COUNTRY : South African (ZA)
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Are there any key considerations for securing the ROCOF protection against maloperation?

The South African Grid Code requires the Renewable Power Producers (RPPs) to detect an Islanding (Loss of Grid) condition and to remove themselves from the network by tripping within 2 seconds. One of the ways to detect islanding is by using ROCOF protection. The Grid Code also stipulates that RPPs should remain connected to the grid for measured ROCOF below ±1.5 Hz/s, provided that the network frequency is still within the minimum operating range. ROCOF elements can thus not be set more sensitively than 1.5Hz/s.

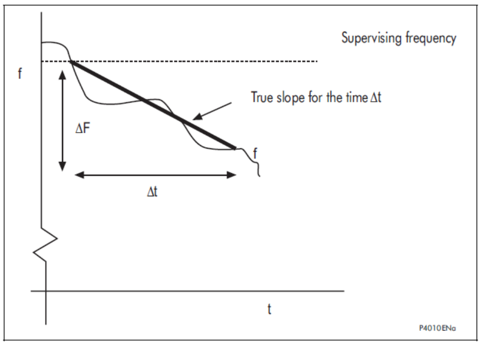
Eskom Transmission has experience with the application of ROCOF protection for the detection of power network islands for the purposes of blocking Under Frequency Load Shedding (UFLS) protection. UFLS relay operations during islanding conditions are a nuisance requiring additional switching to restore supply, and confuse investigators and customers (who may claim that the network outage was caused by a UFLS trip rather than vice versa).

An Eskom Transmission study into causes of UFLS relay misoperations [1] highlights four network scenarios, including typical waveform recordings, that have led to misoperations of level-detection frequency protection:

1) Voltage ring-down events;
2) Rapid voltage changes due to network faults;
3) Rapid voltage changes due to secondary VT circuit connection problems; and
4) Islanding.

Scenarios (1) to (3) can be expected to also cause misoperation of instantaneous ROCOF elements set for islanding detection by RPPs.

A recognised way of stabilising UFLS relays from misoperation, is the application of an “average ROCOF” function [2].



An average ROCOF function, as provided in some IED brands, is based on two level detection elements that are set a with a frequency difference ΔF. A timer is started when the measured frequency crosses the upper frequency threshold, and the IED checks the measured frequency a set time, Δt, later. Should the frequency measured at time Δt be lower than the lower set frequency threshold, then the average ROCOF is higher than the setting ΔF/Δt (the average ROCOF), and the relay operates. Should the measured frequency be higher than the set threshold at time Δt, the average ROCOF is lower than the ΔF/Δt setting, and the relay does not operate.

Eskom experience is that average ROCOF elements are much more secure and reliable than instantaneous ROCOF elements. By assessing ROCOF over a set time window, misoperations due to short duration network disturbances, such as scenarios (1) to (3) can be avoided. In RPP applications where tripping for an islanding condition is only required within 2 seconds, an average ROCOF time window of 0.5s could be applied.

It is surprising that more IED manufacturers do not include average ROCOF protection elements in their IEDs.

References
[1] S.J van Zyl, A.J.M. Kerr, “ Frequency protection performance review ahead of a new UFLS programme roll-out“, 10th CIGRE Southern Africa Regional Conference 2-4 Nov 2021, Johannesburg, South Africa.
[2]IEEE C37.117-2007, “IEEE Guide for the Application of Protective Relays Used for Abnormal Frequency Load Shedding and Restoration”