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Q. 1.04: Are there any key considerations for securing the ROCOF protection against maloperation?

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Frequency estimation issues in power systems

Frequency and ROCOF (rate of change of frequency) estimation are essential in modern power systems because they are used for several applications, from protection services to monitoring electromechanical oscillations. That is due to the fact that frequency reflects active power mismatches between generation and consumption. Therefore, measuring frequency and ROCOF should be provided with high accuracy and confidence.

Nowadays, system inertia is decreasing, due to higher penetration of inverter-based sources (IBS), used, among others, for wind, solar and battery-based generation. Consequently, those systems impose many challenges for frequency precise estimation, such as high ROCOF ratios.

These quantities are estimated by IEDs which apply mathematical algorithms based on digitized voltage signals. In the process, spectial signal processing techniques need to be applyied, like filtering, denoising etc. In the calculation process a number of premises are assumed, which can lead to distinct results for distinct algorithms and power system conditions, which shall be accounted for in the calculations. For example:

- window size to be used is strongly related to precision when high ROCOF is observed
- transitory DC levels and sub-synchronous oscillations, presence of harmonics, inter-harmonics and noise may introduce serious deviations in many calculation methods

For example, the zero-crossing technique is best suited for low varying frequency (calculation is usually performed with one or more fundamental cycles). Precautions in the presence of DC, harmonics and noise should be considered.

Phasor measurement unit frequency calculation is based on phasor rotation speed, a concept that relates frequency to angular speed, usual to rotating machines theory. It must be considered that an estimation based on the rate of phase variation, it can be susceptible to the presence of harmonics and noise. Also, errors may increase in the presence of high ROCOF ratios.

The figure below shows an example of frequency measured by a PMU using the output of a real time simulator. An unexpected transitory in the estimated value, due to lack of filtering, can be observed, a phenomenon that needs to be treated if the output is to be used for a controlling or protection function.