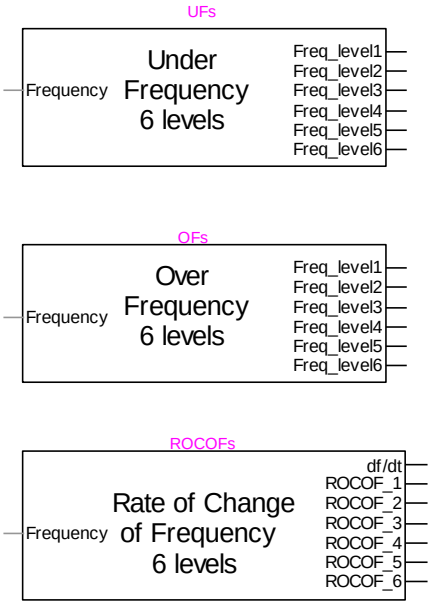
Protection: Frequency functions



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1 Introduction

These frequency functions follow the ANSI standards 81H (Overfrequency), 81L (Underfrequency) and 81R (ROCOF).
The frequency functions monitor the voltage frequency of the 3-phase power voltages. These functions are:

- Over frequency
- Under frequency
- Rate Of Change Of the Frequency (ROCOF)

Each function has 6 levels of settings with adjustable pickup and reset delays.
The 6 levels are also supervised by the minimum condition level applied on the magnitudes of the positive-sequence current and voltage.

2 Input data

2.1 Under/Over frequency

Some details for the parameters entered below are visible in Figure 2-1.

- **Number of Levels**: from 0 to 6. Include the function blocks in the relay. The 0 choice means that the related option is not active.
- **V1$_{min}$**: Minimum level of positive sequence voltage magnitude. Below this threshold, this element is disabled.
- **I1$_{min}$**: Minimum level of positive sequence current magnitude. Bewlo this threshold, the element is disabled.
- **Under/Over freq pkp *i***: Pickup value of frequency (in Hz) of the element of level *i*.
- **Pickup delay *i***: Pickup delay for the detection. Start when the minimum conditions on **V1$_{min}$** and **I1$_{min}$** are true and when the frequency reaches its pickup level.
- **Reset delay *i***: Reset delay after the pickup conditions described above are not true anymore.
- **Averaging *i***: Window length of the averaging in seconds. For more stability, the measured frequency is an average over the sliding window. The minimum value is 20 ms.

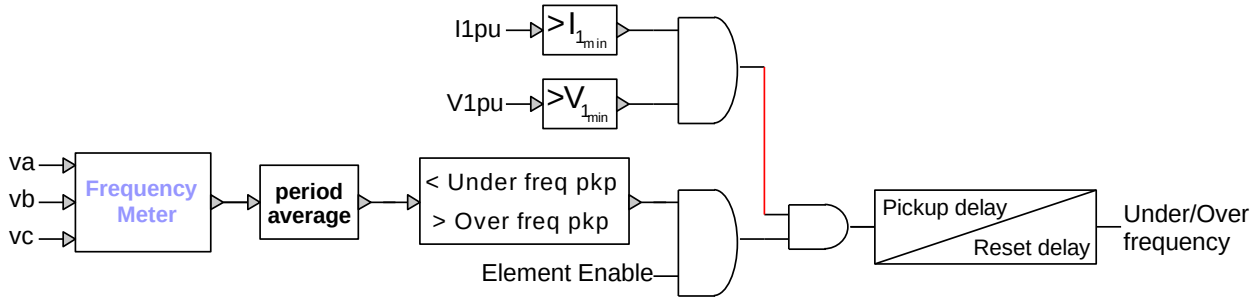

Figure 2-1 Under/Over frequency logic.

2.2 Rate Of Change Of Frequency (ROCOF)

- **Number of Levels**: from 0 to 6. Include the function blocks in the relay. The 0 choice means that the related option is not active.
- **V1$_{min}$**: Minimum level of positive sequence voltage magnitude. Under this threshold, the element is disabled.
- **I1$_{min}$**: Minimum level of positive sequence current magnitude. Under this threshold, the element is disabled.

For each level:

- **Detect for**: Select if the frequency variation detection is applied for Increasing, Decreasing or both ("Non-directional").
- **df/dt pkp *i***: pickup value of the absolute value of the rate of change of frequency for level *i*.
- **Freq min/max *i***: Minimum and maximum frequencies. If the frequency is out of this range, the element is disabled.
- **Pickup delay *i***: Pickup delay for the detection. Start when the minimum conditions on **V1$_{min}$** and **I1$_{min}$** are true, when the frequency is within the minimum and maximum values (specified above) and when the rate of change of frequency reaches its pickup level.
- **Reset delay**: Reset delay after the pickup condition described above are not true anymore.
- **Averaging *i***: Window length of the averaging in seconds. For more stability, the measured frequency is an average over the sliding window. The minimum value is 20 ms.

It is noticed that a hysteresis with a reset level of 95% of the pickup level is applied to the variation of frequency. Some details for the above inputs can be found in Figure 2-2.

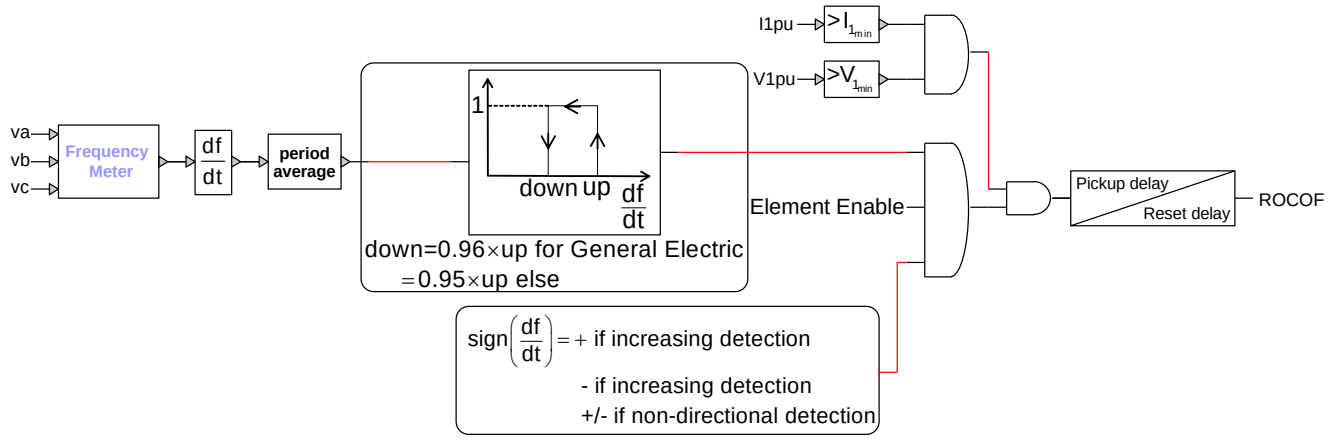

Figure 2-2 ROCOF logic.

3 Flags available in the tripping function and the output bundle of the relay

- OVER_FREQ_*i*: Over frequency detection of level *i*
- UND_FREQ_*i*: Under frequency detection of level *i*
- ROCOF_*i:* Rate of change of frequency detection of level *i*
- FreqI: Frequency calculated with the current input i
- angI: Angle of the positive sequence current for the fundamental frequency
- FreqV: Frequency calculated with the voltage input v
- angV: Angle of the positive sequence voltage for the fundamental frequency
- DfOverDt: derivative of FreqV

4 Scopes

The following scopes are located in the subcircuit: *RelayName/Control/Console*

- OVER_FREQ_*i*: Over frequency detection of level *i*
- UND_FREQ_*i*: Under frequency detection of level *i*
- ROCOF_*i:* Rate of change of frequency detection of level *i*
- FreqI: Frequency calculated with the current input i.
- angI: Angle of the positive sequence current for the fundamental frequency
- FreqV: Frequency calculated with the voltage input v.
- angV: Angle of the positive sequence voltage for the fundamental frequency
- DfOverDt: derivative of FreqV

5 Modifications

The protection functions are updated automatically. For example, for memory usage and computational speed considerations, if an entire element is disabled, the subcircuits associated to its functions are replaced by empty subcircuits with the same inputs and outputs. The outputs will be forced to zero or one. When enabled, the subcircuits can take different architectures considering the user choices. Some elements can be excluded if not enabled in the mask.

The updates are performed immediately after entering the parameters and clicking the OK button. The user should wait for the completion of tasks.

If the user wants to modify the subcircuit manually (for example, when adding new scopes), using in the GUI, and avoid the automatic updates of contents, the attribute DeviceVersion has to be set to “none” as shown

below. To access to this attribute, right click on the desired device, then go to Attributes and select DeviceVersion (see Figure below).
To allow the automatic updates again, just remove the “none” string.

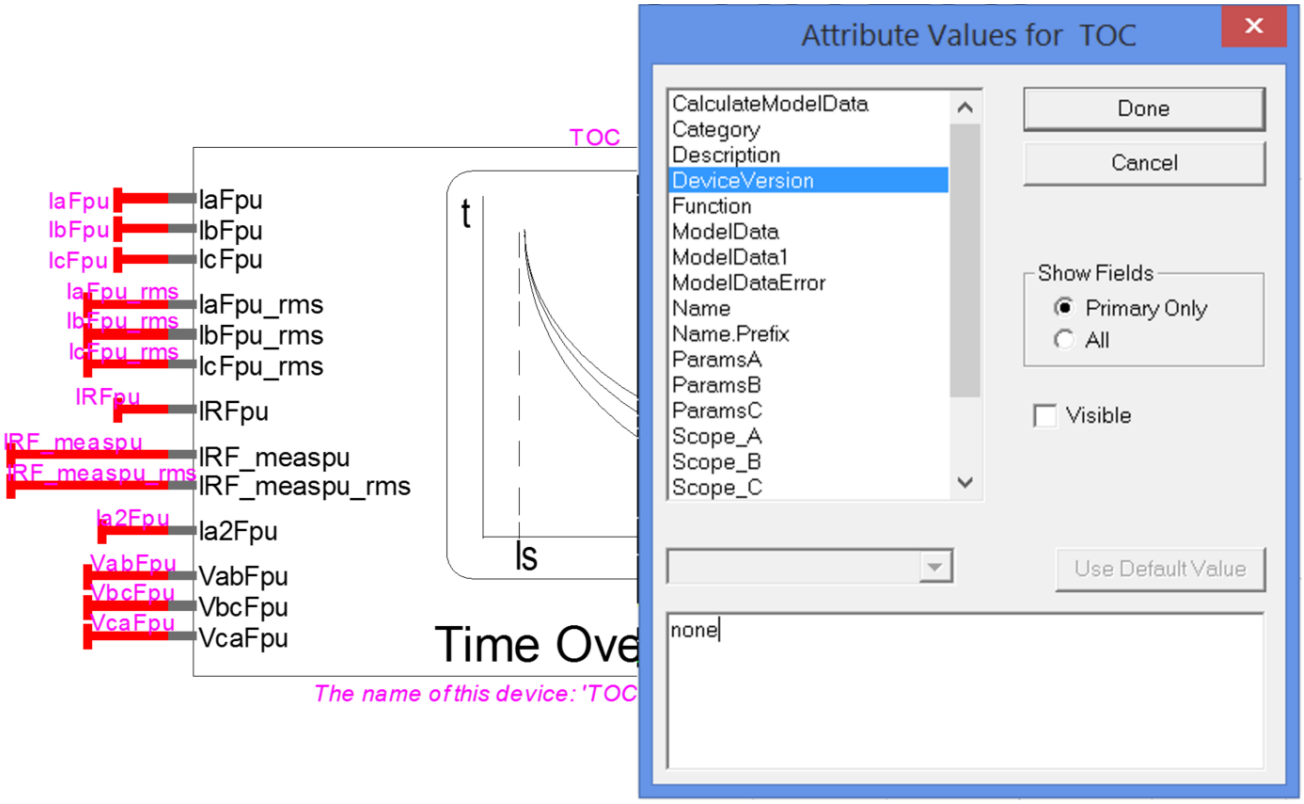

Figure 5-1: How to set the DeviceVersion attribute of the TOC element to allow modifications.

6 References:

[1] D60 Line Distance Protection System, chapter 5.6 p5-159, UR Series Instruction Manual, DE Digital Energy, D60 Revision 7.1x