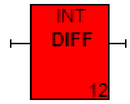
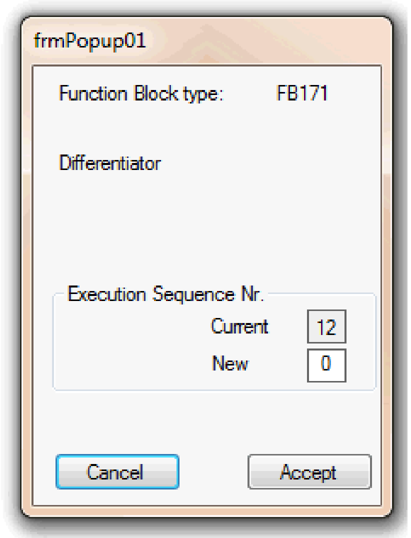
Function Block 171 DIFFERENTIATOR

Function Description

The output is the numerical differentiation of the input at the current input value. That is the rate of change per second, of the input value.





Popup Parameters

- Execution sequence number.

Input/Output and Parameters

Type	Description	Data Type	Range
Input	Input signal	INT	-32768….32767
Output	Output signal	INT	-32768….32767

Theory

The approach followed here is to calculate the average rate of change (i.e. the slope) using the current sample value Y_i, and that of two past values, Y_{i-1} and Y_{i-2}.

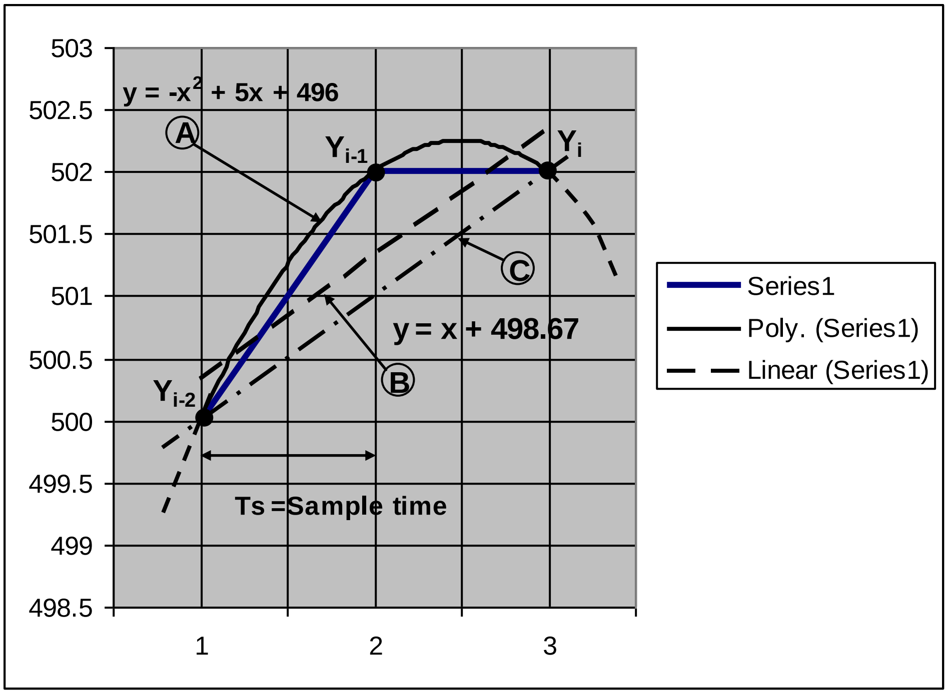
$$\frac{dY}{dt} = \frac{1}{2}\left(\frac{Y_i - Y_{i-1}}{Ts} + \frac{Y_{i-1} - Y_{i-2}}{Ts}\right)$$ where *Ts* is the sample interval time

$$\frac{dY}{dt} = \frac{1}{2T_S}(Y_i - Y_{i-2})$$ -------------------------------------(1)

The above algorithm in (1) was used instead of the popular method of numerical differencing referred to as the 3-point differencing method. With this latter method a 2nd degree polynomial approximation is used that passes through the last three sampled values. The difference at Y_i (current sample) is then obtained by differentiating the polynomial approximation function. The author's experience is that the averaging method of formula (1) above gives better results than the curve fitting method in the case of signals which are exposed to noise and quantitizing/conversion errors, and thus not a true (but on average good) representative of what is happening in the world on the outside of the PIC.

The following figure, generated with Microsoft's Excel, show 3 sample values Y_{i-2}, Y_{i-1}, and Y_i with values 500, 502, and 502 as obtained from the A-to-D converter. The value obtained from the A-to_D converter for Y_{i-1} was 502, while in fact the actual value at time i-1 was 501 (an error of 1 least significant bit). The figure shows 3 curves. Curve A ($y = -x^2 + 5x + 496$) is the 2nd degree polynomial approximation of which the slope (differential) is obviously negative at Y_i. Curve B ($y = x + 498.67$) is the linear least-squares regression line for the 3 sample values, giving a slope of 1.

Curve C is a line representing the slope, or differential as obtained by the formula in (1) above, also giving a slope value of 1.



Application
As it is required that Function Block 171 is executed every Ts seconds it can only be used in Time Tasks.

Use this function block to determine the current rate of change of a signal in units per second. Because the results of differencing is in most cases a 'roughing' process put the output signal from FB171 through a filter block (FB174) to obtain a much smoother signal.

Note
Although this function block contains no user settable parameters you must nevertheless open its popup and then click the Accept button. This is to update the function blocks parameter for the task scan time. If you neglect to do this the compiler will report and error nr. 131 for the function block.
