

## FUNCTION BLOCK DESCRIPTION

# Underfrequency protection

ANSI 81U, IEC  $F_{<}$ ,  $F_{<<}$



DOCUMENT ID: PP-13-21379  
VERSION: 3.0  
2024-12-20, BUDAPEST

PROTECTION, AUTOMATION AND  
CONTROL FOR POWER INDUSTRY

## VERSION INFORMATION

VERSION	DATE	MODIFICATION	COMPILED BY
Preliminary	2009-11-24	Preliminary version, without technical information	Petri
	2010-10-05	Naming revision	Csipke
1.0	2010-11-11	First edition	Petri
1.1	2016-12-21	Technical data table updated, minor formatting	Erdős
1.2	2017-06-08	Min. operate time lowered	Erdős
2.0	2019-06-05	Technical data table updated according to IEC 60255-181 tests; new design (parameter listing updated, new look), event list added, notes for testing added	Erdős
2.1	2020-02-11	On-line data table corrected	Erdős
2.2	2021-04-13	<b>Modified:</b> <ul style="list-style-type: none"> <li>• 2.3 Technical data updated</li> <li>• 0</li> <li>• Notes for testing</li> <li>• Description of parameter U limit added</li> </ul>	Tóth F., Seida Z.
3.0	2024-12-20	<b>Added:</b> <ul style="list-style-type: none"> <li>• Graphic analogue input</li> <li>• IEC61850 data attributes</li> </ul> <b>Modified:</b> <ul style="list-style-type: none"> <li>• Technical data updated with accuracy data applying CVS module</li> <li>• Additional notes for graphic analogue inputs</li> <li>• Minor corrections</li> </ul>	Seida, Ádám, Erdős

## CONTENTS

1	Application .....	4
1.1	Mode of operation .....	4
2	Overview .....	5
2.1	Settings .....	5
2.1.1	Parameters .....	5
2.2	Function I/O.....	6
2.2.1	Analogue inputs .....	6
2.2.2	Analogue outputs (measurements) .....	6
2.2.3	Binary input signals (graphed output statuses) .....	6
2.2.4	Binary output signals (graphed input statuses) .....	6
2.2.5	Online data .....	6
2.2.6	Events .....	7
2.3	Technical data.....	8
2.3.1	Notes for testing.....	9

# 1 Application

The deviation of the frequency from the rated system frequency indicates unbalance between the generated power and the load demand. If the available generation is small compared to the consumption by the load connected to the power system, then the system frequency is below the rated value. The underfrequency protection function is usually applied to increase generation or for load shedding to control the system frequency.

Another possible application is the detection of unintended island operation of distributed generation and some consumers. In the island, there is low probability that the power generated is the same as the consumption; accordingly, the detection of low frequency can be one of the indications of island operation.

## 1.1 Mode of operation

Depending on the hardware-software configuration, the frequency measurement is usually based on channel No. 1 (line voltage) and channel No. 4 (busbar voltage) of any voltage input module.

The accurate frequency measurement is performed by measuring the time period between two rising edges and also between two falling edges at zero crossing of a voltage signal. The frequency value is calculated by the average of these two values. At each zero crossing the average value (and the frequency) is recalculated.

For the acceptance of the measured frequency, at least four subsequent valid measurements are needed. Similarly, four invalid measurements are needed to reset the measured frequency from the last valid value to zero.

The minimum voltage condition can be set as a parameter for enabling the evaluation of the frequency. This parameter is called U limit.

The underfrequency protection function generates a start signal if at least five measured frequency values are below the preset level.

## 2 Overview

The graphic appearance of the function block of the underfrequency protection function is shown below. The block shows all binary input and output status signals which are applicable in the graphic equation editor.

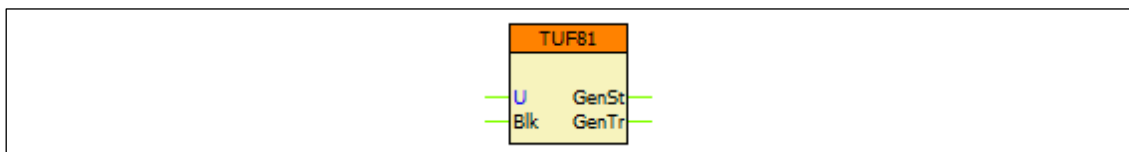


Figure 2-1 Graphic appearance of the function block of the underfrequency protection function

### 2.1 Settings

#### 2.1.1 Parameters

The available parameters are listed below in order of their appearance in the *parameters* menu. If the setting range of a parameter should be extended, contact Protecta Support.

Table 2-1 Parameters of the underfrequency protection function

TITLE	DIM	RANGE	STEP	DEFAULT	EXPLANATION
Operation	-	Off, On	-	Off	Enabling the function
Start Signal Only	-	FALSE, TRUE	-	FALSE	Enabling start signal only
Start Frequency	Hz	40.00 – 70.00	0.01	49.00	Setting value of the comparison
U limit	*Un	0.10 – 1.00	0.01	0.45	Minimum voltage condition for enabling the operation of the function
Time Delay	msec	140* – 60000	1	200	Time delay (including the algorithm time, see Chapter 0 for more explanation)

*\*The minimum operate time is lower than the settable minimum delay, however below this value the timing is less accurate, see Chapter 2.3 for details*

## 2.2 Function I/O

This section describes briefly the analogue and digital inputs and outputs of the function block.

### 2.2.1 Analogue inputs

#### Graphic Analogue inputs (*only from firmware version 2.10.2.3010 and up*)

The sources of the analogue inputs are defined by the user, applying the graphic equation editor (*Logic Editor*). Parts written in **bold** are seen on the left side of the function block in the Logic editor.

The function uses the sampled values of a voltage input or a calculated line-to-line voltage. This is defined in the configuration.

Table 2-2 The analogue input signal of the underfrequency protection function

ANALOGUE INPUT SIGNAL	SIGNAL TITLE	EXPLANATION
TUF81_U_AnIn	Voltage	Input for voltage

The applied analogue connectors must be identical to the analogue input type (i.e. voltage to voltage input etc.), Invalid connections are not allowed

### 2.2.2 Analogue outputs (measurements)

The frequency measurement is displayed *MXU\_F* – frequency measurement function which is an independent function.

### 2.2.3 Binary input signals (graphed output statuses)

The conditions of the binary inputs are defined by the user, applying the graphic equation editor (*Logic Editor*). Parts written in **bold** are seen on the left side function block in the Logic editor.

Table 2-3 The binary input signal of the underfrequency protection function

BINARY INPUT SIGNAL	EXPLANATION
TUF81_Blk_GrO_	Blocking input of the function

### 2.2.4 Binary output signals (graphed input statuses)

These signals can be used in EuroCAP to assign to LED, user LCD object etc. Parts written in **bold** are seen on the right side of the function block in the *Logic Editor*.

Table 2-4 The binary output signals of the underfrequency protection function

BINARY OUTPUT SIGNAL	SIGNAL TITLE	EXPLANATION
TUF81_GenSt_Grl_	General Start	General start signal of the function
TUF81_GenTr_Grl_	General Trip	General trip command of the function

### 2.2.5 Online data

Visible values on the *online data* page.

Table 2-5 Online displayed data of the underfrequency protection function

SIGNAL TITLE	DIMENSION	EXPLANATION
General Start	-	General start signal of the function
General Trip	-	General trip command of the function
<i>Voltage input assignment</i>	-	<i>Status of the graphical analogue input (if exists) (Complete if OK, Missing if not connected)</i>

## 2.2.6 Events

The following events are generated in the event list, as well as sent to the SCADA according to the configuration.

**Table 2-6 Generated events of the underfrequency protection function**

EVENT	VALUE	EXPLANATION	IEC61950 DATA ATTRIBUTES
General Start	off, on	General start of the function	TUF81PTUF1\$ST\$Str
General Trip	off, on	General trip command of the function	TUF81PTUF1\$ST\$Op

## 2.3 Technical data

The technical data, except for the min. operate voltage, are based on the function block testing according to the directives of the **IEC 60255-181:2019** standard.

**Table 2-7 Technical data of the underfrequency protection function**

FUNCTION	VALUE	ACCURACY
Operate range	40 - 60 Hz (50 Hz system)	± 3 mHz (20 mHz*) with VT+/xxxx voltage transformer input module ± 3 mHz (70 mHz*) with CVS+/xxxx sensor input module
	50 - 70 Hz (60 Hz system)	± 3 mHz (20 mHz*) with VT+/xxxx voltage transformer input module ± 3 mHz (90 mHz*) with CVS+/xxxx sensor input module
Effective range	45 - 55 Hz (50 Hz)	± 3 mHz (10 mHz*) with VT+/xxxx voltage transformer input module ± 3 mHz (60 mHz*) with CVS+/xxxx sensor input module
	55 - 65 Hz (60 Hz)	± 3 mHz (10 mHz*) with VT+/xxxx voltage transformer input module ± 3 mHz (80 mHz*) with CVS+/xxxx sensor input module
Min. operate time	93 ms (50 Hz) 73 ms (60 Hz)	± 32 ms ± 27 ms
Time delay	140 – 60000 ms <140 ms (50 Hz) <140 ms (60 Hz)	± 4 ms ± 32 ms ± 27 ms
Reset frequency	[Start freq.] + 101 mHz	± 1 mHz
Reset time	98 ms (50 Hz) 85 ms (60 Hz)	± 6 ms
Reset ratio for U limit	0.8	

*\*with the harmonic content according to the standard*

### 2.3.1 Notes for testing

Normally in the EuroProt+ devices the trip contacts are assigned to the Trip Logic function block, and not to the protection function blocks. Because of this, the testing personnel must make sure that the Trip Logic is switched on ('Operation' parameter is set to other than 'Off') before starting the tests, otherwise there will be no physical trip on the relay.

Note that the time delay parameter incorporates the algorithm time as well, so the time delay *does not mean the time difference between the appearance of the start and trip signals* of the function. In other words: it is not the delay between the detection of the fault and the trip that follows it. This should be taken into consideration when checking the disturbance records.

Instead the time delay parameter defines the elapsed time from the appearance of the faulty state to the trip. Because of this, while testing, the delay measurement should start *from the moment of the fault injection* until the trip signal.

The source voltage for frequency measurement is defined by the voltage input of the functionblock. This can be checked in the functionblock properties in EuroCAP.

Before the fault injection at least 1 second pre-fault should be simulated with nominal frequency and voltage.

Based on IEC 60255-181 standard recommendations, the operation time shall be measured with a frequency of 0.5Hz lower than the setting value for Start frequency.

**Additional notes for Graphic Analogue inputs (only from firmware version 2.10.2.3010 and up):**

Starting from the firmware version **2.10.2.3010**, the majority of the function blocks can be updated to be equipped with graphic analogue inputs which **allow the user to assign the functions' analogue inputs by applying the graphic equation editor**.

The analogue connections of these functions can be checked by examining the source that is connected to their inputs (just like examining the source of a logic signal).

These functions must be placed in the Logic Editor and their graphic analogue inputs must be connected to make them operate. If a connection is intact, the online status of the corresponding analogue input will show "Complete". If it is missing, the status will be "Missing" and the function will not operate.



*Note that these graphical inputs do not exist in the earlier firmware/function versions (2.8.x.xxxx)! Checking and modifying the analogue assignments in these cases are done by using the EuroCAP Software Configuration menu.*