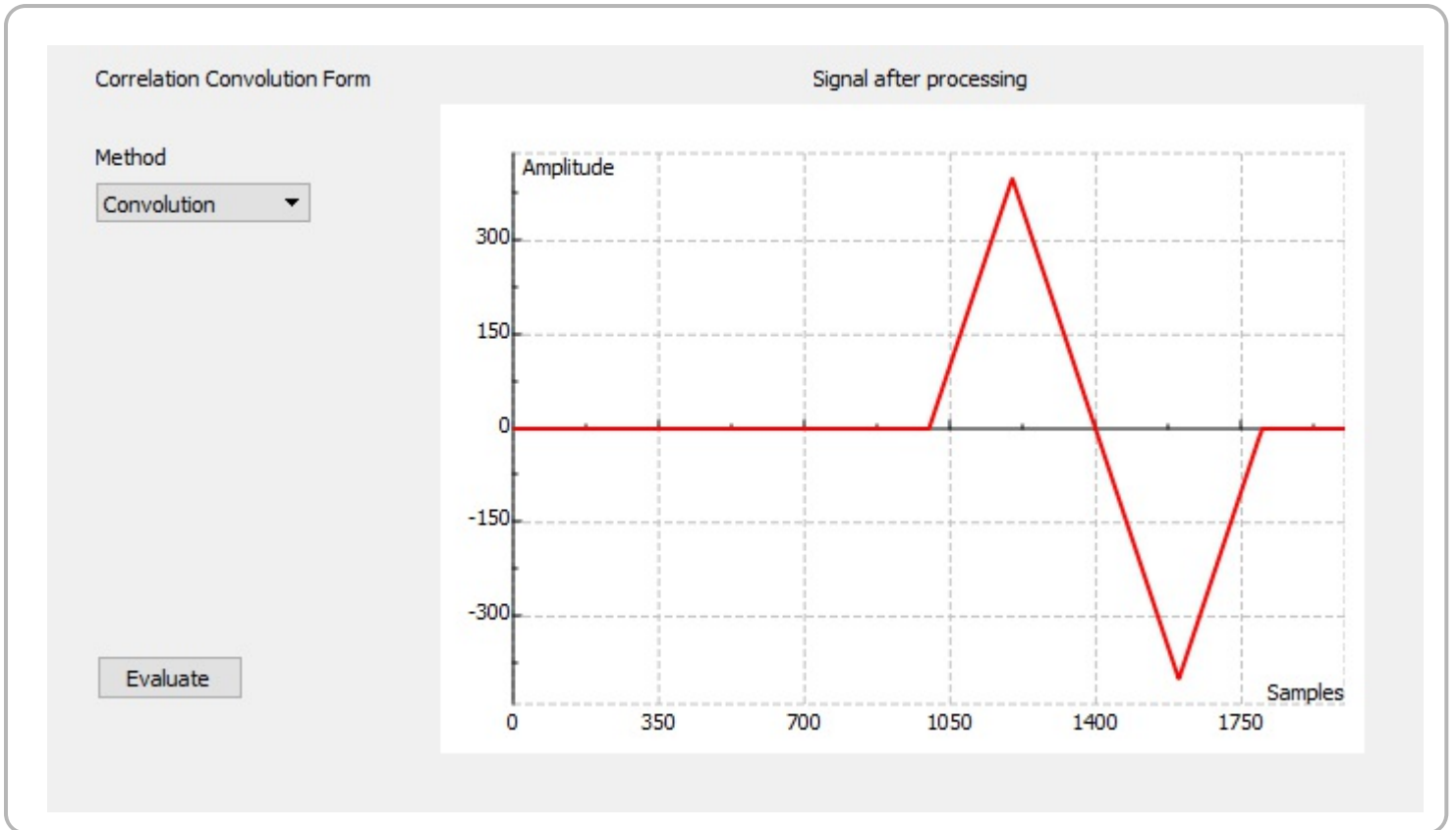
Cross-correlation can be calculated as convolution, where one signal is reflected in time, that is  $g=x(t)*y(-t)$ . For that reason we define the reflected version of  $y(t)$  denoted as  $yr(t)$ .

```
xr := A1 rectangle(-t - T1 , T1)
```

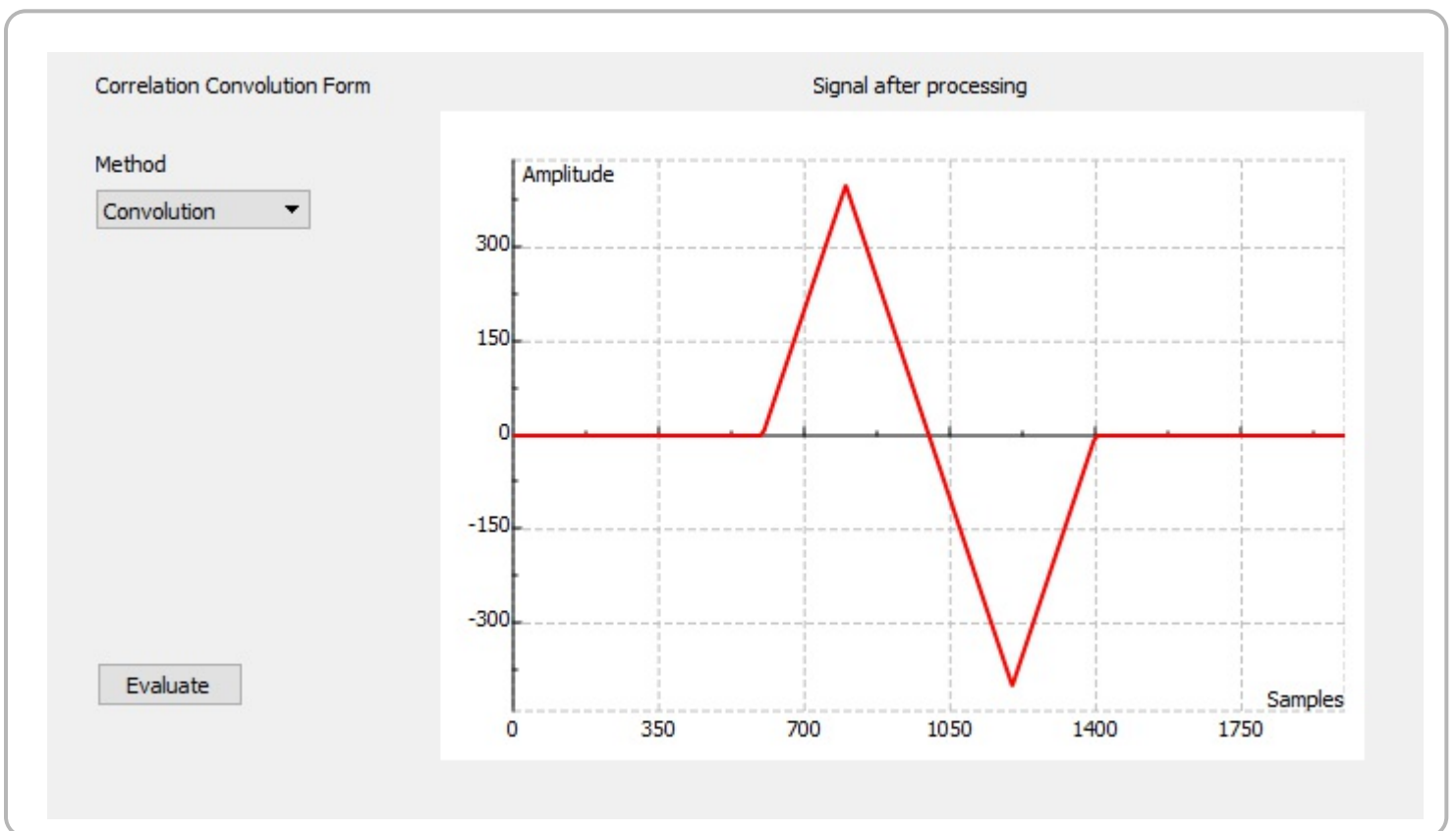
```
xrg := join mat cols(t , xr)
```

```
f3 := corrconvform(0 , "FormCCC3")
```

```
g2 := corrconvresult(f3 , xrg , y)
```



Next, we show the results of the correlation calculated as convolution as explained above.



## Cross-Covariance

The cross-covariance is also relevant in signal processing where the cross-covariance between two signals can be estimated by averaging the product of samples measured from one process and samples measured from the other (and as its time shifts). The cross-covariance of the two signals is

also calculated by using the same form.

```
f5 := corrconvform(0, "FormCCC4")
```

```
gc := corrconvresult(f5, x, y)
```

