



# EuroProt

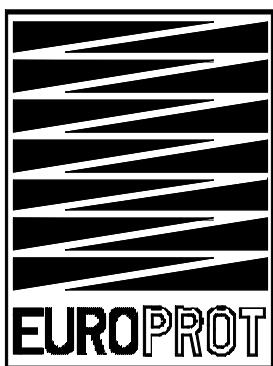
## complex protection

### function library

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## Version information

Version	Date	Modification	Compiled by
00	28.11.2005	First issue, based on the Software library and user's guide	Petri

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# Make\_Io

## ***Task of the function***

Task of the function is to convert the sampled three phase current values to the momentary values of the 3Io zero sequence current. The applied formula is:

$$3Io = Ia + Ib + Ic$$

## ***Inputs***

The inputs of the function are the three phase currents.

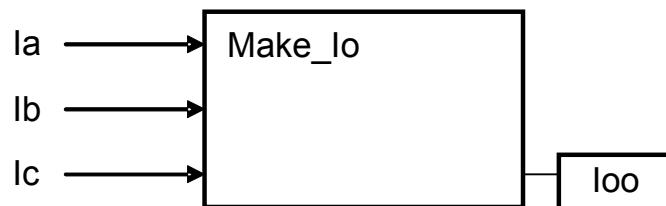
## ***Parameters***

This function does not need any parameters.

## ***Outputs***

The function does not provide any outputs, which could be useful for the configuring engineer. The calculated Io values are stored in the memory as calculated analogue channel values (3Ioo), and they can serve as input values e.g. for the Fourier analysis.

## **Make\_Io**



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# Make\_Uo

## ***Task of the function***

Task of the function is to convert the sampled three phase voltage values to the momentary values of the  $3U_o$  zero sequence voltage. The applied formula is:

$$3U_o = U_a + U_b + U_c$$

## ***Inputs***

The inputs of the function are the three phase currents.

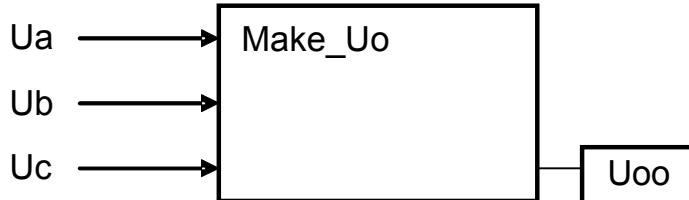
## ***Parameters***

This function does not need any parameters.

## ***Outputs***

The function does not provide any outputs, which could be useful for the configuring engineer. The calculated  $3U_o$  values are stored in the memory as calculated analogue channel values ( $3U_{oo}$ ), and they can serve as input values e.g. for the Fourier analysis.

### **Make\_Uo**



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# Make\_3Ph\_line\_I

## ***Task of the function***

Task of the function is to convert the sampled phase current values to current differences. The calculation is based on the following formulas:

$$I_{ab} = I_a - I_b$$

$$I_{bc} = I_b - I_c$$

$$I_{ca} = I_c - I_a$$

## ***Inputs***

The inputs of the function are the three phase currents.

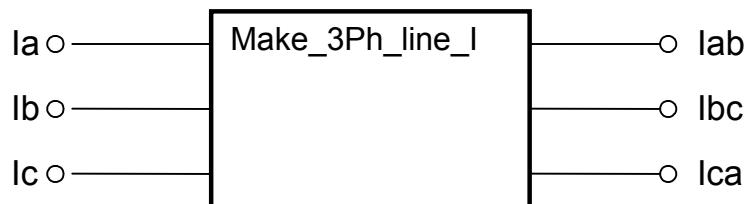
## ***Parameters***

The function does not need any parameter values.

## ***Outputs***

The function does not provide any outputs, which could be useful for the configuring engineer. The calculated  $I_{ab}$ ,  $I_{bc}$ ,  $I_{ca}$  values are stored in the memory as calculated analogue channel values, and they can serve as input values e.g. for the Fourier analysis. They are needed in distance protection calculations.

**Make\_3Ph\_line\_I**



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# **Make\_3Ph\_line\_U**

## ***Task of the function***

Task of the function is to convert the sampled phase voltage values to line voltages. The calculation is based on the following formulas:

$$U_{ab} = U_a - U_b$$

$$U_{bc} = U_b - U_c$$

$$U_{ca} = U_c - U_a$$

## ***Inputs***

The inputs of the function are the three phase voltages.

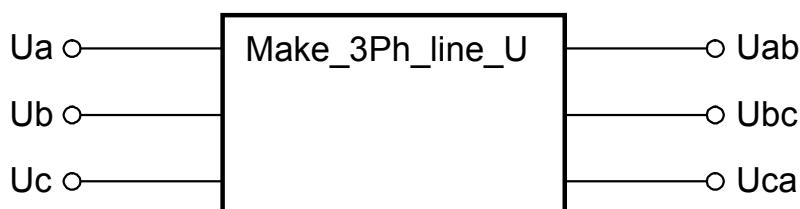
## ***Parameters***

The function does not need any parameter values.

## ***Outputs***

The function does not provide any outputs, which could be useful for the configuring engineer. The calculated  $U_{ab}$ ,  $U_{bc}$ ,  $U_{ca}$  values are stored in the memory as calculated analogue channel values, and they can serve as input values e.g. for the Fourier analysis. They are needed in distance protection calculations.

## **Make\_3Ph\_line\_U**



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# FFT\_CT\_1Ph

## ***Task of the function***

Task of the function is to calculate the basic Fourier harmonic component (RMS value and vector co-ordinates) of a single phase sampled analogue current input signal or that of a calculated analogue input (e.g. 3Io) processed by **Make\_Io** function.

The method of the calculation is the numerical realisation of the Fourier analysis.

## ***Inputs***

The input of the function can be an analogue input current channel or a calculated analogue current channel.

## ***Parameters***

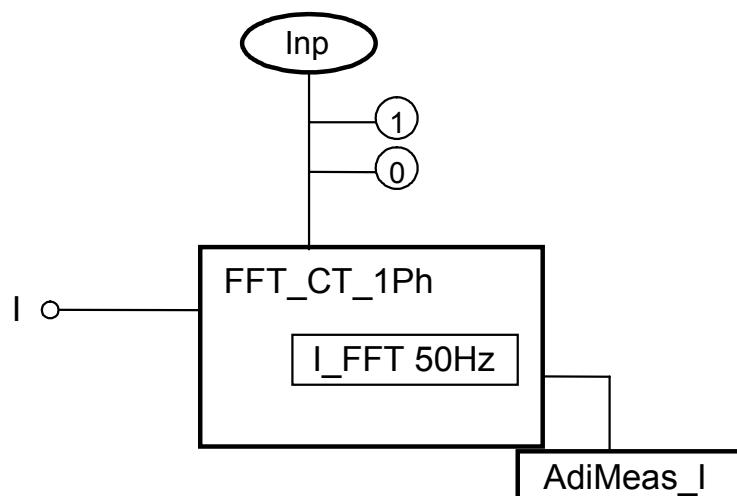
This function does not need any parameters.

The function applies the Inp pre-defined constant value, which is the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer.

## ***Outputs***

The output of the function is the AdiMeas\_I measured value, which is the RMS value of the basic Fourier component, defined in pro-mill of the rated input of the current transformer.

The function stores the calculated vector components of the basic harmonic value and the calculated RMS value in the memory, which can be the basis of the decision by an other protection function, or the values can be processed for example for phase angle calculation.



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# FFT\_VT\_1Ph

## ***Task of the function***

Task of the function is to calculate the basic Fourier harmonic component (RMS value and vector co-ordinates) of a single phase sampled analogue input voltage signal or that of a calculated analogue input (e.g.  $3U_o$ ) processed by **Make\_Uo** function.

The method of the calculation is the numerical realisation of the Fourier analysis.

## ***Inputs***

The input of the function can be an analogue input voltage channel or a calculated analogue voltage channel.

## ***Parameters***

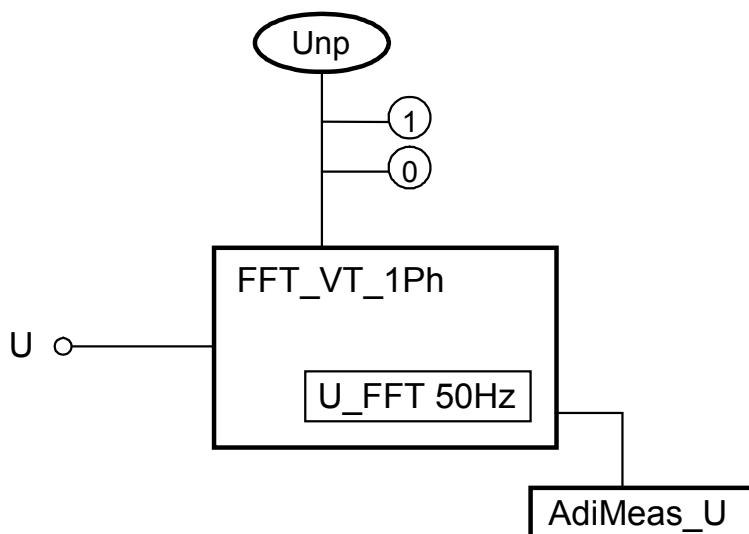
This function does not need any parameters.

The function applies the **Unp** pre-defined constant value, which is the A/D sampled numerical value in case of the rated voltage peak sample. This value depends on the hardware; it is defined by the producer.

## ***Outputs***

The output of the function is the **AdiMeas\_U** measured value, which is the RMS value of the basic Fourier component, defined in pro-mill of the rated input of the voltage transformer.

The function stores the calculated vector components of the basic harmonic value and the calculated RMS value in the memory, which can be the basis of the decision by an other protection function, or the values can be processed for example for phase angle calculation.



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# FFT\_CT\_3PH

## ***Task of the function***

Task of the function is to calculate the basic Fourier harmonic component (RMS value and vector co-ordinates) of three-phase sampled analogue current input signals or those of calculated analogue channels (e.g. I<sub>ab</sub>, I<sub>bc</sub>, I<sub>ca</sub>) processed by **Make\_3Ph\_line\_I** function. (The function involves three single-phase software modules. The aim is to simplify the work of the configuring engineer.

The method of the calculation is the numerical realisation of the Fourier analysis.

## ***Inputs***

The input of the function can be three analogue input current channels or three calculated analogue current channels.

## ***Parameters***

This function does not need any parameters.

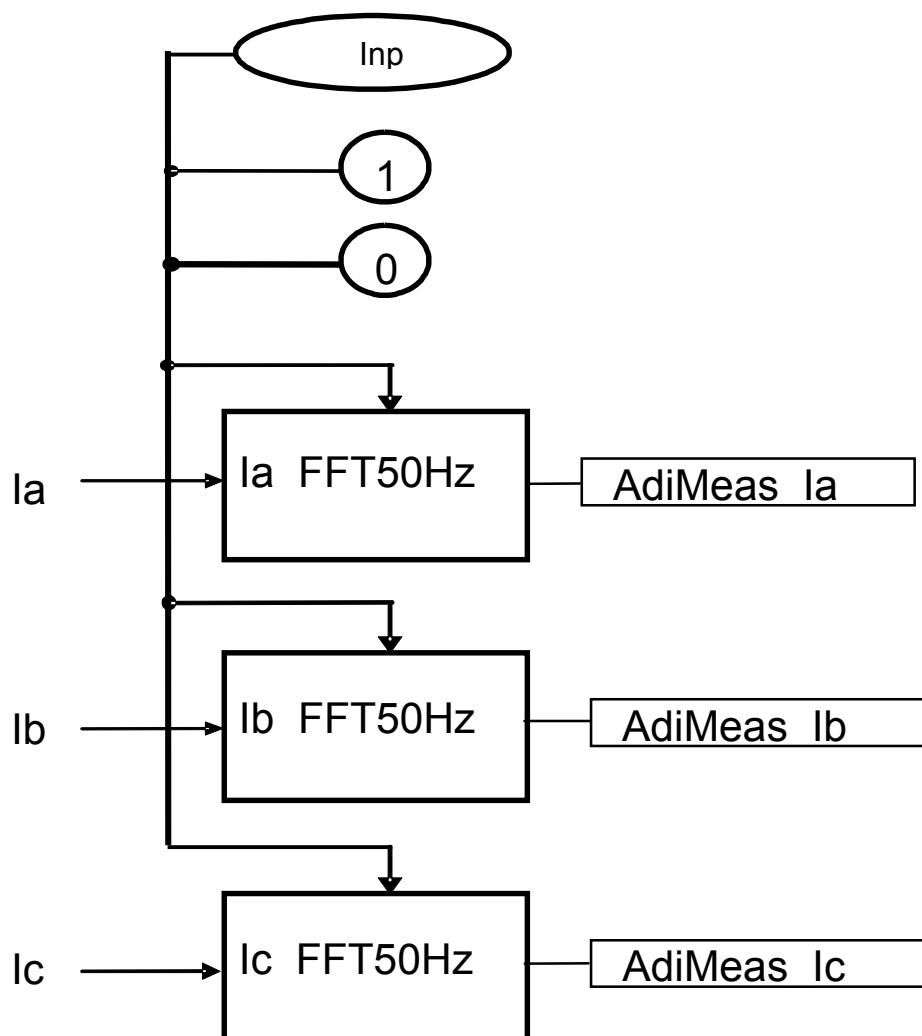
The function applies the Inp pre-defined constant value, which is the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware, it is defined by the producer.

## ***Outputs***

The outputs of the function are AdiMeas\_I<sub>a</sub>, AdiMeas\_I<sub>b</sub>, AdiMeas\_I<sub>c</sub> measured values, which are the RMS value of the basic Fourier components, defined in pro-mill of the rated input of the current transformer.

The function stores the calculated vector components of the basic harmonic value and the calculated RMS value in the memory, which can be the basis of the decision by an other protection function, or the values can be processed for example for phase angle calculation.

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**FFT\_CT\_3Ph**

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# FFT\_VT\_3PH

## ***Task of the function***

Task of the function is to calculate the basic Fourier harmonic component (RMS value and vector co-ordinates) of three-phase sampled analogue voltage input signals or those of calculated analogue input (e.g. Iab, Ibc, Ica) processed by `Make_3Ph_line_I` function. (The function involves three single-phase software modules. The aim is to simplify the work of the configuring engineer.

The method of the calculation is the numerical realisation of the Fourier analysis.

## ***Inputs***

The input of the function can be three analogue input voltage channels or three calculated analogue voltage channels.

## ***Parameters***

This function does not need any parameters.

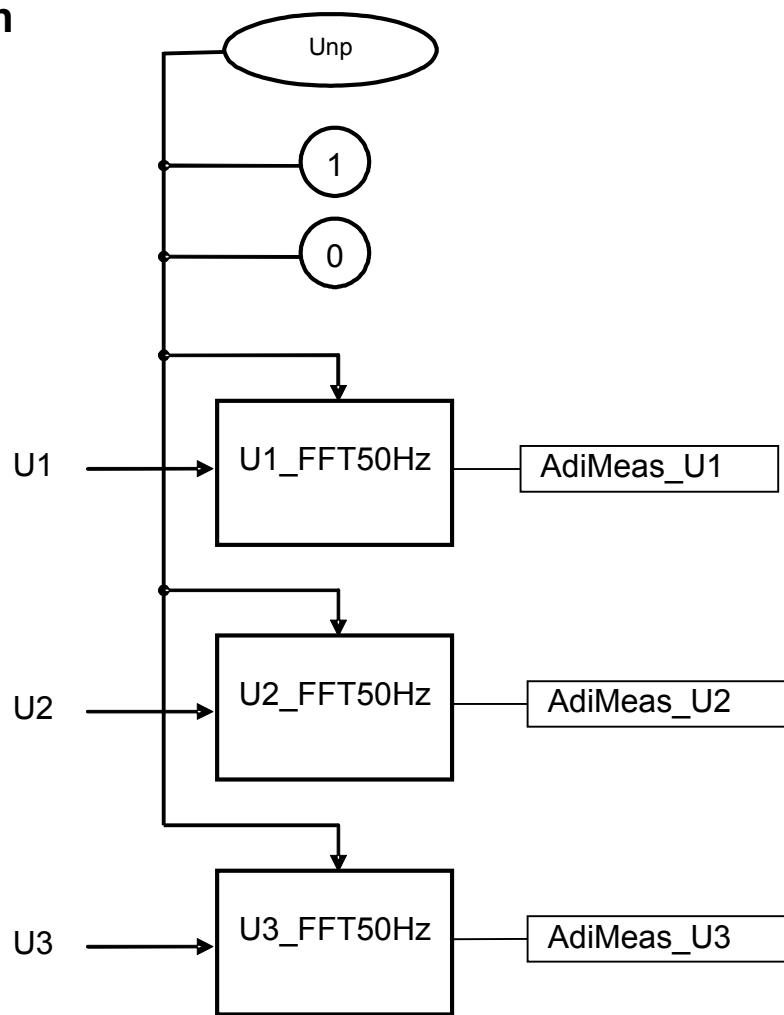
The function applies the Unp pre-defined constant value, which is the A/D sampled numerical value in case of the rated voltage peak sample. This value depends on the hardware; it is defined by the producer.

## ***Outputs***

The outputs of the function are `AdiMeas_U1`, `AdiMeas_U2`, `AdiMeas_U3` measured values, which are the RMS value of the basic Fourier components, defined in pro-cent of the rated input of the voltage transformer.

The function stores the calculated vector components of the basic harmonic value and the calculated RMS value in the memory, which can be the basis of the decision by an other protection function, or the values can be processed for example for phase angle calculation.

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**FFT\_VT\_3Ph**

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# INegSeqFilter3Ph

## **Task of the function**

Task of the function is to calculate the 3I2 negative sequence current component of the three phase currents. The calculation is based on the following formula:

$$3I2 = Ia + a^* Ib + a^{2*} Ic$$

## **Inputs**

The inputs of the function are the Fourier basic harmonic components, calculated based on the three phase currents.

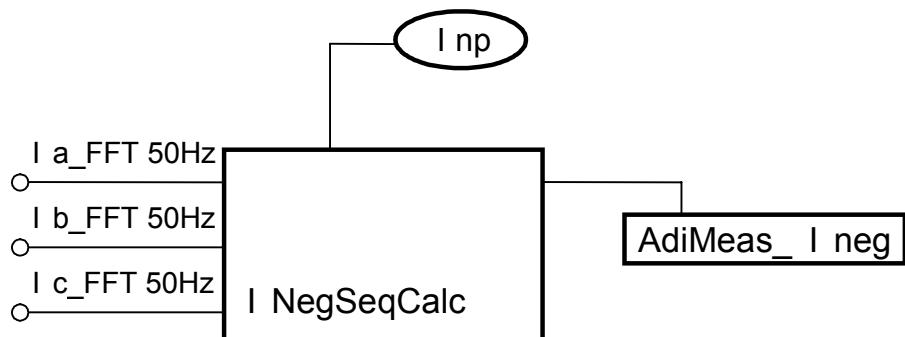
## **Parameters**

There is only one constant, needed to calculate negative sequence component: the Inp pre-defined constant, which is the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer. The same constant is used e.g. by the FFT\_CT\_3PH software function as well.

## **Outputs**

The output of the function is AdiMeas\_Ineg measured value, which is the RMS value of the negative sequent current component, related to the rated current of the current transformer of the device, expressed in pro-mill.

The function stores the calculated vector components and the RMS value in the internal data structure. These values can be applied e.g. by a function prepared for decision, or they can serve as inputs for further data processing to calculate angle values.



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# UNegSeqFilter3Ph

## **Task of the function**

Task of the function is to calculate the 3U2 negative sequence voltage component of the three phase voltages. The calculation is based on the following formula:

$$3UI2 = Ua + a^*Ub + a^{2*} Uc$$

## **Inputs**

The inputs of the function are the Fourier basic harmonic components, calculated based on the three phase voltages.

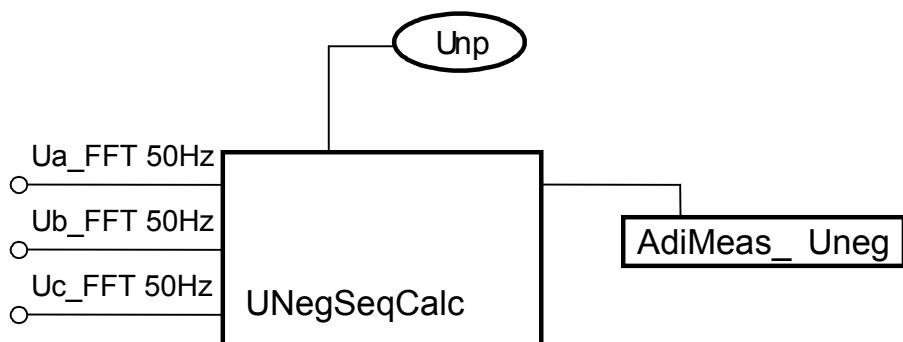
## **Parameters**

There is only one constant, needed to calculate negative sequence component: the Unp pre-defined constant, which is the A/D sampled numerical value in case of the rated voltage peak sample. This value depends on the hardware; it is defined by the producer. The same constant is used e.g. by the FFT\_VT\_3PH software function as well.

## **Outputs**

The output of the function is AdiMeas\_Uneg measured value, which is the RMS value of the negative sequent voltage component, related to the rated voltage of the voltage transformer of the device, expressed in pro-cent.

The function stores the calculated vector components and the RMS value in the internal data structure. These values can be applied e.g. by a function prepared for decision, or they can serve as inputs for further data processing to calculate angle values.



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# ANSI 50\_50N

## ***Task of the function***

This function is the realisation of a definite time overcurrent function with a single current, which can be a phase current, but the usual application is the zero sequence overcurrent protection. The threshold value is a parameter. The function generates a start signal without time delay, this signal can not be delayed. The trip time delay is defined by a parameter as well. (This function differs from the ANSI50N\_Sens sensitive earth-fault protection function by the threshold setting limit values and the steps).

This function performs the decisions and the measurement of the time delay only, for the operation it needs for example a Fourier algorithm too. It processes the values stored in the data structure of the Fourier routine.

## ***Inputs***

This function processes the calculated results of a Fourier routine, performs comparision and decision. (See e.g. FFT\_CT\_1PH.)

## ***Parameters***

The function needs two parameter values:

- POC\_1Ph: the threshold value of the overcurrent function (30...2500, step 5) % related to the rated current of the input current transformer,
- P\_TOC\_1Ph: time delay of the overcurrent function (0...60000,10) ms.

LCD text	Min	Max	Step	Remark
I>/In [CT] %	30	2500	5	Current setting value, related to the rated current of the CT input, expressed in %
t [I>] = ms	0	60000	10	Time delay in ms

For the operation two constants are needed as well:

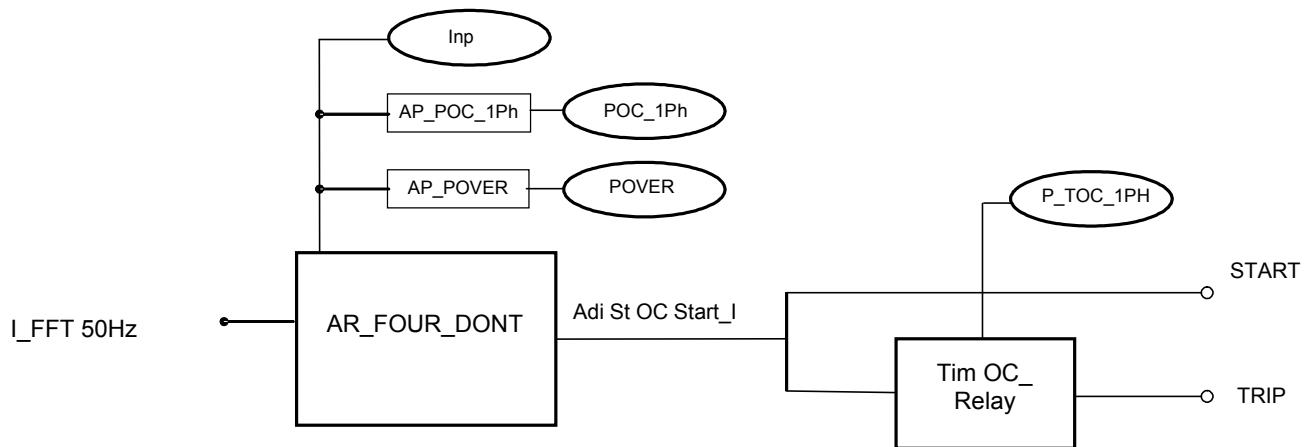
- Inp is the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer. The same constant is applied e.g. by FFT\_CT\_1PH.
- POVER defined constant parameter, which selects „over-„, function.

## ***Outputs***

The function generates two status signals:

- The start status signal,
- The timeout state of the assigned timer.

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**ANSI 50\_N**

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# **ANSI50N\_Sens**

## ***Task of the function***

This function is the realisation of a sensitive definite time overcurrent function with a single current, which can be a phase current, but the usual application is the zero sequence overcurrent protection. The threshold value is a parameter. The function generates a start signal without time delay, this signal can not be delayed. The trip time delay is defined by a parameter as well. (This function differs from the ANSI50\_N earth-fault protection function by the threshold setting limit values and the steps).

This function performs the decisions and the measurement of the time delay only, for the operation it needs for example a Fourier algorithm too. It processes the values stored in the data structure of the Fourier routine.

## ***Inputs***

This function processes the calculated results of a Fourier routine, performs comparison and decision. (See e.g. FFT\_CT\_1PH.)

## ***Parameters***

The function needs two parameter values:

- POC\_1Ph: the threshold value of the overcurrent function (10...140, step 1) % related to the rated current of the input current transformer,
- P\_TOC\_1Ph: time delay of the overcurrent function (0...60000, step 10) ms.

LCD text	Min	Max	Step	Remark
I <sub>o&gt;/I<sub>on [CToProt]</sub></sub> %	10	140	1	Current setting value, related to the rated current of the CT input, expressed in %
t [I>] = ms	0	60000	10	Time delay in ms

For the operation two constants are needed as well:

- Inp is the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer. The same constant is applied e.g. by FFT\_CT\_1PH.
- POVER defined constant parameter, which selects „over-“ function.

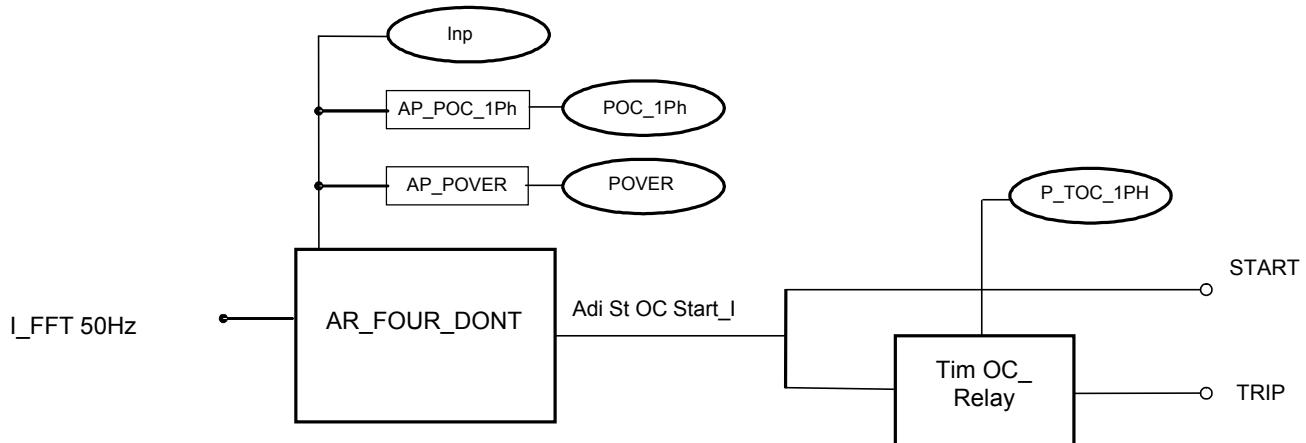
## ***Outputs***

The function generates two status signals:

- The start status signal,
- The timeout state of the assigned timer.

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## ANSI 50N\_Sens



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# ANSI 50\_3Ph

## ***Task of the function***

This function is the realisation of a definite time overcurrent function with a three currents. The threshold value is a parameter. The function generates a start signal without time delay; this signal cannot be delayed. The trip time delay is defined by a parameter as well. The function evaluates the started states of the three phase current comparisons in „OR” relation, and the time delay is common for the three phases

This function performs the decisions and the measurement of the time delay only, for the operation it needs for example three Fourier algorithms too. It processes the values stored in the data structure of the Fourier routines.

## ***Inputs***

This function processes the calculated results of three Fourier routines, performs comparision and decision. (See e.g. FFT\_CT\_3PH.)

## ***Parameters***

The function needs two parameter values:

- POC: the threshold value of the overcurrent function (30...2500, step 5) % related to the rated current of the input current transformer,
- P\_TOC: time delay of the overcurrent function (0...60000, step 10) ms.

LCD text	Min	Max	Step	Remark
I>/In [CT] %	30	2500	5	Current setting value, related to the rated current of the CT input, expressed in %
t [I>] = ms	0	60000	10	Time delay in ms

For the operation two constants are needed as well:

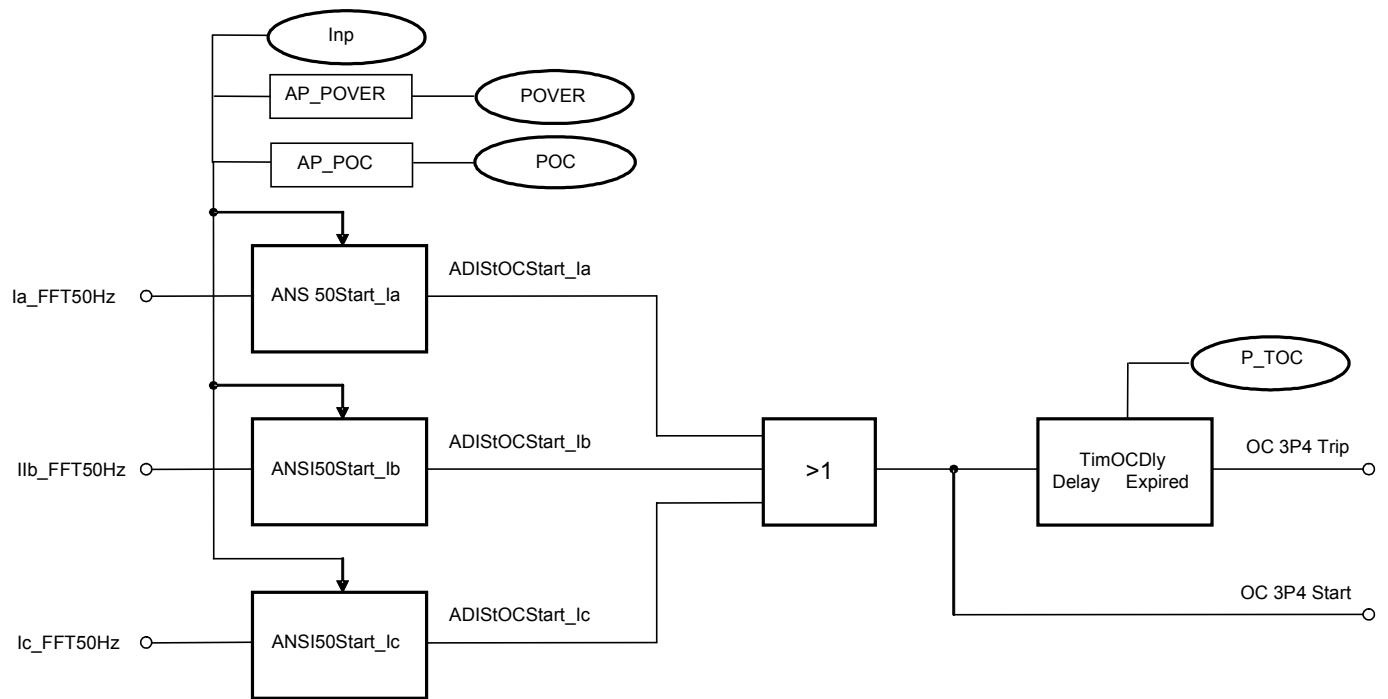
- Inp is the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer. The same constant is applied e.g. by FFT\_CT\_3PH.
- POVER defined constant parameter, which selects „over-“ function.

## ***Outputs***

The function generates two status signals:

- The start status signal, which is the „OR” relation of the three phase start values,
- The timeout state of the assigned timer.

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**ANSI50\_3Ph**


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# **ANSI 50\_3x1Ph**

## ***Task of the function***

This function is the realisation of a definite time overcurrent function with a three currents. The threshold value is a parameter. The function generates a start signal without time delay; this signal can not be delayed. The trip time delay is defined by a parameter as well. The function evaluates the started states of the three phase current comparisons individually, and the time delay is measured for the three phases individually too.

This function performs the decisions and the measurement of the time delays only, for the operation it needs for example three Fourier algorithms too. It processes the values stored in the data structure of the Fourier routines.

## ***Inputs***

This function processes the calculated results of three Fourier routines, performs comparison and decision. (See e.g. FFT\_CT\_3PH.)

## ***Parameters***

The function needs two parameter values:

- POC: the threshold value of the overcurrent function (30...2500, step 5) % related to the rated current of the input current transformer,
- P\_TOC: time delay of the overcurrent function (0...60000, step 10) ms.

LCD text	Min	Max	Step	Remark
I>/In [CT] %	30	2500	5	Current setting value, related to the rated current of the CT input, expressed in %
t [I>] = ms	0	60000	10	Time delay in ms

For the operation two constants are needed as well:

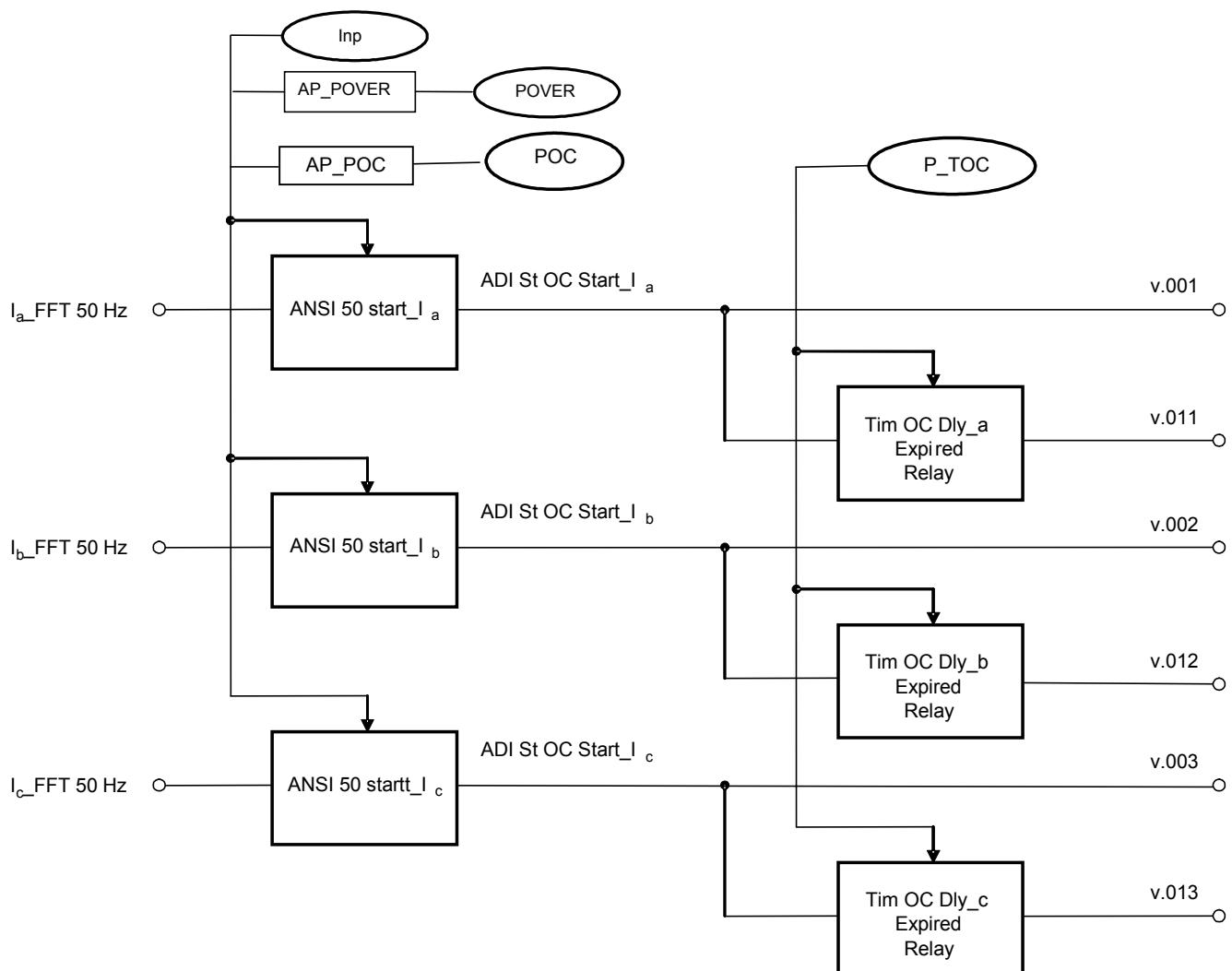
- Inp is the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer. The same constant is applied e.g. by FFT\_CT\_3PH.
- POVER defined constant parameter, which selects „over-“ function.

## ***Outputs***

The function generates the following status signals:

- The start status signals of the three phase starting individually,
- The timeout states of the assigned timers.

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# ANSI 51

## ***Task of the function***

This function realises inverse definite minimum time overcurrent protection tasks with a single current. Principally this current can be a phase current, but the usual application is the negative sequence overcurrent protection. The status signal of the starting is generated without additional time delay. The time delay of the trip command is generated according to standard current dependent characteristics. The type of the inverse characteristics can be selected by a parameter:

$$\text{Normal inverse (Type =0)} \quad T = T_N \frac{0.14}{\left(\frac{I}{I_N}\right)^{0.02}} - 1$$

$$\text{Very inverse (Type =1)} \quad T = T_N \frac{13.5}{\left(\frac{I}{I_N}\right)^1} - 1$$

$$\text{Extremely inverse (Type =2)} \quad T = T_N \frac{80}{\left(\frac{I}{I_N}\right)^2} - 1$$

In all three cases the rated starting current ( $I_N$ ) and the time multiplier ( $T_N$ ) is to be set by parameters.

The relation of the time multiplier and the assigned parameter is explained by the following formula:

$$T = T_N \frac{c1}{\left(\frac{I_2}{I_N}\right)^{c2} - 1} = \frac{P\_IDMT}{20} \frac{c1}{\left(\frac{I_2}{I_N}\right)^{c2} - 1}$$

Which means that the parameter is 20 times the usual time multiplier. If for example the parameter setting is  $P\_TIDMT=1$ , then it corresponds to the time multiplier  $T_N = 0.05$  s. The parameter is expressed in [s].

The function is extended with a minimum time delay as well (IDMT). This time delay can be set by a dedicated parameter. The function generates a trip command if both the delay of the inverse characteristics AND this minimal time delay is over.

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This function performs the decision and the time delay only. For the operation it needs for example a Fourier algorithm, the data stored in the data structure of this algorithm are processed.

## Inputs

This function processes the calculated results of three Fourier routines, performs comparison and decision. (See e.g. FFT\_CT\_1PH.)

## Parameters

The function applies the following parameters:

- PIn: threshold value of the function (10...104,1) % related to the rated current of the current transformer input,
- P\_TIDMT: 20-times value of the time multiplier (1...256,1) [\*20 ms].
- PType: parameter for selection among the types of the inverse characteristic (0, 1, 2)
- P\_TDMT: the minimal delay time (50 ... 500, 1) ms.

LCD text	Min	Max	Step	Remark
IDMT Type (0,1,2)	0	2	1	Type selection for the characteristics, see equations above
Ipick/In %	10	104	1	Pick-up value of the function, related to the rated current of the CT, expressed in %
IDMT time multip /20 s	0	256	1	20*(time multiplier), expressed in s
Min.time delay ms	50	500	1	Minimal time delay, expressed in ms

The function needs the following constants:

- Inp is the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer. The same constant is applied e.g. by FFT\_CT\_1PH

The function needs the following constant parameters (both have factory settings):

- Pconst100 its value is 100% (in a motor protection for example it is a variable parameter)
- PconstInegrDown This parameter defines the rate of the drop-off.

## Outputs

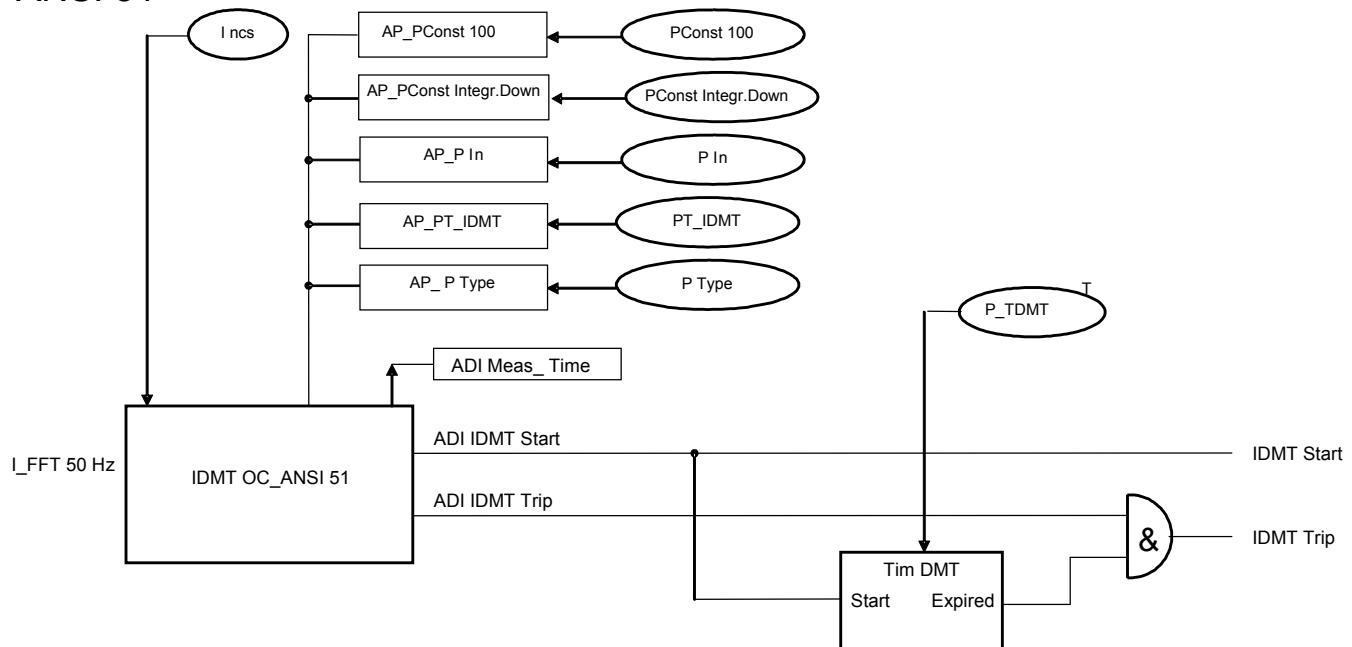
The function generates two status signals:

- Started state,
- Time-out of the function based on the selected current-dependent characteristics.

Additionally there is a value available which is proportional to the time remaining to the trip command. This value decreases starting from 1000, at the generation of the trip command its value is 0.

- Transfer the time-out of the characteristics AND the time-out of the minimum delay time to the other internal variable.

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**ANSI 51**


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# ANSI 51\_3Ph

## **Task of the function**

This function realises inverse definite minimum time overcurrent protection tasks with three currents. The status signals of the individual starting are generated without additional time delay. The time delay of the trip command is generated according to standard current dependent characteristics. The type of the inverse characteristic can be selected by a parameter:

$$\text{Normal inverse (Type =0)} \quad T = T_N \frac{0.14}{\left(\frac{I}{I_N}\right)^{0.02} - 1}$$

$$\text{Very inverse (Type =1)} \quad T = T_N \frac{13.5}{\left(\frac{I}{I_N}\right)^1 - 1}$$

$$\text{Extremely inverse (Type =2)} \quad T = T_N \frac{80}{\left(\frac{I}{I_N}\right)^2 - 1}$$

In all three cases the rated starting current ( $I_N$ ) and the time multiplier ( $T_N$ ) is to be set by parameters.

The relation of the time multiplier and the assigned parameter is explained by the following formula:

$$T = T_N \frac{c1}{\left(\frac{I_2}{I_N}\right)^{c2} - 1} = \frac{P\_IDMT}{20} \frac{c1}{\left(\frac{I_2}{I_N}\right)^{c2} - 1}$$

Which means that the parameter is 20 times the usual time multiplier. If for example the parameter setting is  $P\_TIDMT=1$ , then it corresponds to the time multiplier  $T_N = 0.05$  s. The parameter is expressed in [s].

The function is extended with a minimum time delay as well (IDMT). This time delay can be set by a dedicated parameter. The function generates a trip command if both the delay of the inverse characteristics AND this minimal time delay is over.

This function performs the decision and the time delay only. For the operation it needs for example a Fourier algorithm, the data stored in the data structure of this algorithm are processed.

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## Inputs

The function processes the calculated results of three Fourier current routines, and generates trip command. (See for example FFT\_CT\_3PH.)

## Parameters

The function applies the following parameters:

- PIn: threshold value of the function (10...104, step 1) % related to the rated current of the current transformer input,
- P\_TIDMT: 20-times value of the time multiplier (1...256, step 1) [\*20 ms].
- PType: parameter for selection among the types of the inverse characteristic (0, 1, 2)
- P\_TDMT: the minimal delay time (50 ... 500, step 1) ms.

LCD text	Min	Max	Step	Remark
IDMT Type (0,1,2)	0	2	1	Type selection for the characteristics, see equations above
Ipick/In %	10	104	1	Pick-up value of the function, related to the rated current of the CT, expressed in %
IDMT time multip /20 s	0	256	1	20*(time multiplier), expressed in s
Min.time delay ms	50	500	1	Minimal time delay, expressed in ms

The function needs the following constants:

- Inp is the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer. The same constant is applied e.g. by FFT\_CT\_3PH

The function needs the following constant parameters (both have factory settings):

- Pconst100 its value is 100% (in a motor protection for example it is a variable parameter)
- PconstInegrDown This parameter defines the rate of the drop-off.

## Outputs

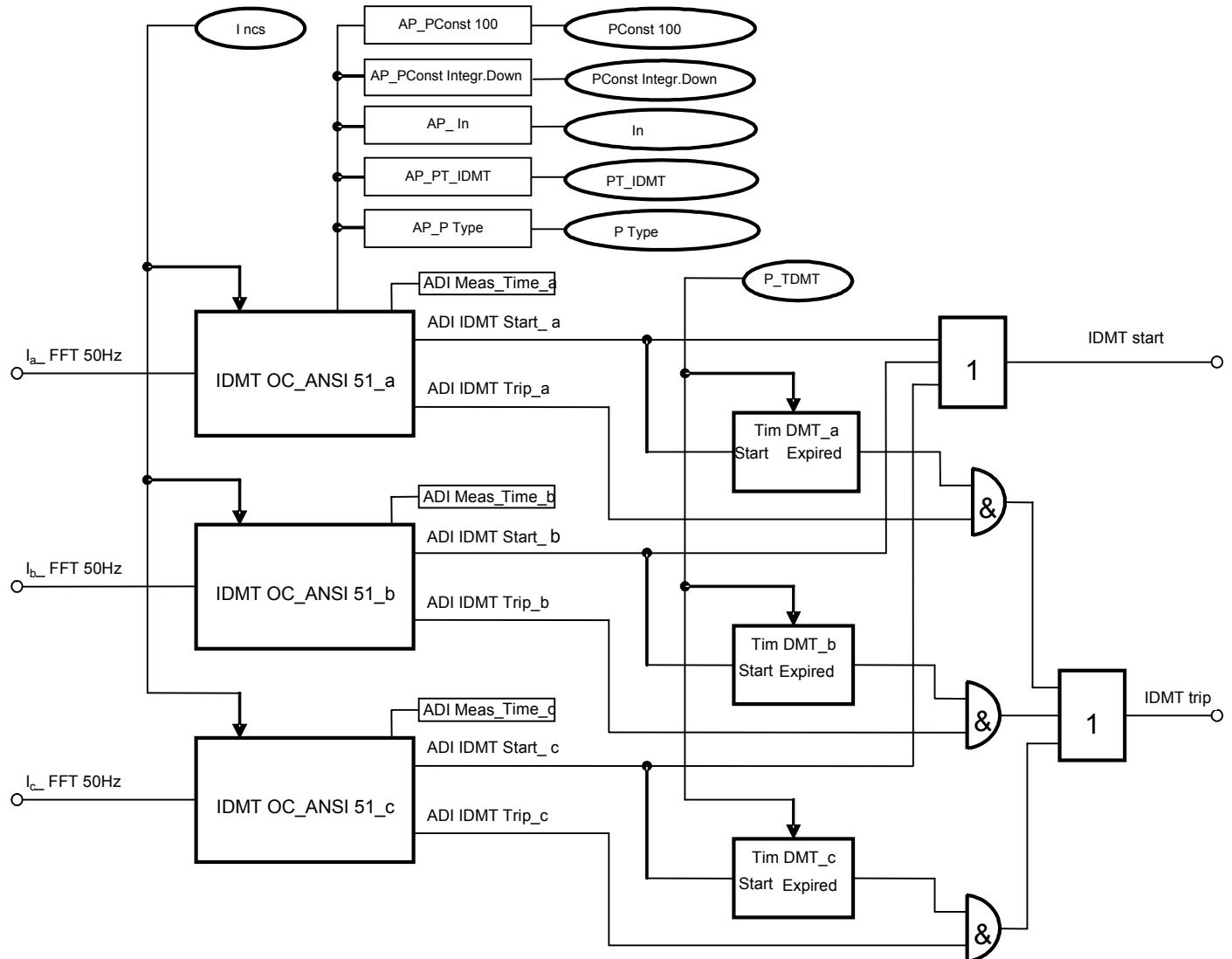
The function generates two status signals:

- Started state, which gets logic 1 if any of the phase currents is above the threshold value (OR relation of the three phases),
- Time-out of the function based on the selected current-dependent characteristics. This status gets logic 1 if there is time-out in any phases AND in the same phase the minimum time delay is over as well.

Additionally for each phases there is a value available which is proportional to the time remaining to the trip command. This values decrease starting from 1000, at the generation of the trip command its value is 0.

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## ANSI 51\_3Ph



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# ANSI67N

## ***Task of the function***

Aim of the function is the realisation of the directional earth-fault protection.

## ***Inputs***

The inputs of the function are the Fourier basic harmonic components of the zero sequence current and those of the zero sequence voltage.

## ***Parameters***

For the operation of the function the following constants are needed:

- Unp is the A/D sampled numerical value in case of the rated voltage peak sample. This value depends on the hardware; it is defined by the producer. The same constant is applied e.g. by FFT\_VT\_1PH
- Inp is the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer. The same constant is applied e.g. by FFT\_CT\_1PH
- POVER pre-defined constant, which selects the “over-“ function.

The parameters of the function are:

- PuOR the threshold value for the 3Uo zero sequence voltage, below which no directionality is possible. (10 ... 110, step 1) % related to the rated voltage of the voltage transformer input.
- POC\_3IoSens the threshold value for the 3Io zero sequence current, below which no operation is possible. (10 ... 140, step 1) % related to the rated current of the current transformer input.
- PioUoFiMin lower limit of the operating angle range, ( 0 ... 359, step 1 degrees)
- PioUoFiMax upper limit of the operating angle range, ( 0 ... 359, step 1 degrees)
- PioUoFiHist hysteresis of the operating angle range, ( 0 ... 359, step 1 degrees)
- PioUoFiComp compensating angle to correct the angle error differences of the current transformer and the voltage transformer, ( 0 ... 3599, step 1/10 degrees)
- PTOC3IoFiDly time delay of the function,

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LCD text	Min	Max	Step	Remark
Io>/Ion [CToProt] %	10	140	1	Threshold value of the overcurrent function
Uo>/Un [VT] %	10	110	1	Threshold value of the overvoltage function
Fi(IoUo) min deg	0	359	1	Angle characteristics lower limit in degrees
Fi(IoUo) max deg	0	359	1	Angle characteristics upper limit in degrees
Fi(IoUo) hist deg	0	359	1	Hysteresis of the characteristics
Fi(IoUo) comp /10 deg	0	3500	1	Angle error compensation in deg/10
t[IoFi>] ms	0	60000	1	Time delay in ms

## Outputs

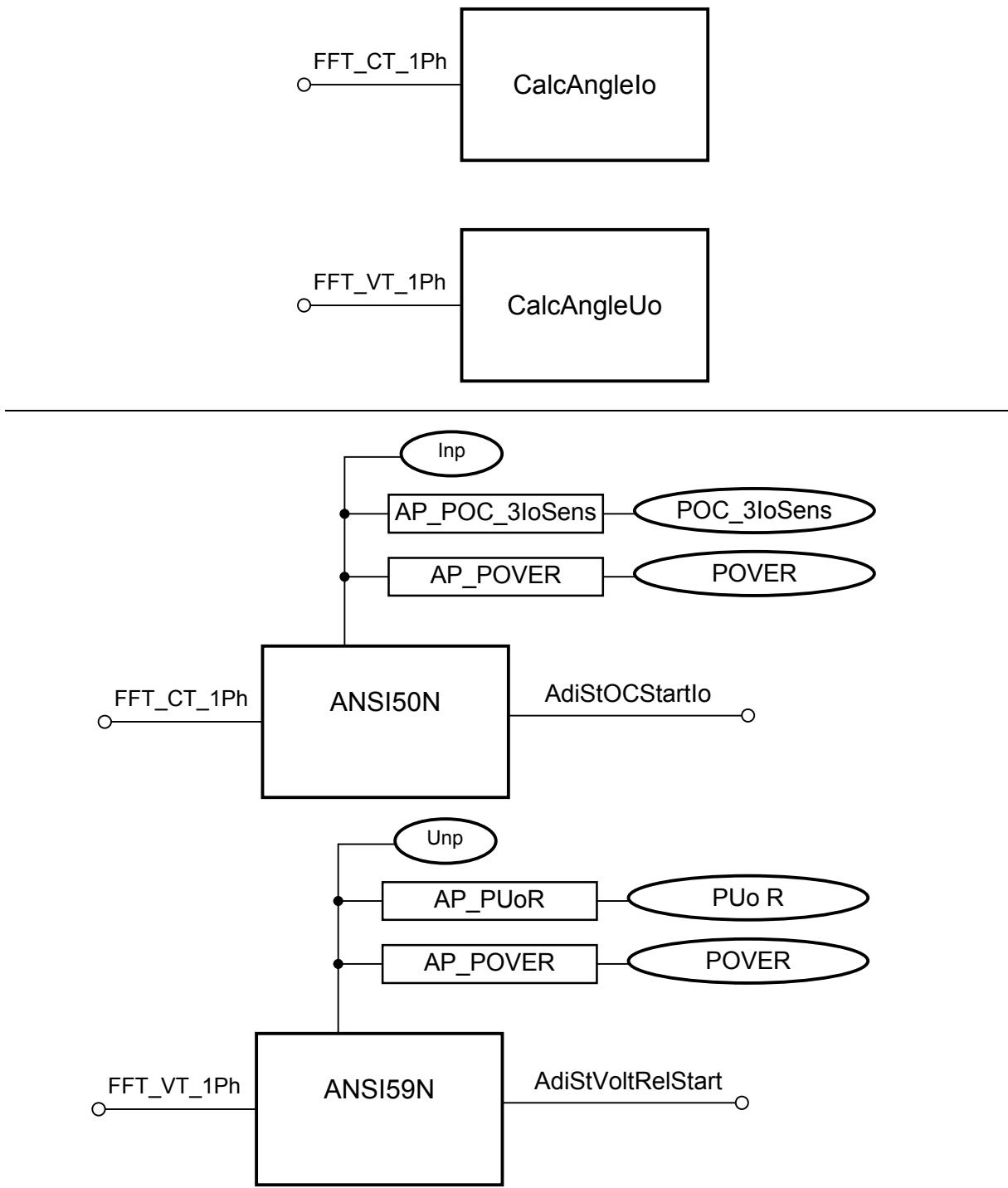
The output of the function is the AdiMeas\_Fi measured angle value between the voltage and the current.

Status outputs:

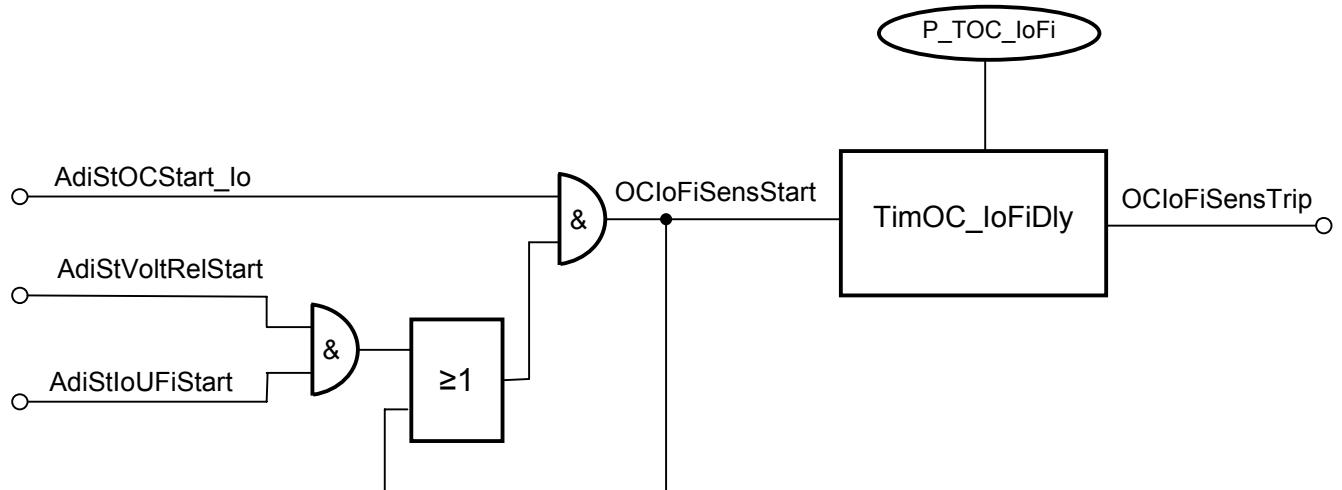
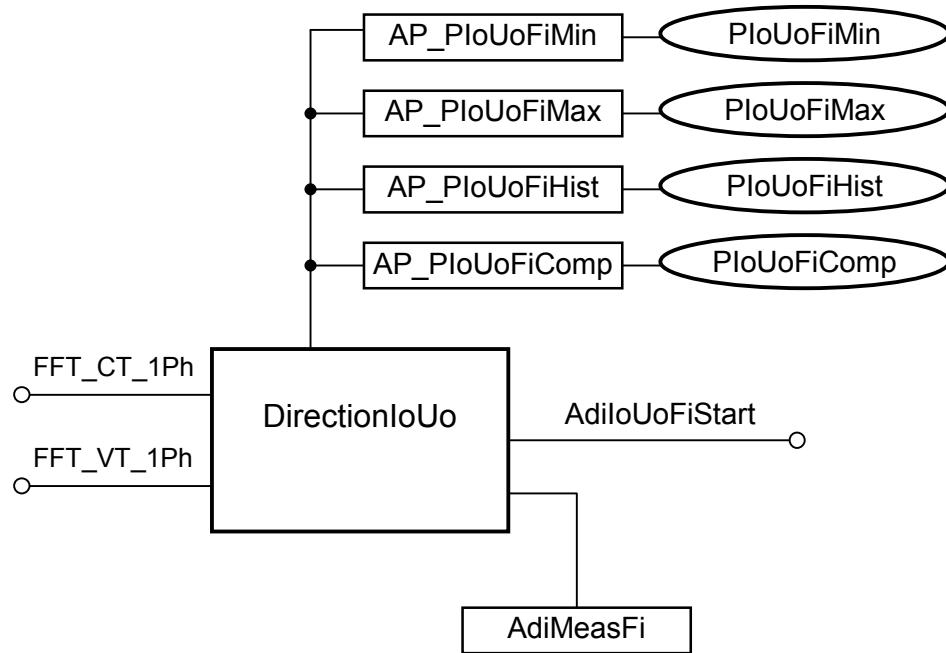
- Started state, which gets logic 1 if the current is above the threshold value, and in the moment of starting the voltage is above the threshold value and the angle between the voltage and the current is within the defined angle range.
- Time-out state of the dedicated timer.

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# **ANSI59\_27\_1Ph**

## ***Task of the function***

This is the realisation of the over-/undervoltage function with a single voltage, which can be a phase voltage, a calculated line-to-line voltage, but the usual application processes the zero sequence voltage. The threshold value is a parameter. The function starts with no additional time delay. The trip command can be delayed with parameter setting.

This function performs the decision and the timing only, it needs for the operation the results of a Fourier function as an example; it processes the data stored in the data structure of the Fourier function.

## ***Inputs***

This function performs data processing on the stored results of a Fourier function (see for example FFT\_VT\_1PH.)

## ***Parameters***

This function needs three parameter values:

- PUR: this is the threshold value of the over-/undervoltage function (10...110, step 1) % expressed related to the rated voltage transformer input voltage,
- PUType: this parameter defines if overvoltage (0) or undervoltage (1) function is applied,
- P\_TUR: this is the time delay of the function (0...60000, step 10) ms.

LCD text	Min	Max	Step	Remark
U<>/Un [VT] %	10	110	1	Voltage relay start level, related tom the rated voltage of the VT, expressed in %
U<>type= [0=U>]	0	1	1	Selection parameter for over/undervoltage function
t [U<>] = ms	0	60000	10	Voltage relay time delay in ms

The function applies the following constant:

- Unp the A/D sampled numerical value in case of the rated voltage peak sample. This value depends on the hardware; it is defined by the producer, (see e.g. FFT\_VT\_1PH)

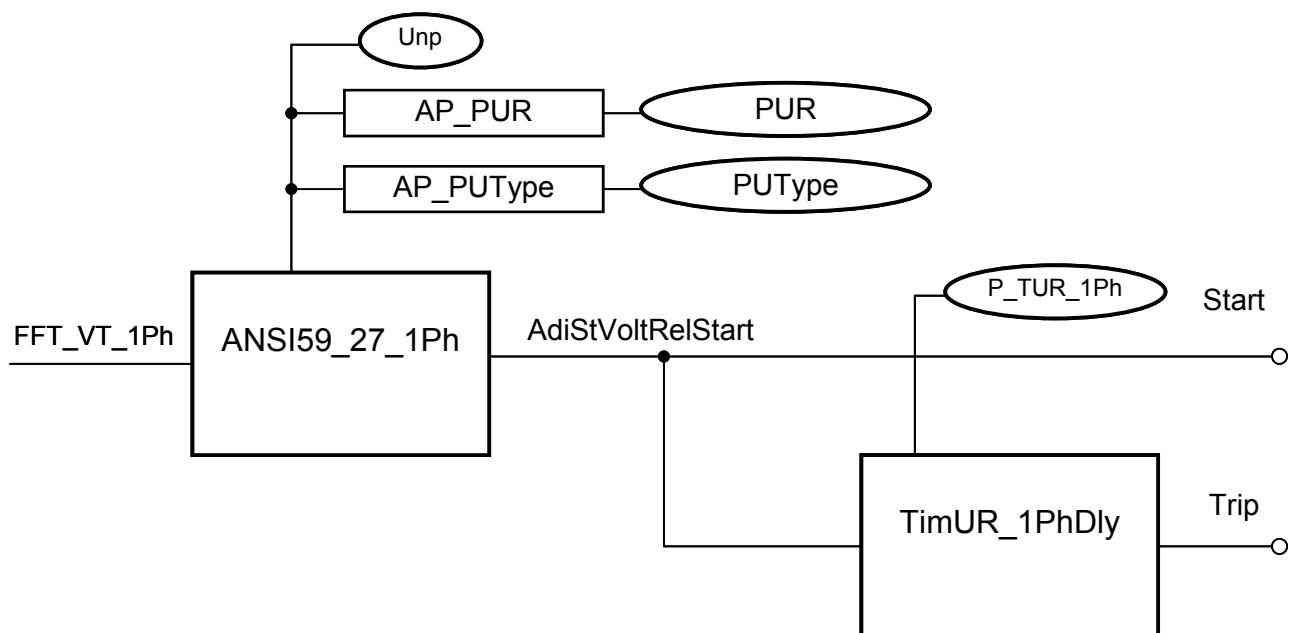
## ***Outputs***

The function generates two status values:

- Starting state,
- Time-out state.

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## ANSI59\_27\_1Ph



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# ANSI59\_27\_3Ph

## **Task of the function**

This is the realisation of the over-/undervoltage function with three voltages, which can be a phase voltages, or calculated line-to-line voltages. The threshold value is a parameter. The function starts with no additional time delay. The trip command can be delayed with parameter setting. The function evaluates the result of three measurement, and a parameter decides if one or at least two out of three limit violations are needed for the function to start the operation. The time delay is performed with a common timer.

This function performs the decision and the timing only, it needs for the operation the results of three Fourier functions; it processes the data stored in the data structures of the Fourier functions.

## **Inputs**

This function performs data processing on the stored results of three Fourier functions (see for example FFT\_VT\_3PH.)

## **Parameters**

The function needs the following parameters:

- PUR3Ph: threshold value of the function (10...110, step 1) % related to the rated voltage of the voltage transformer input,
- PUType3Ph: this parameter defines if overvoltage (0) or undervoltage (1) function is applied,
- PU3\_2: this parameter defines if one or at least two out of three limit violations are needed for the function to start the operation,
- P\_TUR\_3Ph: time delay of the function (0...60000, step 10) ms.

LCD text	Min	Max	Step	Remark
U<>/Un [VT] %	10	110	1	Voltage relay start level, related to the rated voltage of the VT, expressed in %
U<>type= [0=U>]	0	1	1	Selection parameter for over/undervoltage function
t [U<>] = ms	0	60000	10	Voltage relay time delay in ms
2 out of 3 log : (1=ena)	0	1	1	Enabling parameter for the 2 out of 3 logic (1=ena)

The function needs the following constants:

- Unp the A/D sampled numerical value in case of the rated voltage peak sample. This value depends on the hardware; it is defined by the producer, (see e.g. FFT\_VT\_3PH)

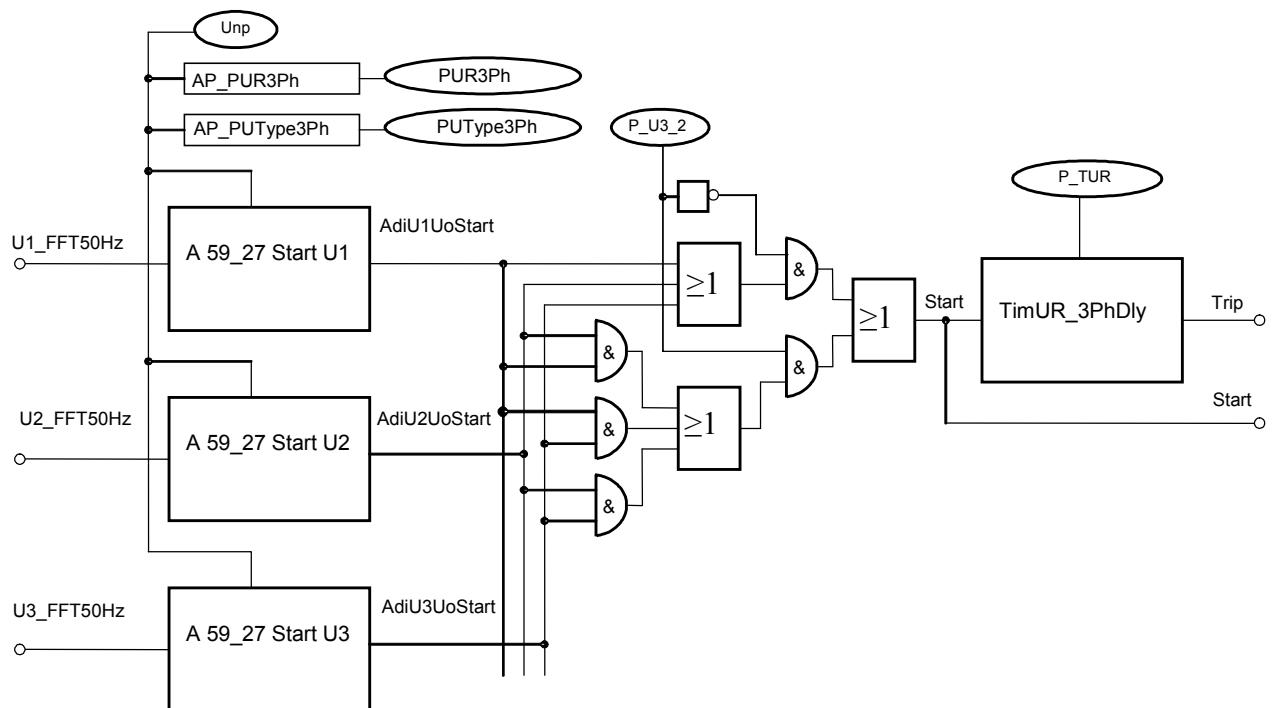
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## Outputs

The status variables assigned to the function are:

- Started state (in „OR” relationship of the phases),
- Time-out state.

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# ANSI67\_Four\_3Ph-MV

## ***Task of the function***

This function realises directional phase-fault overcurrent protection.

## ***Inputs***

This function processes data which are pre-calculated based on sampled phase currents and phase voltages. These data are:

- the Fourier basic harmonic components calculated from phase currents, processed by the **FFT\_CT\_3Ph** software module.
- the Fourier basic harmonic components calculated from line-to line voltages. Here the line-to line voltages are calculated by the **Make\_3Ph\_line\_U** module based on the sampled phase voltages. The Fourier analysis is performed by the **FFT\_CT\_3Ph** software module.
- the Fourier basic harmonic components calculated from phase current differences. Here the current differences are calculated by the **Make\_3Ph\_line\_I** module based on the sampled phase currents. The Fourier analysis is performed by the **FFT\_VT\_3Ph** software module.

## ***Parameters***

For the operation of the function the following constants are needed:

- Unp is the A/D sampled numerical value in case of the rated voltage peak sample. This value depends on the hardware; it is defined by the producer. The same constant is applied e.g. by **FFT\_VT\_3PH** module.
- Inp is the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer. The same constant is applied e.g. by **FFT\_CT\_3PH** module.
- POVER pre-defined constant, which selects the “over-“ function.

The parameters of the function are:

- PUR is the threshold value for the voltage, below which no directionality is possible. (3 ... 15, step 1) % related to the rated voltage of the voltage transformer input.
- POC\_Ansi67 is the threshold value for the current, below which no operation is possible. (3 ... 2500, step 5) % related to the rated current of the current transformer input.
- PiUoFiMin lower limit of the operating angle range, ( 0 ... 359, step 1 degrees),
- PiUoFiMax upper limit of the operating angle range, ( 0 ... 359, step 1 degrees),
- PiUoFiHist hysteresis of the operating angle range, ( 0 ... 359, step 1 degrees),
- PiUoFiComp compensating angle to correct the angle error differences of the current transformer and the voltage transformer, ( 0 ... 3599, step 1/10 degrees),
- PTOCIoFiDly is the time delay of the function, (0 ... 6000, step 10) ms.

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LCD text	Min	Max	Step	Remark
I>/In [CT] %	30	2500	5	Threshold value of the overcurrent function
U>dir/Un [VT] = %	3	15	1	Threshold value of the overvoltage function
Fi(IU) min deg	0	359	1	Angle characteristics lower limit in degrees
Fi(IU) max deg	0	359	1	Angle characteristics upper limit in degrees
Fi(IU) hist deg	0	359	1	Hysteresis of the characteristics
Fi(IU) comp /10 deg	0	3500	1	Angle error compensation in deg/10
t [IFI>] ms	0	60000	1	Time delay in ms

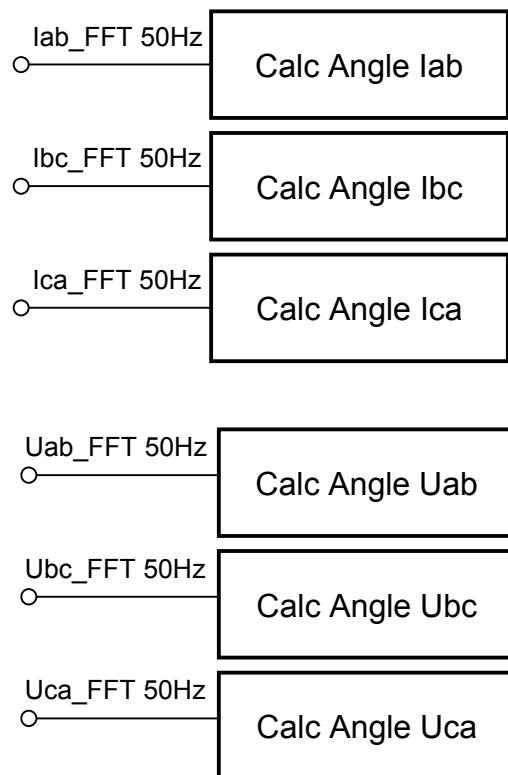
## Outputs

The outputs of the function are the AdiMeas\_Fi\_ab, AdiMeas\_Fi\_bc AdiMeas\_Fi\_ca measured angle values between the voltages and the currents.

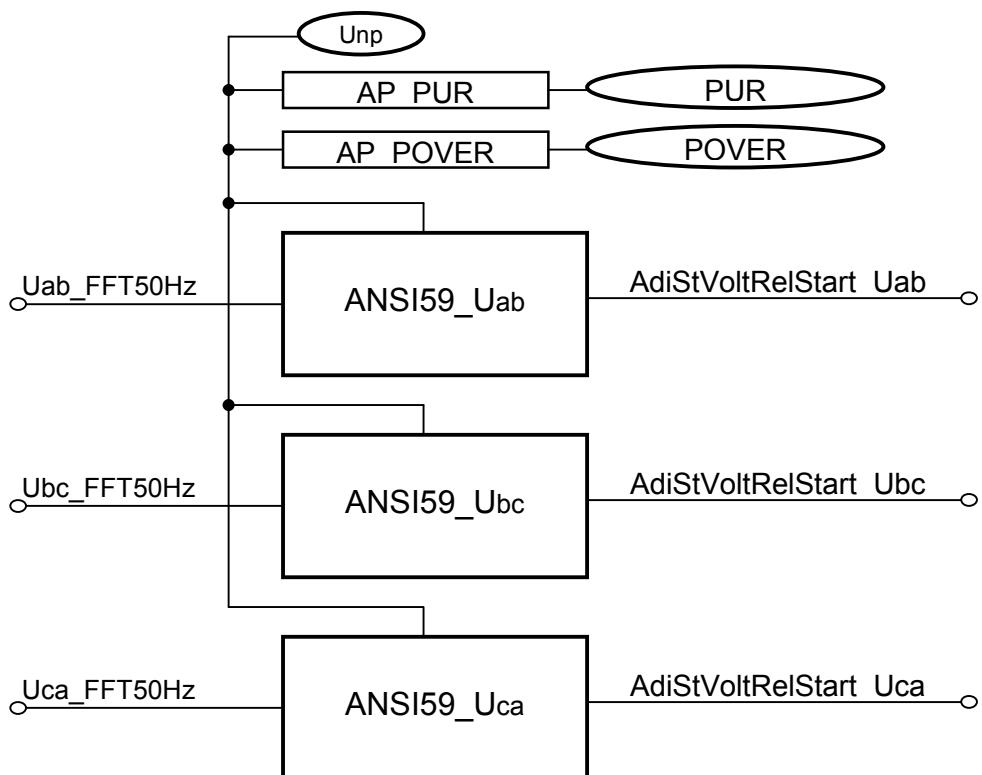
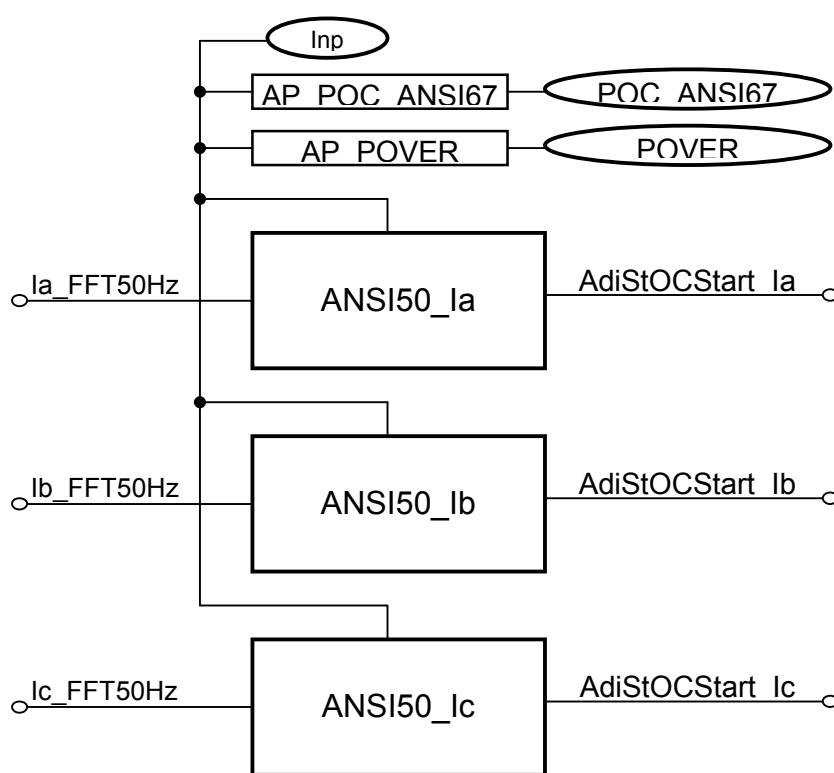
Status outputs:

- Started state, which gets logic 1 if there is a line-to line voltage and current pair, where the voltage is above the threshold value, the angle between them is within the defined angle range, and the current of the pair involves the phase current first in the phase sequence, which is above the threshold value. The parameter setting defines if the starting state is generated only by the current, without the voltage and directionality constraints. There is additionally a PROTLOG logic equation output, the influence of which is that the function starts with current level violation only.
- Time-out state of the dedicated timer.
- It is useful to define two internal status variables, which are to be assigned to the OC3PhStart and OC3PhTrip status signals. (Remark: instead of internal status signals relay outputs or LED-s can be assigned as well.)

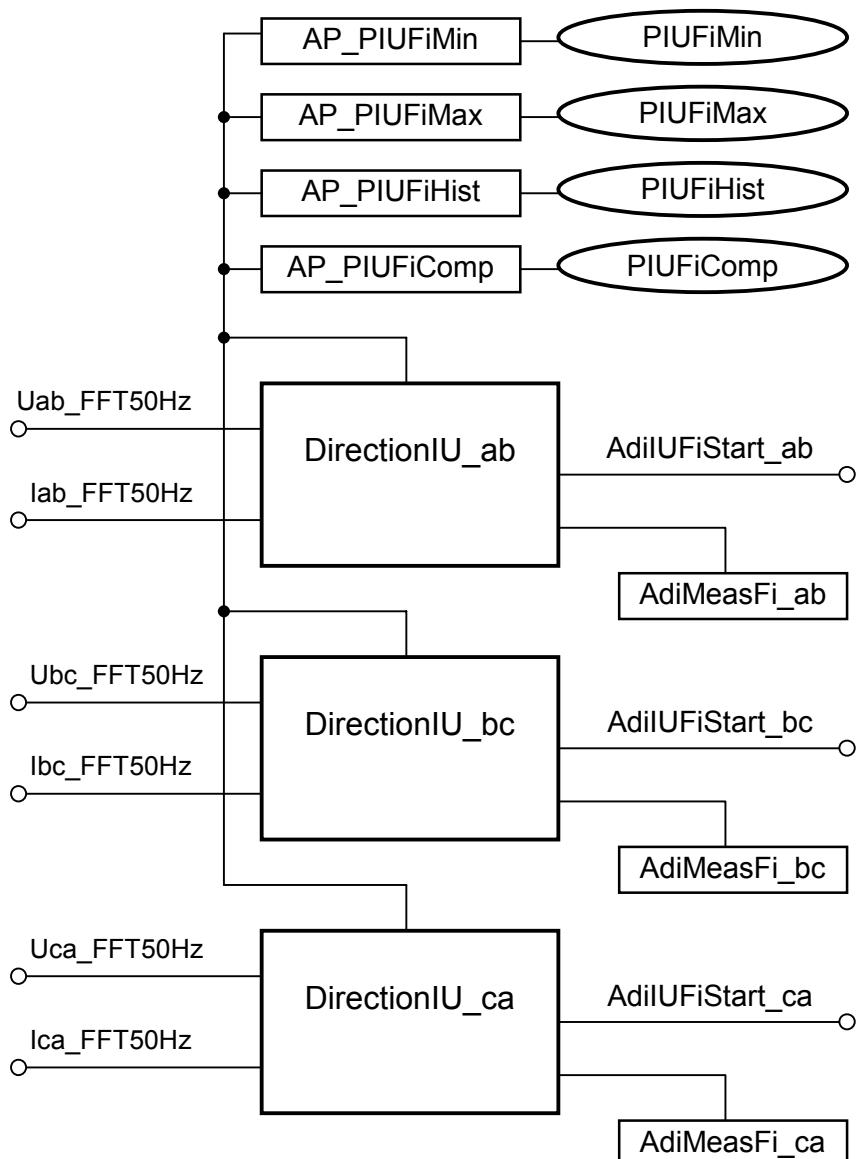
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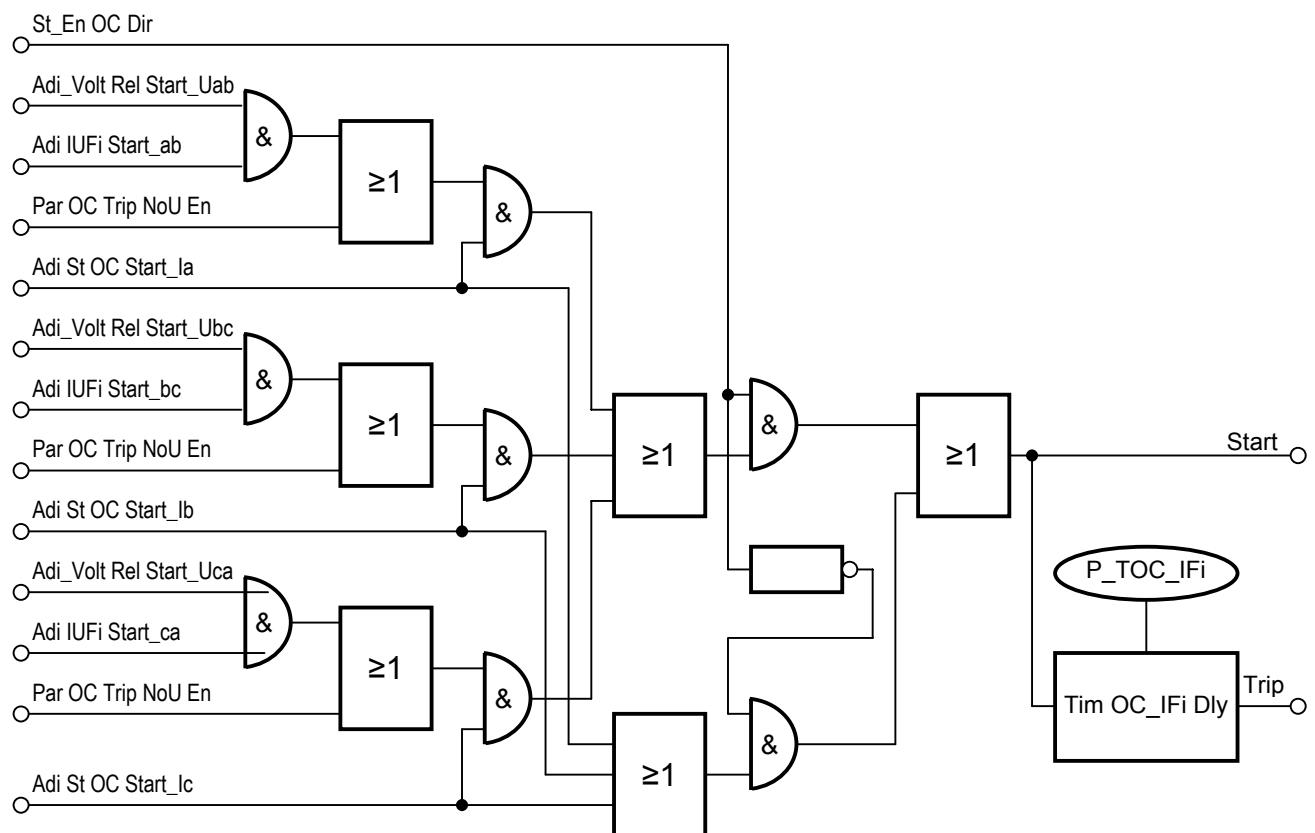
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# CB failure

## **Task of the function**

This function realises circuit breaker failure protection function.

## **Inputs**

The function processes the results of three Fourier current software modules fro the decision.  
(See e.g. CT\_3PH.)

The binary inputs of the function:

- |                  |  |
|------------------|--|
| CB_Failure_start | This is the starting status signal for the function, this must be defined in the configuration process.                            |
| CB_Open          | This is the status signal, indicating the open state of the circuit breaker.<br>This must be defined in the configuration process. |

## **Parameters**

The circuit breaker failure function involves three overcurrent functions, the parameter of which is the threshold value.

- POC\_: threshold value of the overcurrent function (10...2500,5) % related to the rated current of the current transformer,
- P\_TCB\_Fail: this is the time delay parameter of the circuit breaker failure function (0...60000,10) ms.

LCD text	Min	Max	Step	Remark
I [CBFail] / In [CT]	10	2500	5	Threshold value of the overcurrent function related to the rated current of the CT
t [CB Fail] ms	0	64000	10	Time delay in ms

The constants needed for the operation of the function are:

- |          |  |
|----------|--|
| Inp      | the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer, (the same constant is applied e.g. by FFT_CT_3PH) |
| AP_POVER | transferred constant parameter, which selects the “over-“ function.  |

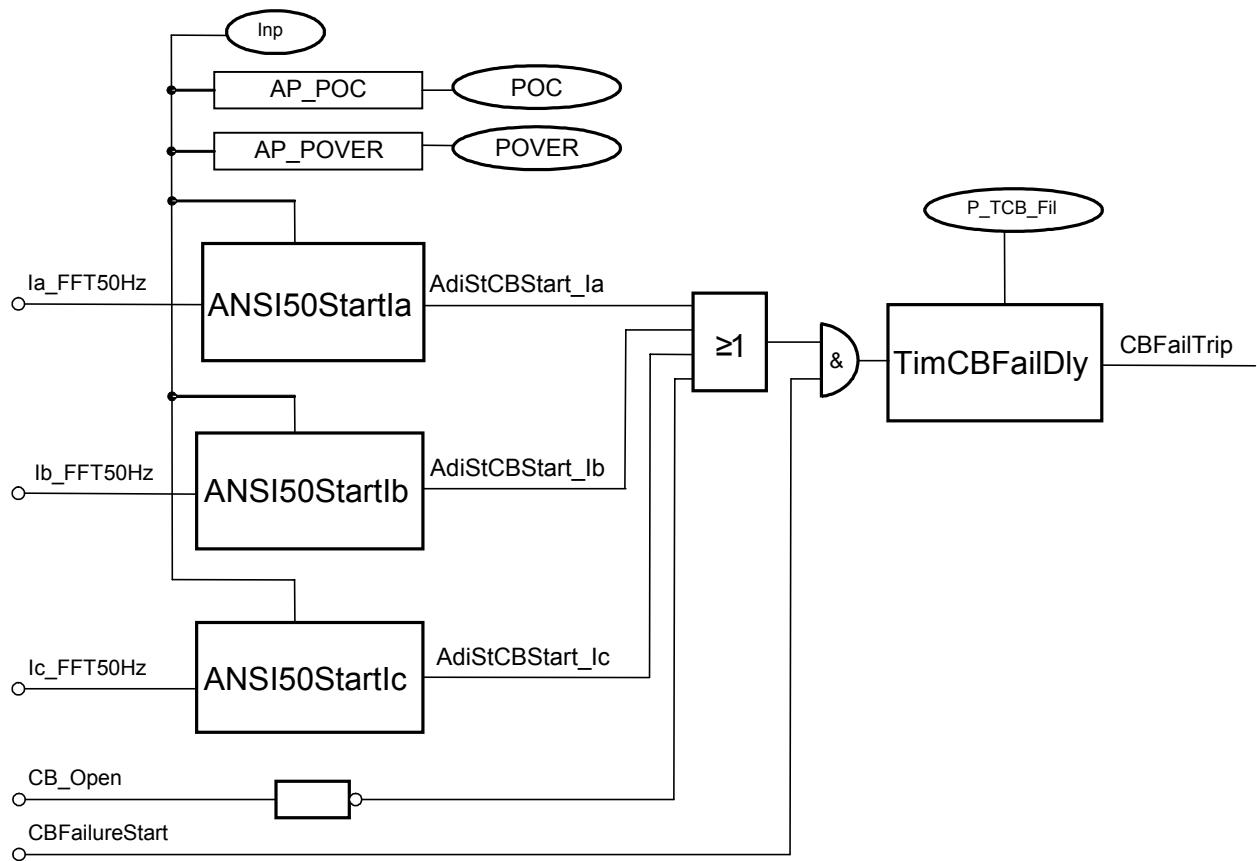
## **Outputs**

The function has only one digital output:

- CBFailTrip which indicates the time-out state of the dedicated timer.

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## CB\_Failure



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# **ANSI 50\_3x1Ph\_Start**

## ***Task of the function***

This function is the realisation of a definite time overcurrent starting function with a three currents. The threshold value is a parameter. The function generates a start signal without time delay; this signal cannot be delayed. The function evaluates the started states of the three phase current comparisons individually.

This function performs the decisions only, for the operation it needs for example three Fourier algorithms too. It processes the values stored in the data structure of the Fourier routines.

## ***Inputs***

This function processes the calculated results of three Fourier routines, performs comparison and decision. (See e.g. FFT\_CT\_3PH.)

## ***Parameters***

The function needs one parameter value:

- POC: the threshold value of the overcurrent function (30...2500, step 5) % related to the rated current of the input current transformer,

LCD text	Min	Max	Step	Remark
I>/In [CT] %	30	2500	5	Current setting value, related to the rated current of the CT input, expressed in %

For the operation two constants are needed as well:

- Inp is the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer. The same constant is applied e.g. by FFT\_CT\_3PH.
- POVER defined constant parameter, which selects „over-“ function.

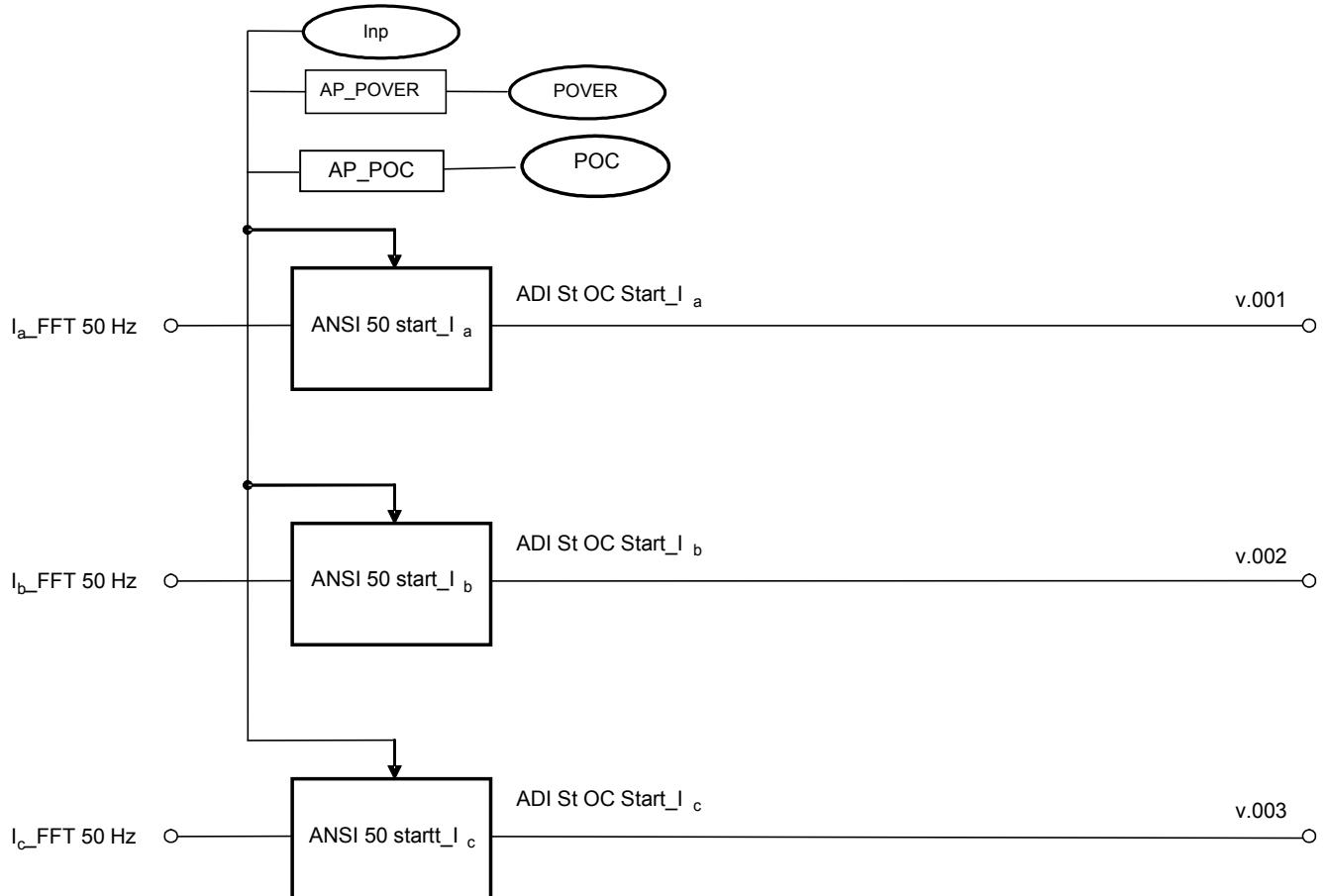
## ***Outputs***

The function generates the following status signals:

- The start status signals of the three-phase starting individually.

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### ANSI 50\_3x1PhStart



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## ZphE\_Calc\_3point\_3Ph

### **Task of the function**

This function calculates the impedances of the three phase-earth loops. For this calculation the zero sequence current is needed too, which is usually calculated from the three measured phase currents. In applications with parallel lines the zero sequence current of the parallel line influences the measured impedance too. In this case a dedicated analogue input receives this current.

The theoretical formula to calculate the complex impedance is:

$$Z_{Ph\_E} = \frac{U_{Ph}}{I_{Ph} + \alpha 3I_o + \beta 3I_{oP}}$$

where

- $U_{Ph}$  the phase voltage vector,
- $I_{Ph}$  the phase current vector,
- $3I_o$  the zero sequence current component,
- $\alpha$  the complex mixing factor for the zero sequence current (dependent on the positive and zero sequence impedance of the protected line),
- $3I_{oP}$  the zero sequence current component of the parallel line,
- $\beta$  the complex mixing factor for the zero sequence current of the parallel line (dependent on the mutual and positive sequence impedance of the protected line).

The method of calculation is solving the differential equation of the faulty loop. In this method the complex mixing factors are resolved by two real factors individually:

$$\alpha_R = \frac{R_0 - R_1}{3R_1}, \alpha_L = \frac{L_0 - L_1}{3L_1}, \beta_R = \frac{R_m}{3R_1}, \beta_L = \frac{L_m}{3L_1}$$

where

- $R_0$  the zero sequence resistance of the protected line (for 1 km length),
- $R_1$  the positive sequence resistance of the protected line (for 1 km length),
- $L_0$  the zero sequence inductance of the protected line (for 1 km length),
- $L_1$  the positive sequence inductance of the protected line (for 1 km length),
- $R_m$  the mutual resistance of the protected line and of the parallel line (for 1 km length),
- $L_m$  the zero sequence inductance of the protected line and of the parallel line (for 1 km length),

The impedances are calculated with three sampled current and voltage values just after the zero crossing of the current. This method ensures correct calculated values even with serious current transformer saturation.

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The calculation is enabled, if the current value is above the pre-determined current limit. This avoids division by zero, and avoids errors caused by division with small and noisy sampled current values.

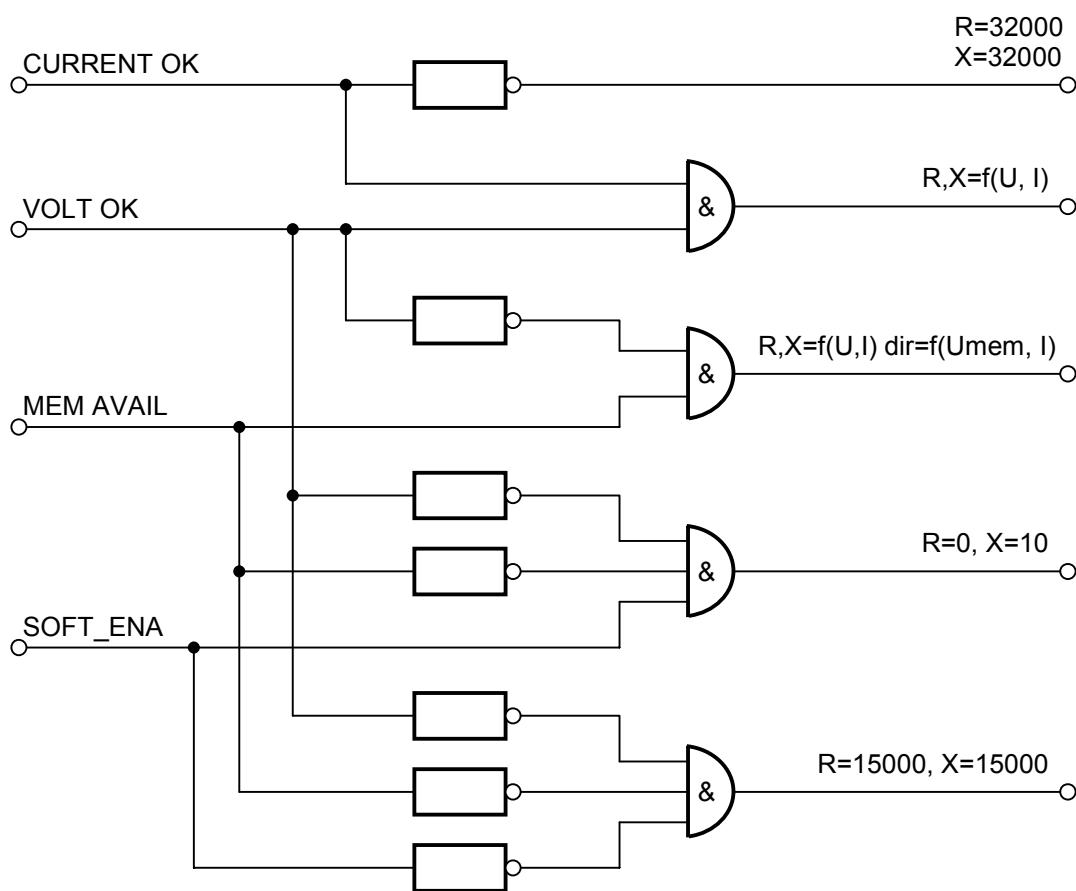
If the voltage is small because of close-in faults, the direction of the fault is decided based on pre-fault voltage samples, stored in the memory. The application of stored voltages is enabled if the voltage is below the pre-determined voltage limit.

In case of switch-onto-fault (SOTF) no voltages are stored in the memory. In this case – after a manual close command to the circuit breaker – the switch-onto-fault logic is enabled for a time span, determined by a parameter value.

The following Figure shows the internal logic of the impedance calculation. The decision needs three internal logic signals, (CURRENT\_OK, VOLT\_OK and MEM\_AVAIL) and additionally a logic parameter setting SOTF\_ENA. The explanation of these signals is as follows:

Status signal	Explanation
CURRENT_OK	The current is suitable for impedance calculation in the processed loop, if after a zero crossing there are three sampled values above a defined limit (constant parameter)
VOLT_OK	The voltage is suitable for the calculation, if among the last sampled three values there is a sample above the defined limit (constant parameter)
MEM_AVAIL	This status signal is true, if the voltage memory is filled up with available samples above the defined limit for 80 ms.
SOTF_ENA	This logic parameter is true, if the “switch-onto-fault” logic is enabled.

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*Fig Z\_CALC internal logic*

The short explanation of the internal logic for the impedance calculation is as follows:

If the CURRENT\_OK status signal is false, the current is very small and so no fault is possible. In this case the impedance is set to extreme high values, and no further calculation is performed:

$$R=32000, X=32000 (*10 m\Omega).$$

The subsequent decisions are performed, if the current is sufficient for the calculation.

If the CURRENT\_OK status signal is true, and the VOLT\_OK status signal is true as well, then the current is suitable for calculation, and the voltage is sufficient for the directionality decision. In this case normal impedance calculation is performed based on the sampled currents and voltages. (The calculation method is explained later.)

$$R, X=f(u, i)$$

If the CURRENT\_OK status signal is true, but the VOLT\_OK status signal is false, it means that the directionality decision cannot be performed based on the available voltage signals. In

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this case the magnitude of R and X is calculated based on the sampled currents and voltages, but the direction of the fault (the +/- sign of R and X) must be decided based on voltage value stored in the memory 80 ms earlier. This decision is possible only, if there are stored values in the memory for 80 ms, and these values were sampled during a healthy period.

$$R, X = f(u, i) \quad \text{direction} = f(u_{\text{mem}}, i)$$

If the voltage is not sufficient for directional decision, and no stored voltage samples are available, then the SOTF\_ENA parameter is needed for the process: If the “switch-onto-fault” logic is enabled, then the fault is supposed to be just in front of the bus-bar in forward direction:

$$R=0, \quad X=10 (*10 m\Omega).$$

If the voltage is not sufficient for directional decision, and no stored voltage samples are available, and “switch-onto-fault” logic is not enabled, then the impedance is set to a high value:

$$R=15000, \quad X=15000 (*10 m\Omega).$$

The applied numerical method is solving the differential equation of the faulty loop, based on tree consecutive samples.

## Inputs

The inputs of the function are

- the three phase currents,
- the three phase voltages,
- the zero sequence current ( $3I_0$ , calculated with the three phase currents, see e.g. *MakeIo*),
- the zero sequence current of the parallel line ( $3I_{0p}$ , measured on dedicated analogue input).

## Parameters

The function needs the following parameters:

- PTSOTF delay time of the switch-onto-fault (SOTF) logic, expressed in ms,
- PAlfaL the mixing factor for the zero sequence current calculated with the inductances (reactances), expressed in %. WARNING: If this parameter is set to 0, then the zero sequence current of the line and the zero sequence current of the parallel line is not taken into consideration!
- PAlfaR the mixing factor for the zero sequence current calculated with the resistances, expressed in %,
- PBetaL the mixing factor for the zero sequence current of the parallel line calculated with the inductances (reactances), expressed in %,
- PbetaR the mixing factor for the zero sequence current of the parallel line calculated with the resistances, expressed in %,

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LCD text	Min	Max	Step	Remark
SOTF delay= ms	0	60000	100	delay time of the switch-onto-fault (SOTF) logic
AlphaX(IoXcomp.) %	0	100	2	the mixing factor for the zero sequence current calculated with the inductances (reactances)
AlphaR(IoRcomp.) %	0	100	2	the mixing factor for the zero sequence current calculated with the resistances
BetaX(IopXcomp.) %	0	100	2	the mixing factor for the zero sequence current of the parallel line calculated with the inductances (reactances)
BetaR(IopRcomp.) %	0	100	2	the mixing factor for the zero sequence current of the parallel line calculated with the resistances

The constants needed for the operation of the function are:

- |         |  |
|---------|--|
| Inp     | the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer,   |
| Unp     | the A/D sampled numerical value in case of the rated voltage peak sample. This value depends on the hardware; it is defined by the producer,   |
| Izp     | minimal current value, which is needed for impedance calculation,  |
| UdirLim | minimal voltage value under which the sampled voltage values stored in the memory are applied for directional decision. If the CB gets manual close command, and the voltage is below this level, then the SOTF logic gets active. |

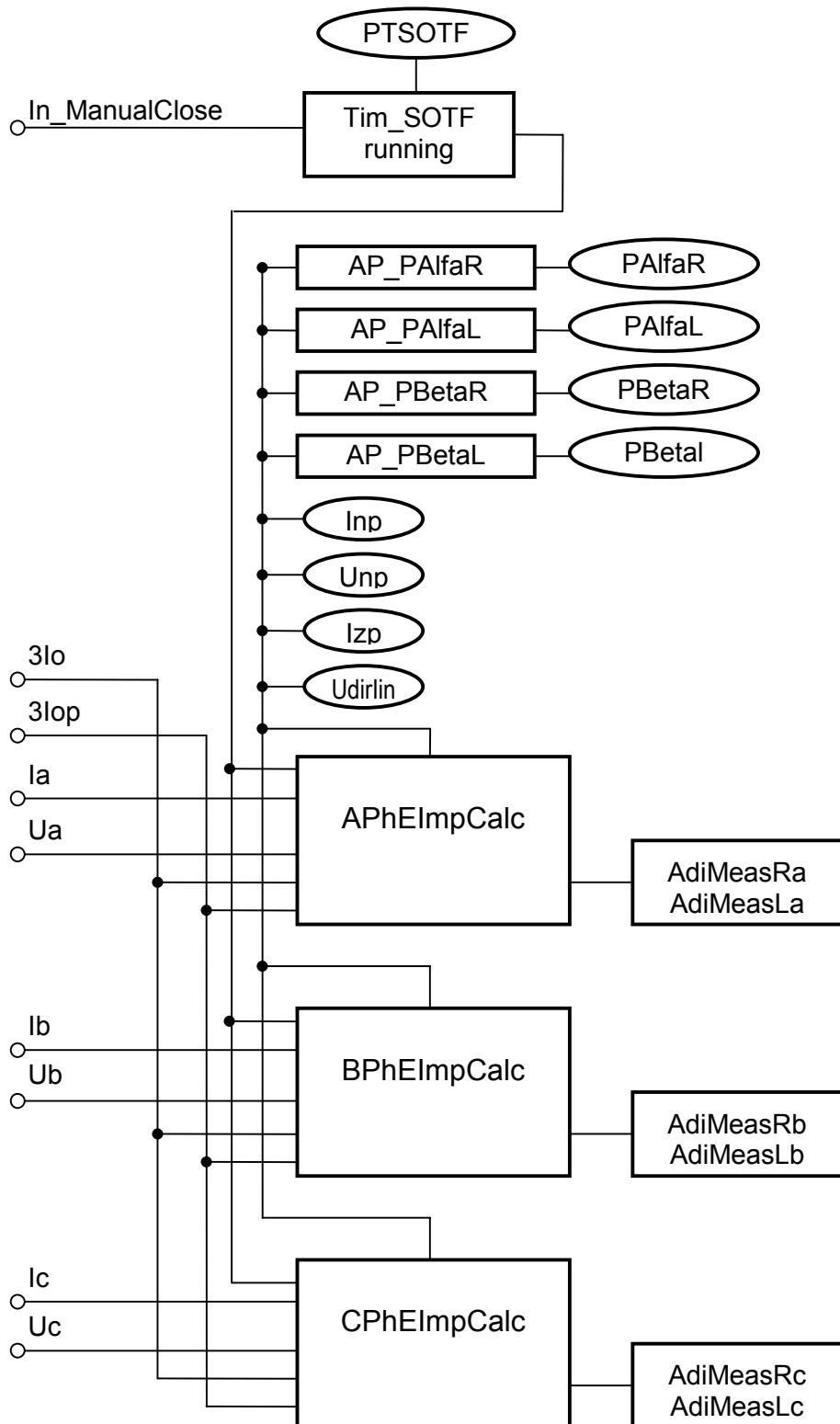
## *Outputs*

Based on the measured voltages and currents the function calculates the components of the impedances:

- AdiMeasRy (y=a,b,c) resistance component of the indicated phase “a”-earth loop expressed in secondary ohm value and multiplied with the “Cu, Ci” factors,
  - AdiMeasXy (y=a,b,c) resistance component of the indicated phase “a”-earth loop expressed in secondary ohm value and multiplied with the “Cu, Ci” factors.

(The “Cu, Ci” factors depend on the input VT and CT measuring transformers.)

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# Zline\_Calc\_3point\_3Ph

## **Task of the function**

This function calculates the impedances of the three phase-phase loops.

The theoretical formula to calculate the complex impedance is:

$$Z_{Ph\_Ph} = \frac{U_{line}}{I_{line}}$$

where

- |            |  |
|------------|--|
| $U_{line}$ | the line voltage vectors ( $Ua-Ub$ , $Ub-Uc$ , $Uc-Ua$ ) (See Make_3Ph_line_U function)    |
| $I_{line}$ | the line difference vectors ( $Ia-Ib$ , $Ib-Ic$ , $Ic-Ia$ ) (See Make_3Ph_line_I function) |

The method of calculation is solving the differential equation of the faulty loop.

The impedances are calculated with three sampled current and voltage values just after the zero crossing of the current difference. This method ensures correct calculated values even with serious current transformer saturation.

The calculation is enabled, if the current value is above the pre-determined current limit. This avoids division by zero, and avoids errors caused by division with small and noisy sampled current values.

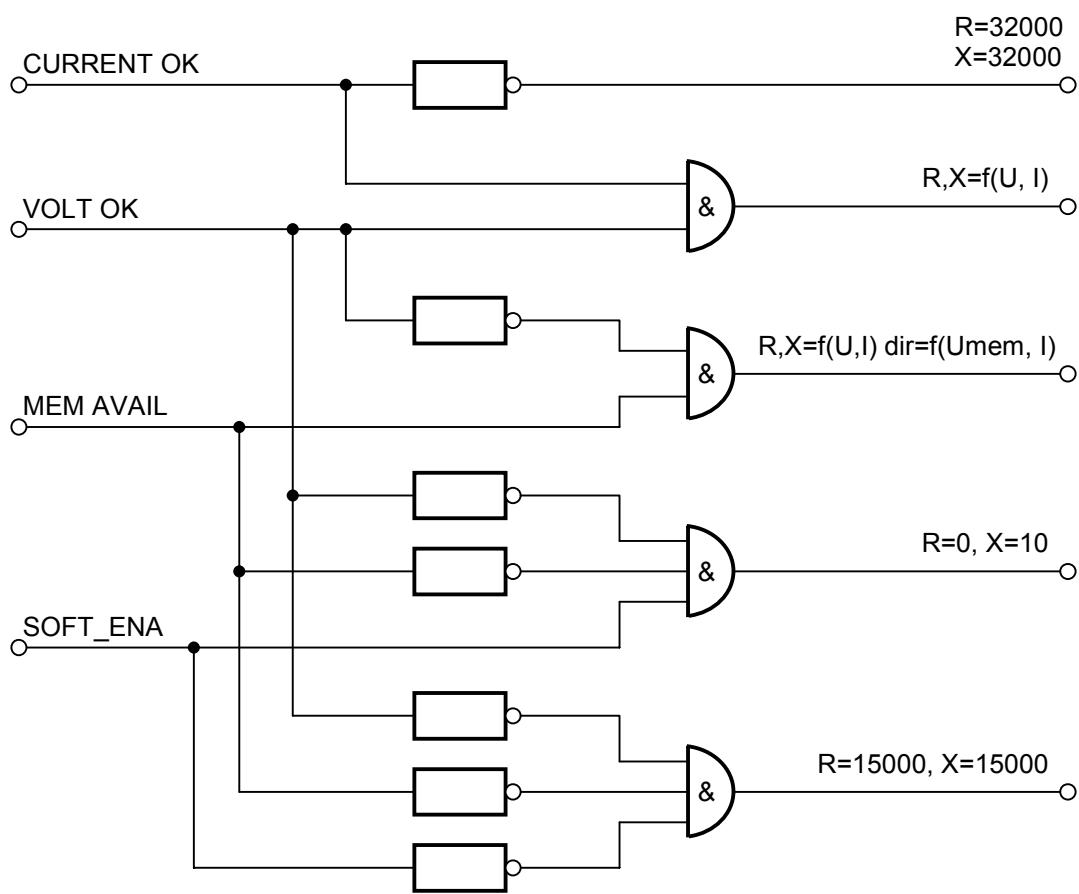
If the voltage is small because of close-in faults, the direction of the fault is decided based on pre-fault voltage samples, stored in the memory. The application of stored voltages is enabled if the voltage is below the pre-determined voltage limit.

In case of switch-onto-fault (SOTF) no voltages are stored in the memory. In this case – after a manual close command to the circuit breaker – the switch-onto-fault logic is enabled for a time span, determined by a parameter value.

The following Figure shows the principal scheme of the internal logic for the impedance calculation. The decision needs three internal logic signals, (CURRENT\_OK, VOLT\_OK and MEM\_AVAIL) and additionally a logic parameter setting SOTF\_ENA. The explanation of these signals is as follows:

Status signal	Explanation
CURRENT_OK	The current is suitable for impedance calculation in the processed loop, if after a zero crossing there are three sampled values above a defined limit
VOLT_OK	The voltage is suitable for the calculation, if among the last sampled three values there is a sample above the defined limit
MEM_AVAIL	This status signal is true, if the voltage memory is filled up with available samples above the defined limit for 80 ms.
SOTF_ENA	This logic parameter is true, if the “switch-onto-fault” logic is enabled.

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*Fig Z\_CALC internal logic*

The short explanation of the internal logic for the impedance calculation is as follows:

If the CURRENT\_OK status signal is false, the current is very small and so no fault is possible. In this case the impedance is set to extreme high values, and no further calculation is performed:

$$R=32000, X=32000 (*10 m\Omega).$$

The subsequent decisions are performed, if the current is sufficient for the calculation.

If the CURRENT\_OK status signal is true, and the VOLT\_OK status signal is true as well, then the current is suitable for calculation, and the voltage is sufficient for the directionality decision. In this case normal impedance calculation is performed based on the sampled currents and voltages. (The calculation method is explained later.)

$$R, X=f(u, i)$$

If the CURRENT\_OK status signal is true, but the VOLT\_OK status signal is false, it means that the directionality decision cannot be performed based on the available voltage signals. In

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this case the magnitude of R and X is calculated based on the sampled currents and voltages, but the direction of the fault (the +/- sign of R and X) must be decided based on voltage value stored in the memory 80 ms earlier. This decision is possible only, if there are stored values in the memory for 80 ms, and these values were sampled during a healthy period.

$$R, X = f(u, i) \quad \text{direction} = f(u_{\text{mem}}, i)$$

If the voltage is not sufficient for directional decision, and no stored voltage samples are available, then the SOTF\_ENA parameter is needed for the process: If the “switch-onto-fault” logic is enabled, then the fault is supposed to be just in front of the bus-bar in forward direction:

$$R=0, \quad X=10 (*10 m\Omega).$$

If the voltage is not sufficient for directional decision, and no stored voltage samples are available, and “switch-onto-fault” logic is not enabled, then the impedance is set to a high value:

$$R=15000, \quad X=15000 (*10 m\Omega).$$

The applied numerical method is solving the differential equation of the faulty loop, based on three consecutive samples.

## Inputs

The inputs of the function are

- the three line currents (phase current differences, produced by the *Make\_3Ph\_line\_I* function),
- the three line voltages (phase voltage differences, produced by the *Make\_3Ph\_line\_U* function).

## Parameters

The function needs the following parameters:

- PTSOTF delay time of the switch-onto-fault (SOTF) logic, expressed in ms,
- PNoAlfa constant parameter, because no mixing factor for the zero sequence current is needed.

LCD text	Min	Max	Step	Remark
SOTF delay= ms	0	60000	100	delay time of the switch-onto-fault (SOTF) logic

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The constants needed for the operation of the function are:

Inp	the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer,
Unp	the A/D sampled numerical value in case of the rated voltage peak sample. This value depends on the hardware; it is defined by the producer,
Izp	minimal current value, which is needed for impedance calculation,
UdirLim	minimal voltage value under which the sampled voltage values stored in the memory are applied for directional decision. If the CB gets manual close command, and the voltage is below this level, then the SOTF logic gets active.

The constant parameter needed for the operation of the function is:

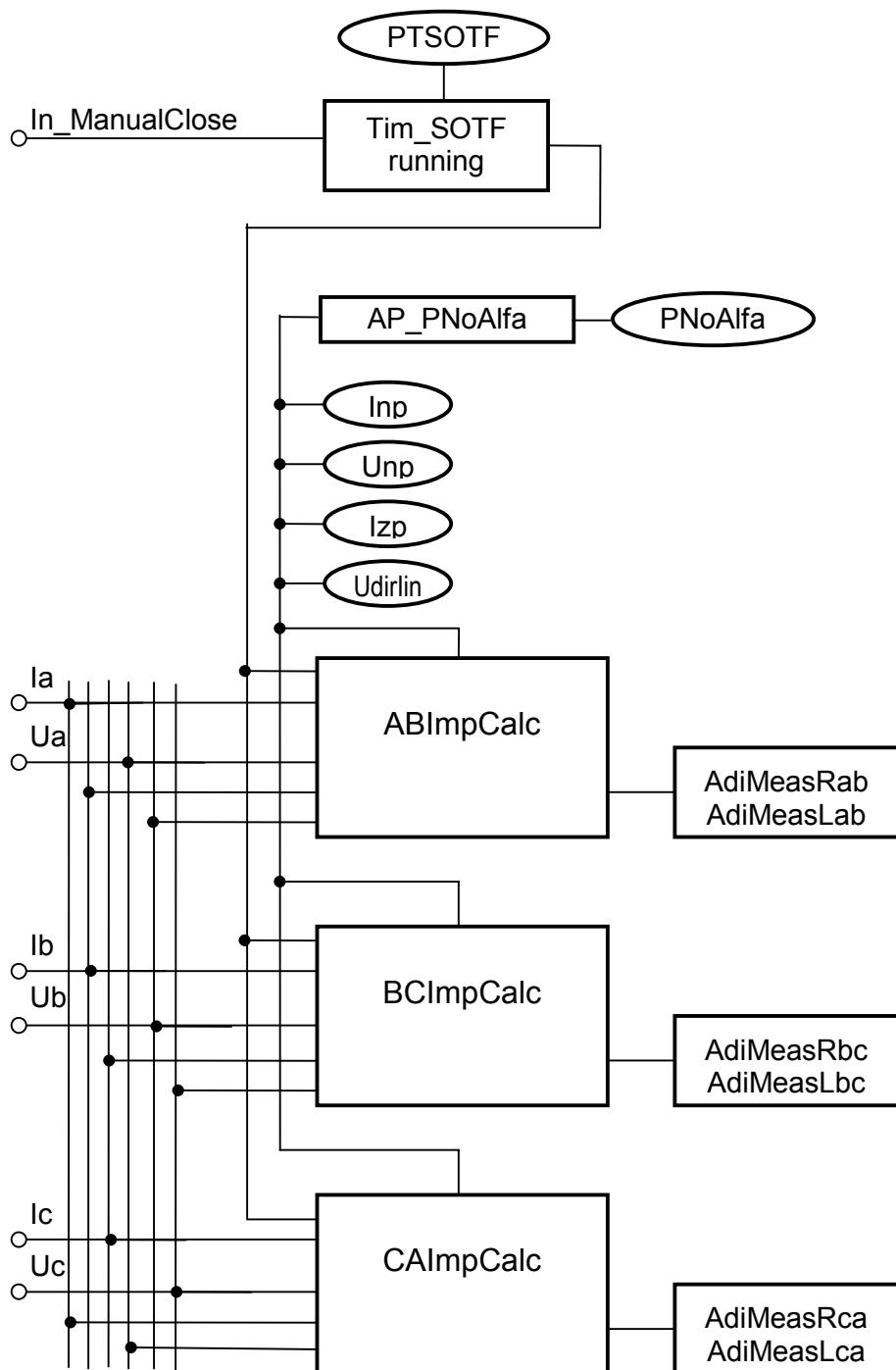
## **Outputs**

Based on the measured voltages and currents the function calculates the components of the impedances:

- AdiMeasRyz (yz=ab,bc,ca) resistance component of the indicated phase -phase loop expressed in secondary ohm value and multiplied with the “Cu, Ci” factors,
- AdiMeasXyz (yz=ab,bc,ca) resistance component of the indicated phase -phase loop expressed in secondary ohm value and multiplied with the “Cu, Ci” factors.

(The “Cu, Ci” factors depend on the input VT and CT measuring transformers.)

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# Bias\_ANSI50N

## **Task of the function**

This function is usually needed by the measuring loop selection of the distance protection functions. If considerable zero sequence current is present, then one of the phase-earth loops is faulty. In absence of zero sequence current the distance decision is based on measurement of phase-phase loops. This function supports this selection.

In the decision the basic harmonic Fourier component of the zero sequence current (calculated as the sum of the three phase currents) is compared to the biasing current. The zero sequence current must be above the base sensitivity, defined by the parameter (PIon) and above the line defined by the slope parameter (PfIo) and the biasing current. The biasing current is the maximum of the basic harmonic Fourier components of the phase currents.

## **Inputs**

The function uses the calculated basic harmonic components of the three phase currents, and the calculated basic harmonic components of the zero sequence current (3Io), which is calculated by the *MakeIo* function.

- $I_x_{FFT50Hz}$  ( $x=a,b,c$ ) the basic harmonic Fourier components of the three phase currents,
- $I_{FFT50Hz}$  the basic harmonic Fourier components of the  $3Io$  zero sequence current, calculated by the *MakeIo* function.

## **Parameters**

The function

- PIon the base sensitivity of the function, given is % of the CT rated input,
- PfIo the slope of the characteristics expressed in %.

LCD text	Min	Max	Step	Remark
$3Io>/In =$ %	10	50	2	the base sensitivity of the function, given is % of the CT rated input
$Io$ biasing = %	5	30	2	the slope of the characteristics expressed in %

The constant needed for the operation of the function is:

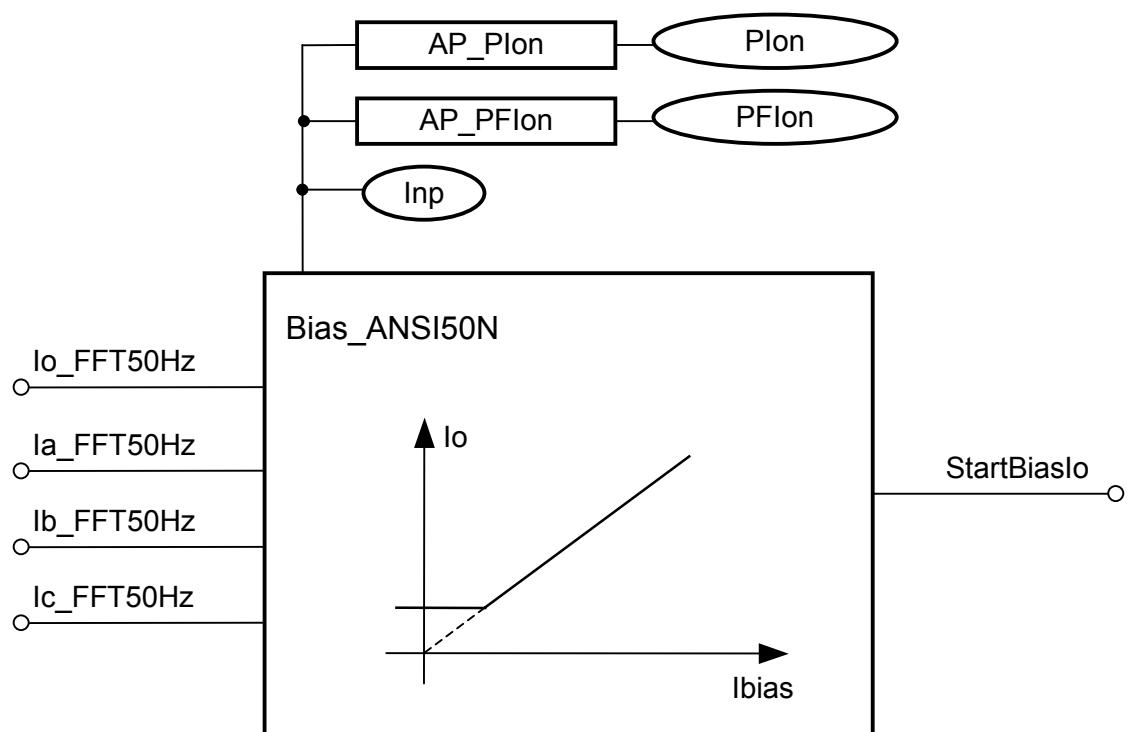
Inp the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer, (the same constant is applied e.g. by FFT\_CT\_3PH)

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## Outputs

The function has a single output:

- StartBiasIo which is an internal variable stating that the zero sequence current is above the defined characteristics.



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# HvDist1Zone

## Task of the function

This function decides if the calculated complex impedances of all fault loops are inside the polygon characteristics of the first impedance zone, and performs phase selection as well. This stage performs all decisions after each impedance calculations (within 1 ms).

## Inputs

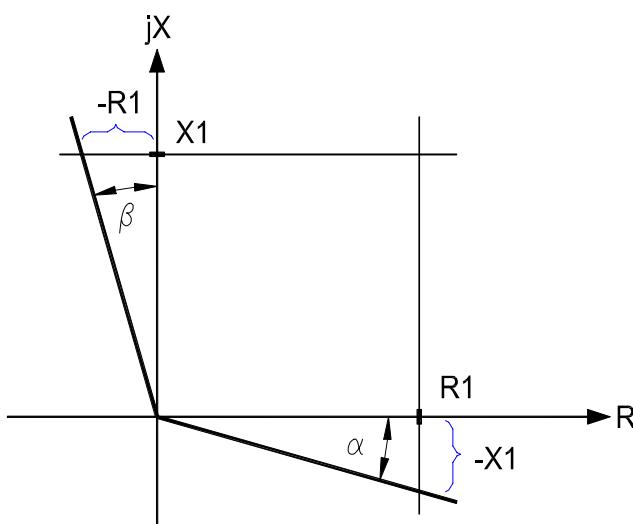
The function gets the complex impedance calculated by *Zline\_Calc\_3point\_3Ph* and *ZPhE\_Calc\_3point\_3Ph* library functions for all six fault-loops.

The function needs the results of the *Bias\_ANSI50N* function, which processes the zero sequence current to help phase selection: If considerable zero sequence current is present, then one of the phase-earth loops is faulty. In absence of zero sequence current the distance decision is based on measurement of phase-phase loops.

The function additionally needs the results of the three-phase overcurrent function *ANSI50\_3Ph* to avoid errors in decision if no voltage and no current is present.

## Parameters

The function needs the parameters of the polygon characteristics:



- PZR setting value of the first zone polygon in R direction,
- PZX setting value of the first zone polygon in X direction,
- PZXperR slope of the polygon line for negative reactances ( $\alpha$ ),
- PZRperX slope of the polygon line for negative resistances ( $\beta$ ),
- PZDir parameter for selection of forward or reverse direction.

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LCD text	Min	Max	Step	Remark
R [mOhm] = [*10*Cu*Ci]	10	10000	10	setting value of the first zone polygon in R direction *
X [mOhm] = [*10*Cu*Ci]	10	10000	10	setting value of the first zone polygon in X direction *
-X/R = %	0	50	1	slope of the polygon line for negative reactances
-R/X = %	0	50	1	slope of the polygon line for negative resistances
Zdir(0=forward)=	0	1	1	parameter for selection of forward or reverse direction

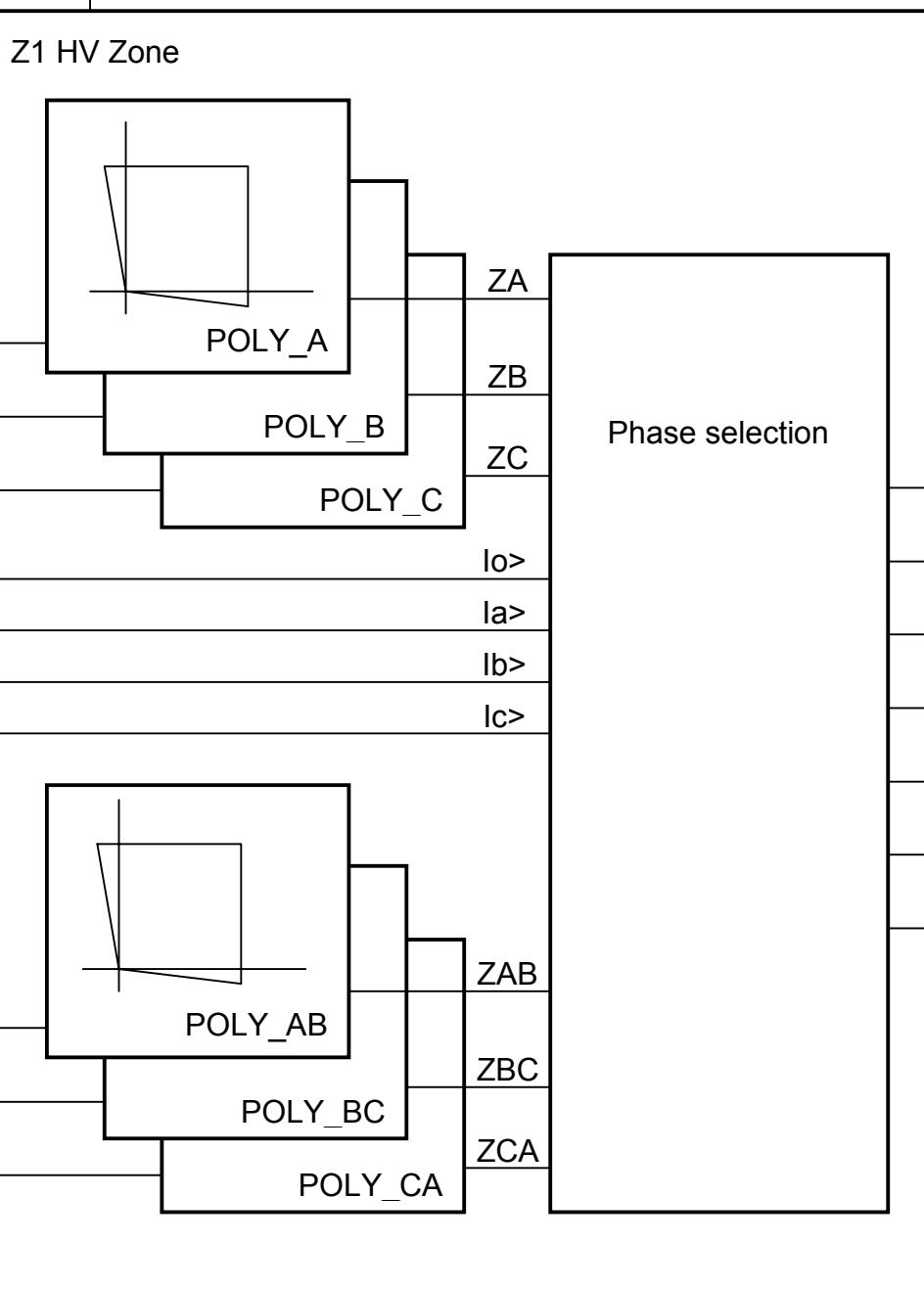
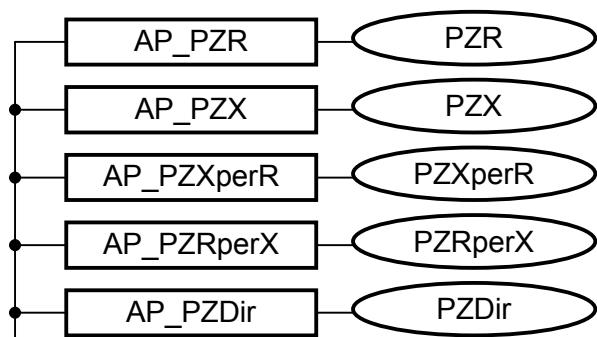
\* The value can be calculated in secondary ohms by multiplying with 10 and with the *Cu* and *Ci* factors, which depend on the rated secondary values of the voltage transformer and that of the current transformer.

## Outputs

The function has seven internal status variables, out of which only one can be active:

- AdiStZ13Ph indicating three-phase fault,
- AdiStZ1ab indicating AB fault,
- AdiStZ1bc indicating BC fault,
- AdiStZ1ca indicating CA fault,
- AdiStZ1a indicating A phase fault,
- AdiStZ1b indicating B phase fault,
- AdiStZ1c indicating C phase fault.

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The **phase selection logic** can be explained with the following figures:

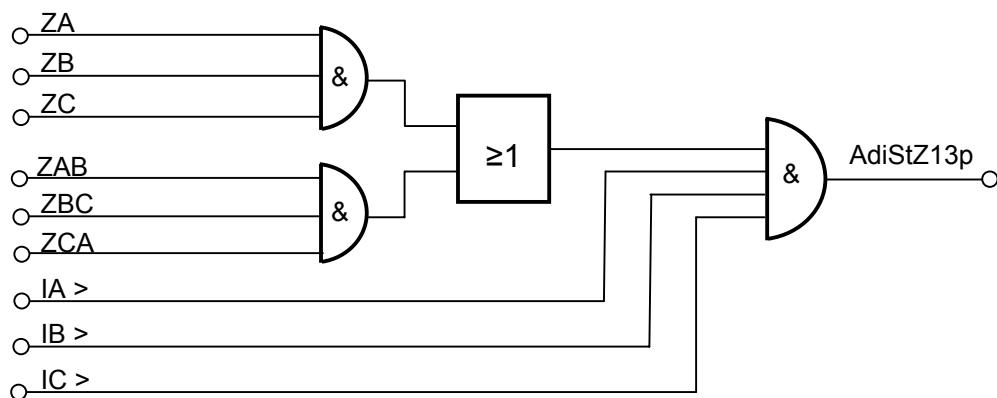
### Detection three phase fault

The processing of logic diagrams in the following Figures is sequential. If the result of one of them gets true, no further processing is performed.

The following Figure shows that if

- all three phase-earth loops caused start of the polygon impedance logic,
- or all three phase-phase loops caused start of the polygon impedance logic,
- and the currents in all three phases are above the setting limit,

then three phase fault is detected, and no further check is performed.



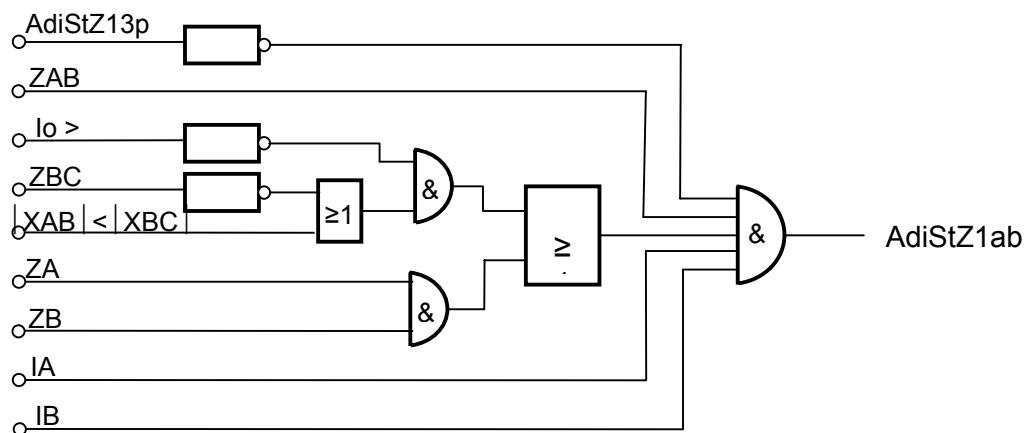
*FigThree phase fault detection*

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## Detection “AB”, “BC”, “CA” faults

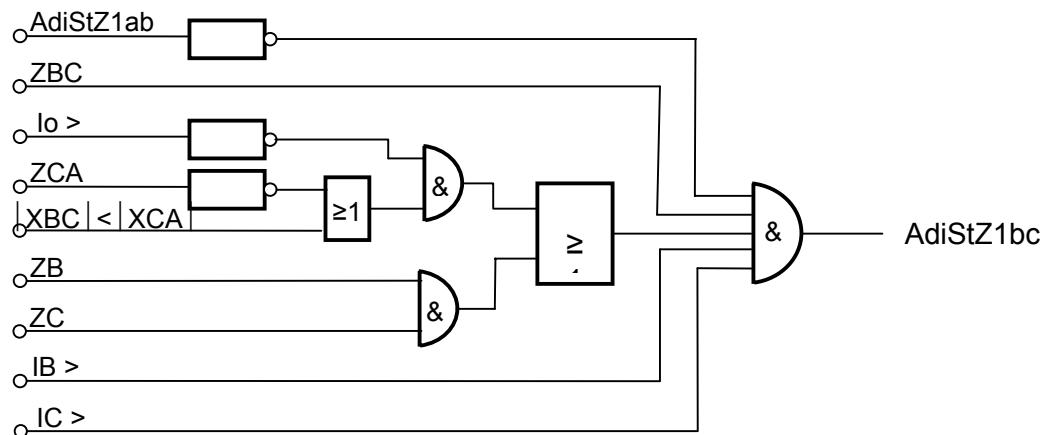
The following Figure explains detection of phase-to-phase fault between phases “A” and “B”:

- no three phase fault is detected,
- start of the polygon impedance logic in the loop “AB”,
- “OR” relation of the following logic states:
  - no zero sequence current above the limit, and no start of the polygon logic in an other phase-to-phase loop or the loop “AB” detects the lowest reactance, or
  - start of the polygon impedance logic in the loops “A” and ”B” individually as well,
- the currents in the involved phases are above the setting limit.



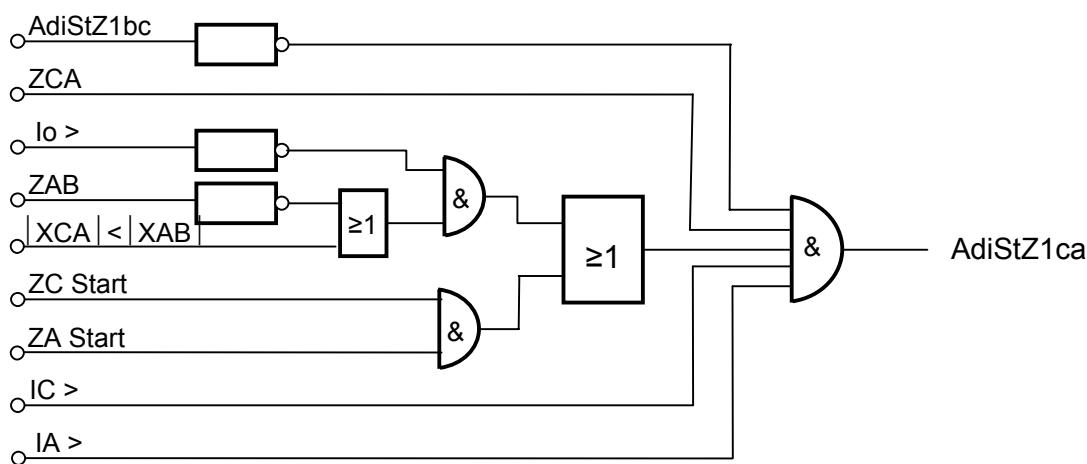
*Fig AB fault detection*

Fig. 5.c and Fig. 5.d show similar logic for the loops “BC” and “CA” respectively.



*Fig. BC fault detection*

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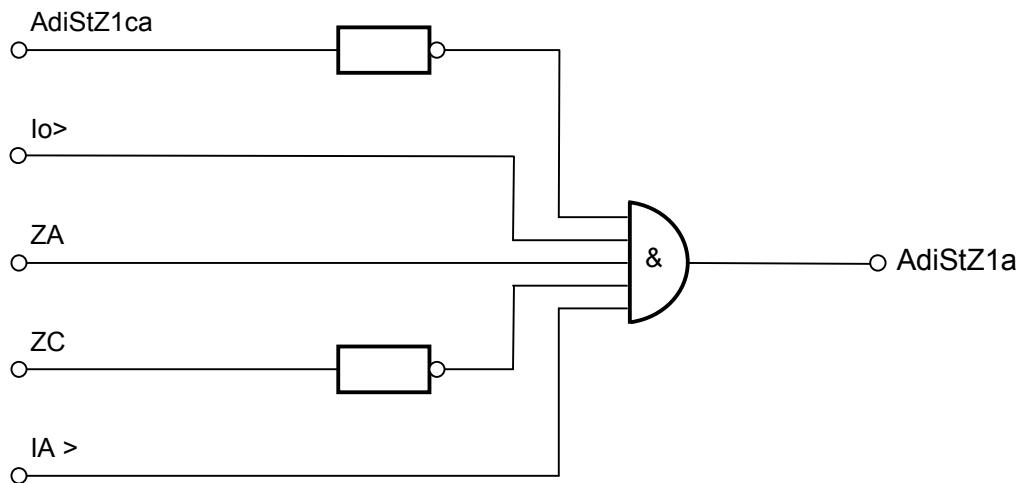


*Fig. CA fault detection*

### Detection “A”, “B”, “C” faults

The following Figure explains detection of phase-to-ground fault in phase “A”:

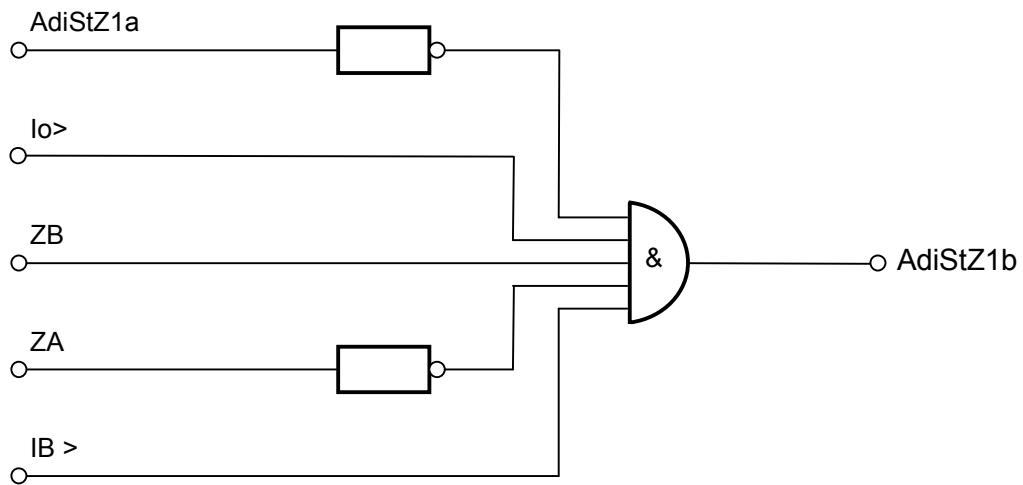
- no fault between phases “C” and “A” is detected,
- the zero sequence current above the limit,
- start of the polygon impedance logic in the loop “A”,
- no start of the polygon logic in an other phase-to-ground loop,
- the current in the involved phase is above the setting limit.



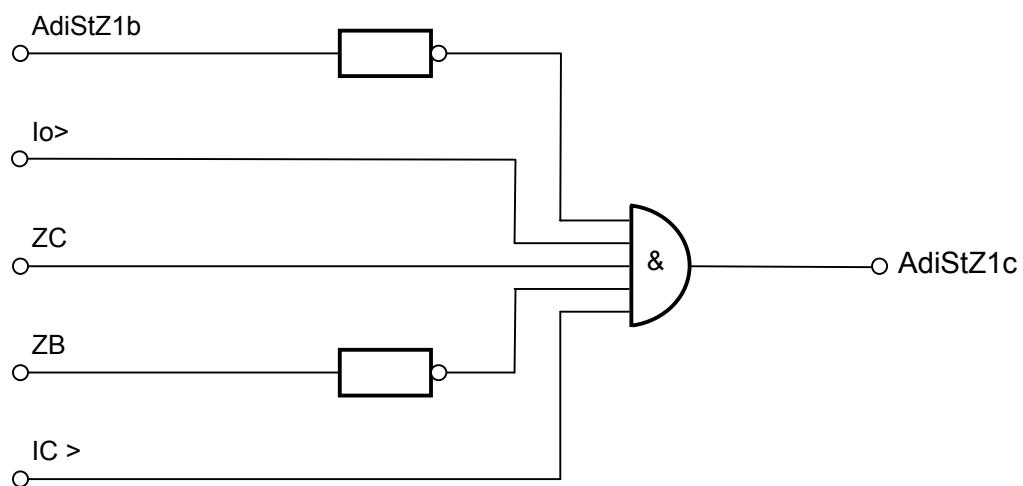
*Fig. A-N fault detection*

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The following figures show similar logic for the loops “B” and “C” respectively.



*Fig. B-N fault detection*



*Fig. C-N fault detection*

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## HvDist25Zone

### **Task of the function**

This function decides if the calculated complex impedance of a fault loop is inside the polygon characteristics of the second (or higher) impedance zone, and performs phase selection as well. This function is basically the same as function *HvDist1Zone* with the exception that this function calculates impedance after each zero crossing (in each 10 ms).

## HvDist25ZoneHTX

### **Task of the function**

This function decides if the calculated complex impedance of a fault loop is inside the polygon characteristics of the second (or higher) impedance zone, and performs phase selection as well. This function is basically the same as function *HvDist25Zone* with the exception that this function calculates distance relative to the line length.

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# PowSwingBlock

## **Task of the function**

This function can block operation of the distance zones during power swings.

Power swings are relatively slow phenomena. One period of the swing is in the “s” (second) range. During this time the symmetrical current increases and the symmetrical voltage decreases, which results that the calculated fault impedance slowly moves into the operating zones of the distance protection. A fault however is a sudden change in the network state, the calculated impedance “jumps” into the operating zones of the distance protection.

If during power swings the blocking of the distance protection for three-phase symmetrical faults is needed, this function can be applied. For asymmetrical faults this function allows operation of the distance protection function.

The realisation is as follows: there are two concentric circles on the impedance plane with the centre of the origin. The radius of both circles is defined by parameter setting. If the impedance calculated with the phase “A” voltage and current (symmetrical state is supposed) is between these two circles for at least the time period determined by parameter setting, then the power swing blocking gets active until time-out, according to parameter setting.

## **Inputs**

The function measures the phase “A” voltage, as calculated e.g. by the *Ua\_FFT50Hz* function and the phase “A” current as calculated e.g. by the *Ia\_FFT50Hz* function, and calculates the absolute value of the impedance.

## **Parameters**

The function needs the following parameters:

- PPsBlZ1      radius of the inner circle on the impedance plane,
- PPsBlZ2      radius of the outer circle on the impedance plane,
- PPsBlT1      time during which the calculated impedance should be between the circles to activate power swing blocking,
- PpsBlTimOut maximum duration of the blocking.

LCD text	Min	Max	Step	Remark
Z1 (PSwBl) = [*10mOhm*Cu*Ci]	1000	10000	10	Radius of the inner circle
Z2 (PSwBl) = [*10mOhm*Cu*Ci]	1000	10000	10	Radius of the outer circle
t [PSwBl.Sart] = ms	100	60000	10	time during which the calculated impedance should be between the circles to activate power swing blocking
t [timeout PSwBl] = ms	100	60000	10	maximum duration of the blocking

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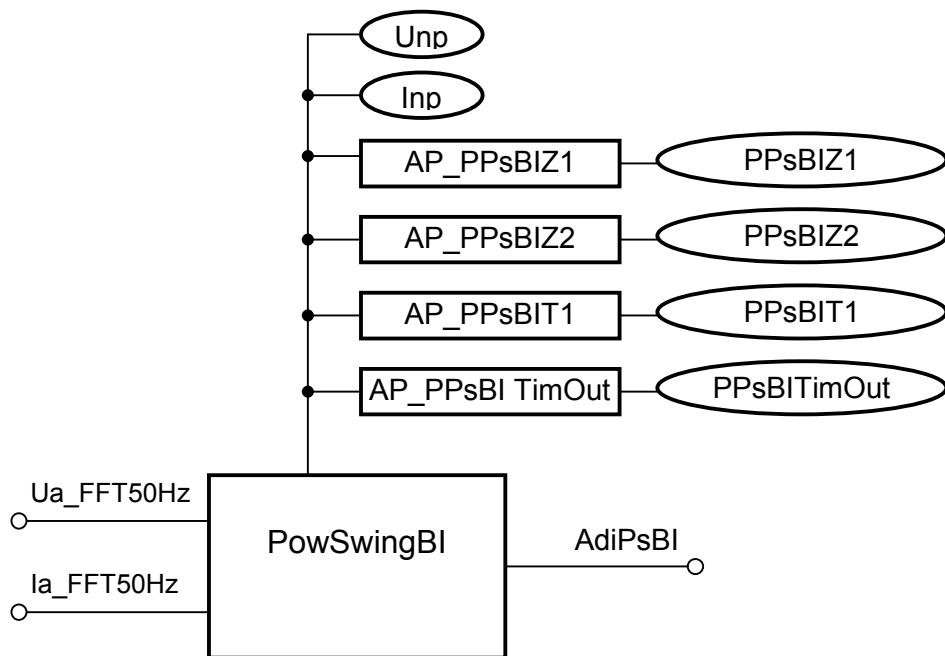
The constants needed for the operation of the function are:

- Inp                    the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer, (the same constant is applied e.g. by FFT\_CT\_3PH)
- Unp                    the A/D sampled numerical value in case of the rated voltage peak sample. This value depends on the hardware; it is defined by the producer, (the same constant is applied e.g. by FFT\_VT\_3PH)

### Outputs

The function has one output only:

- AdiPsBl                    which is the status variable for power swing blocking.



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# VTS

## Task of the function

This function realises voltage transformer supervision. If the fuse in one of the voltage transformer secondary circuits blows out, then zero sequence voltage is detected. If at the same time no zero sequence current component or negative sequent current component is measured, then the false zero sequence voltage component is caused by not asymmetrical faults, but by error in the VT secondary circuit.

## Inputs

The function processes the result of

- the basic harmonic Fourier component of the zero sequence current (See FFT\_CT\_1Ph),
- the basic harmonic Fourier component of the zero sequence voltage (See FFT\_VT\_1Ph),
- the basic harmonic Fourier component of the zero sequence current (See InegSequFilter3Ph).

Setting the following logic variable with Protlog equation can disable the VTS function:

- VTSDisable.

## Parameters

The function needst the following parameters:

- PIo\_VTS zero sequence current limit for VTS function,
- PI2\_VTS negative sequence current limit for VTS function,
- PUo zero sequence voltage limit for VTS function

LCD text	Min	Max	Step	Remark
Io>VTS/In [CT] = %	100	500	2	zero sequence current limit
Uo>VTS/Un [VT] = %	10	100	1	zero sequence voltage limit
I2>VTS/In [CT] = %	10	100	2	negative sequence current limit

The constants needed for the operation of the function are:

PUType_VTS	constant parameter for selection overvoltage function,
POVER	constant parameter for selection overcurrent function,
Inp	the A/D sampled numerical value in case of the rated current peak sample. This value depends on the hardware; it is defined by the producer, (the same constant is applied e.g. by FFT_CT_3PH)
Uonp	the A/D sampled numerical value in case of the rated voltage peak sample. This value depends on the hardware; it is defined by the producer,

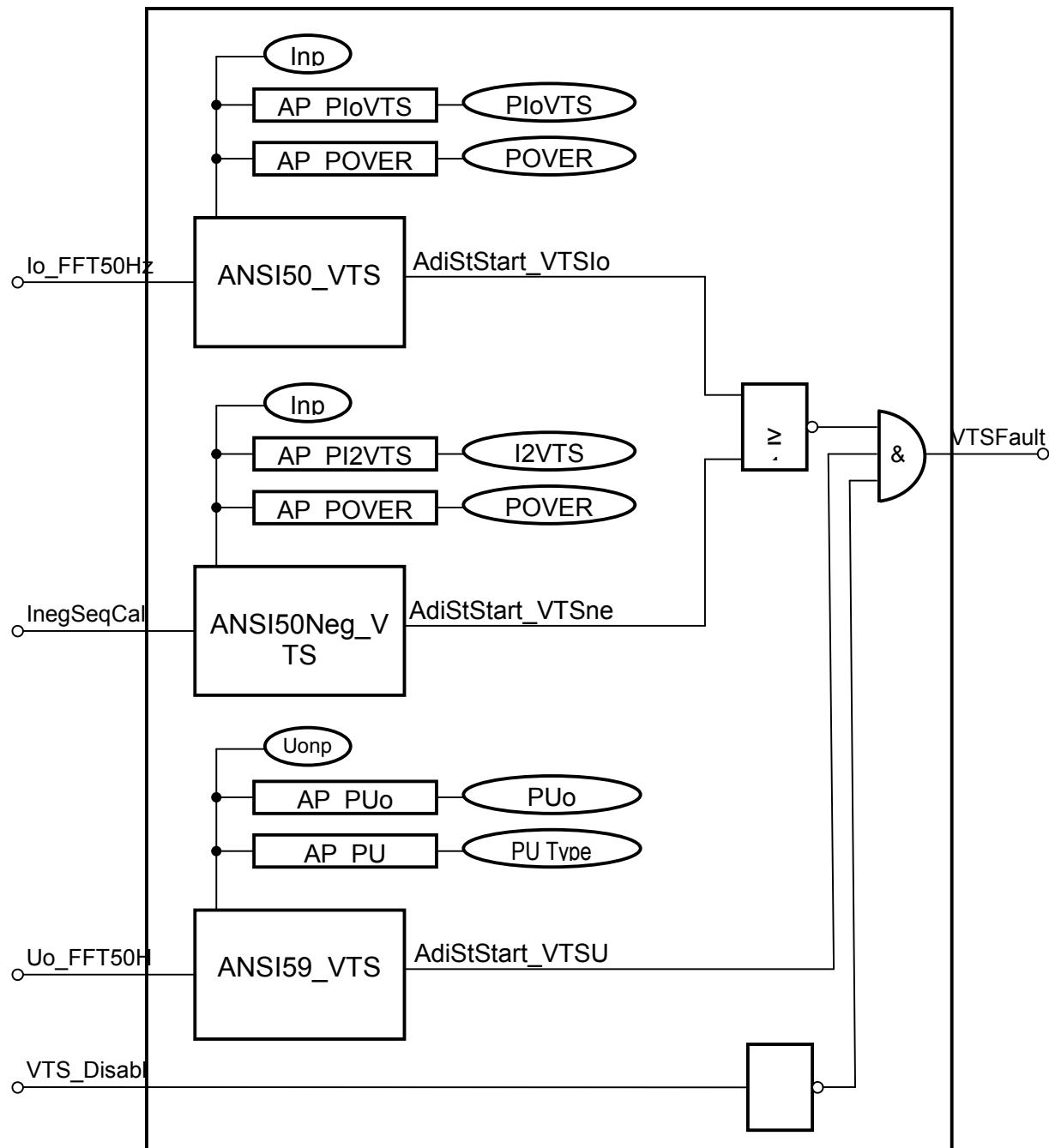
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## Outputs

The function has a single digital output, which is active if the VTS function is not disabled, there is zero sequence voltage over the limit, and there is no zero or negative sequence current above the limit:

- VTSFault status variable announcing detected VTS fault.

## VTS



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# PQCalc3Ph

## ***Task of the function***

This function calculates active and reactive power individually for the three phases.

## ***Inputs***

The function processes the basic harmonic components of the phase voltages and phase currents (See e.g. FFT\_VT\_3Ph, FFT\_CT\_3Ph)

## ***Parameters***

The function calculates the power values related to the CT and VT rated values. It needs the following constant parameters to scale the calculated power values:

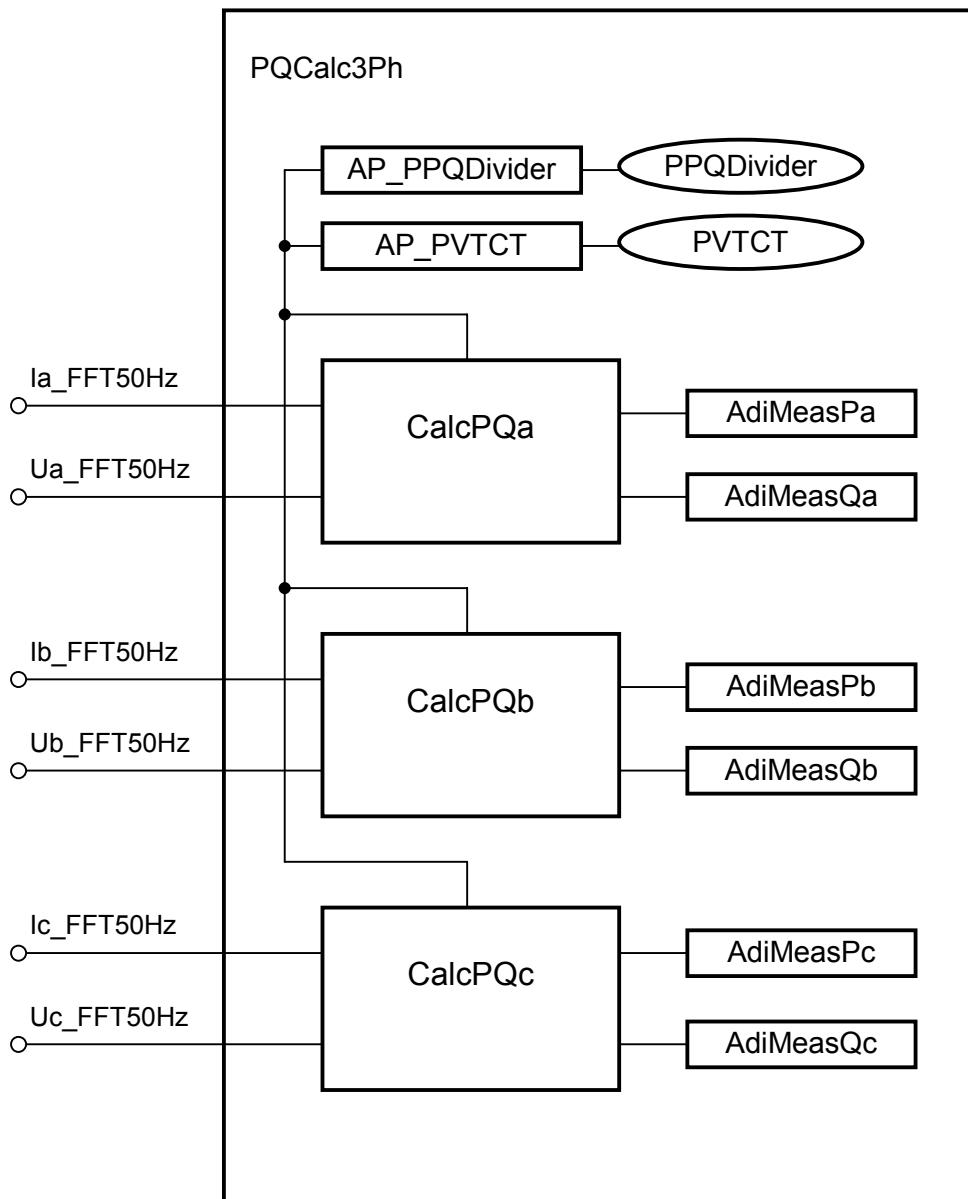
PVTCT	the multiplier factor for the calculated power values,
PPQDivide	the divider factor for the calculated power values.

If the multiplier factor is 1000 and the divider factor is 1, then the power values are displayed in pro-mill, related to the rated VT and CT values.

## ***Outputs***

- The function calculates active and reactive power for the three phases.

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