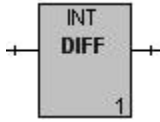


## Function Block 171 DIFFERENTIATOR

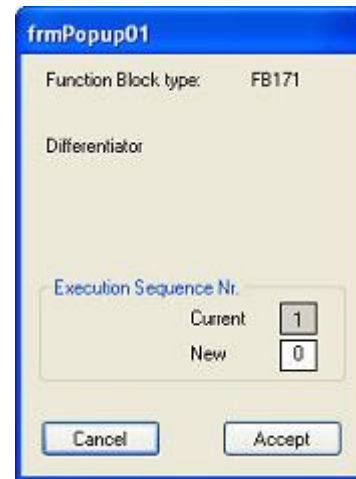


### Function Description

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

None



### 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  $Y_{i-2}$ .

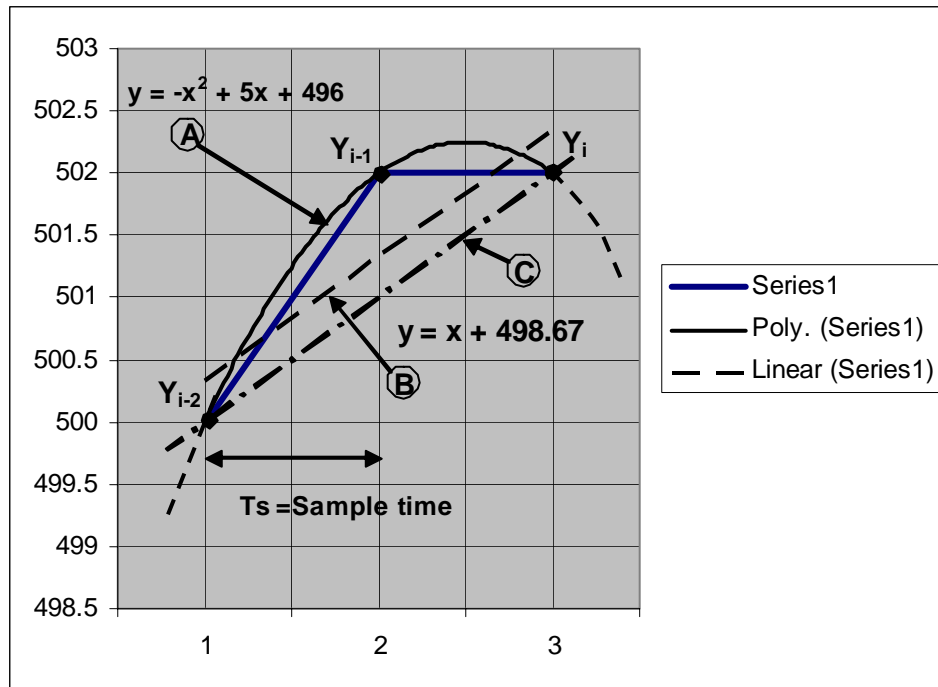
$$\frac{dY}{dt} = \frac{1}{2} \left( \frac{Y_i - Y_{i-1}}{T_s} + \frac{Y_{i-1} - Y_{i-2}}{T_s} \right)$$

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

The above algorithm was used instead of the popular method of numerical differencing called the 3-point differencing method. With this latter method a 2<sup>nd</sup> degree polynomial approximation is used that passes through the three sampled values. The difference at  $Y_i$  is then obtained by using 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 quantizing/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 for  $Y_{i-1}$  was 502, but the actual value applied 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 2<sup>nd</sup> 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  $T_s$  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 an error nr. 131 for the function block.

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