RATE OF CHANGE OF FREQUENCY (ROCOF)
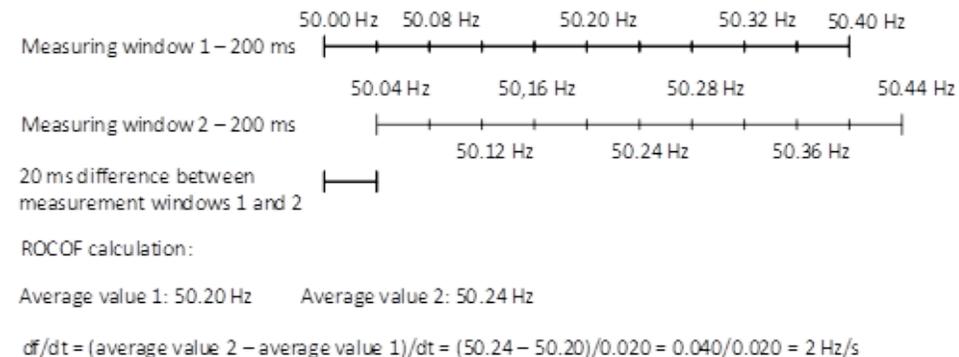
Energinet's guidelines for validation

Please note: This translation of the original Danish text is for informational purposes only and is not a substitute for the official Danish text. The English text is not legally binding and offers no interpretation on the Danish text. In case of inconsistency, the Danish version applies.

UNDERSTANDING THE REQUIREMENTS

The requirements for robustness in relation to frequency changes come from two separate requirements/incidents

1. The independent requirement, RoCoF, of 2 Hz/s approved under Requirements for Generators (EU) 2016/631.

Example:

| | 50.00 Hz | 50.08 Hz | | 50.20 Hz | | 50.32 Hz | 50.40 Hz |

Measuring window 1 – 200 ms

| | 50.04 Hz | | 50,16 Hz | | 50.28 Hz | | 50.44 Hz |

Measuring window 2 – 200 ms

| | 50.12 Hz | | 50.24 Hz | | 50.36 Hz |

20 ms difference between measurement windows 1 and 2

ROCOF calculation:

Average value 1: 50.20 Hz   Average value 2: 50.24 Hz

df/dt = (average value 2 − average value 1)/dt = (50.24 − 50.20)/0.020 = 0.040/0.020 = 2 Hz/s

2. The independent requirement for robustness against momentary voltage phase jumps ≤ 20°.

UNDERSTANDING THE REQUIREMENTS

In addition to the independent requirements and individual incidents, coinciding incidents may occur

- When calculating RoCoF, and specifically when validating coinciding incidents, voltage phase jumps must be filtered out so that this does not affect (is included in) the calculation of RoCoF (see illustration below).
- The frequency at which the phase jump ends must be comparable to the initial frequency of the phase jump.
- During the periods when phase jumps are filtered out, RoCoF must be set to 0 Hz/s.
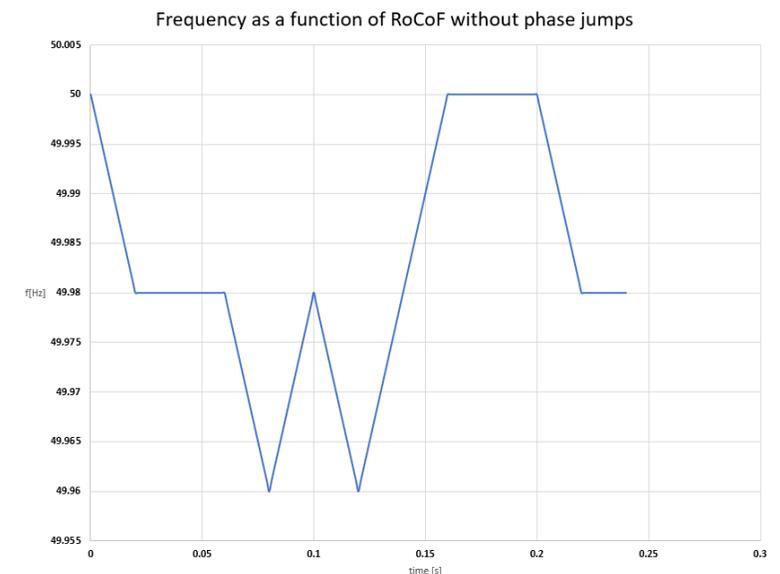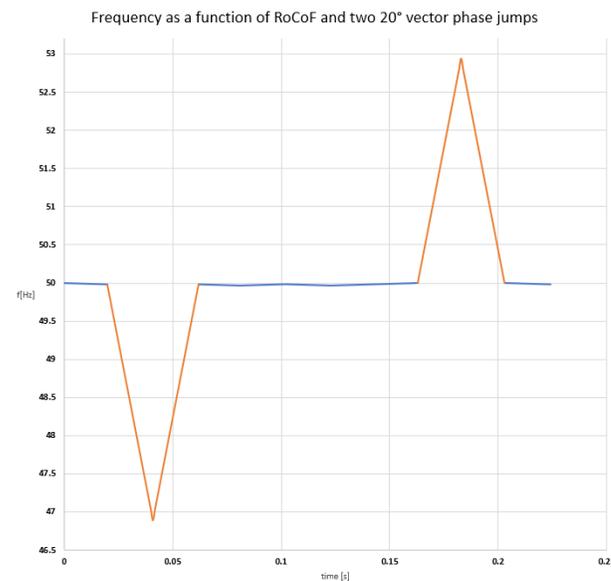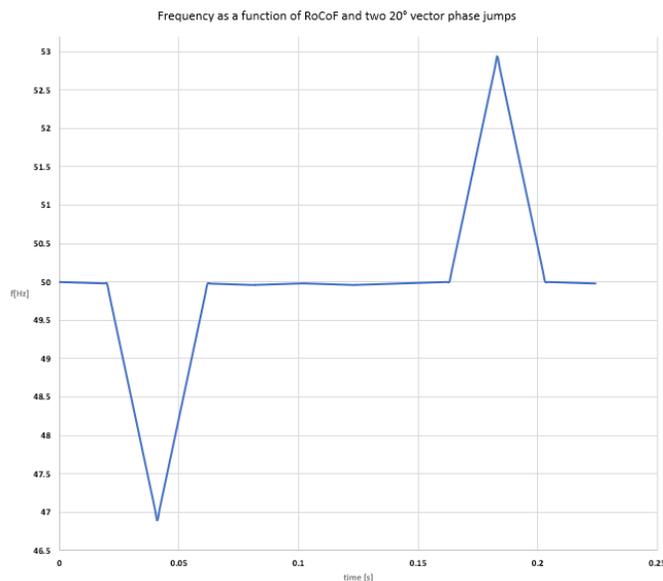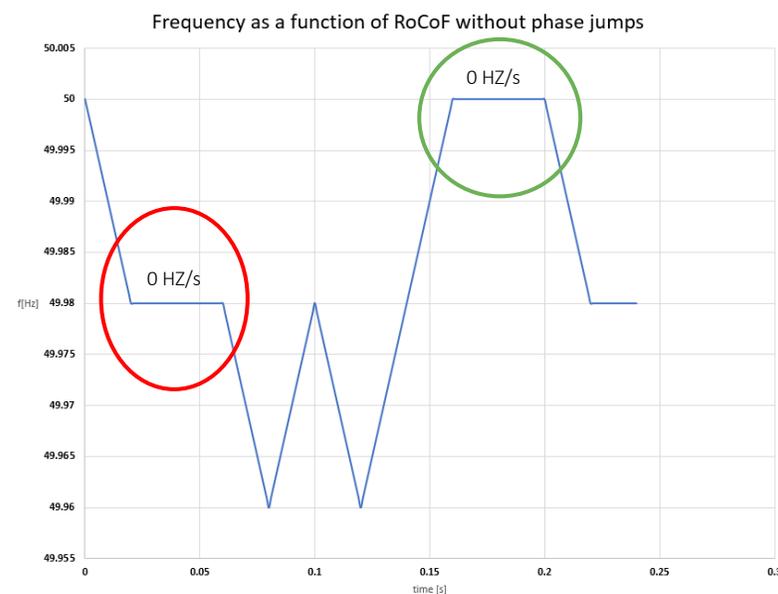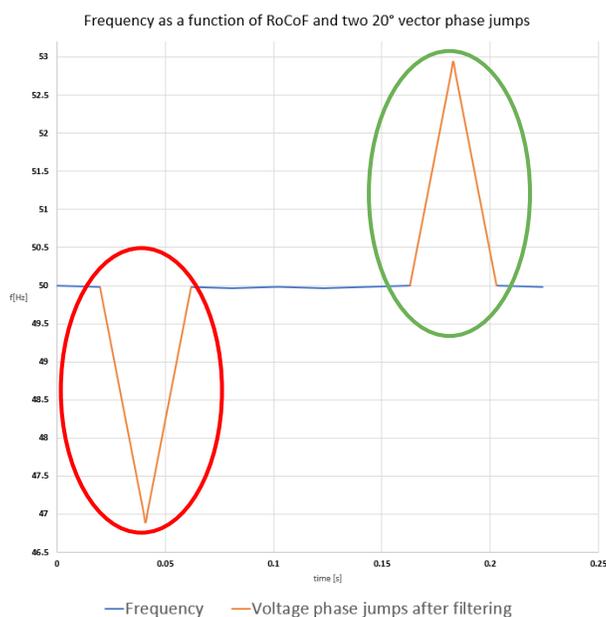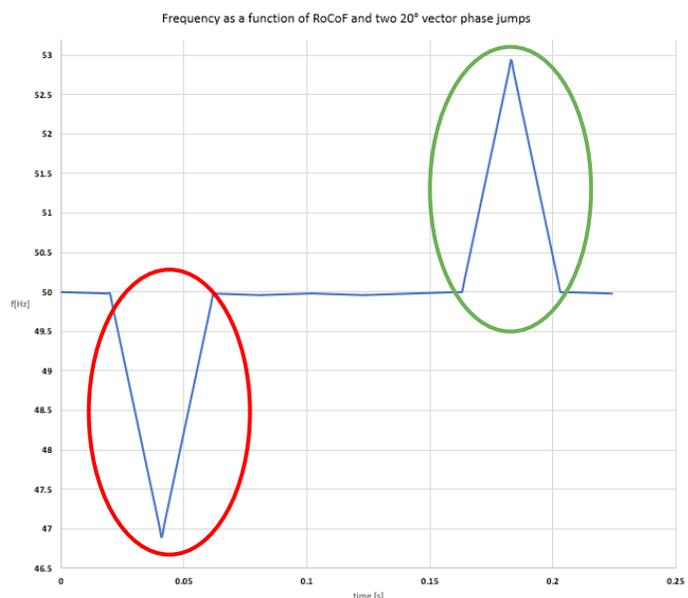
UNDERSTANDING THE REQUIREMENTS (DETAILED ILLUSTRATION)

In addition to the independent requirements and individual incidents, coinciding incidents may occur

Note:

- The respective coloured circles show and explain the interdependent relation.
- The rightmost figure uses a different resolution on the y-axis than the other two figures.

Frequency as a function of RoCoF and two 20° vector phase jumps

Frequency as a function of RoCoF and two 20° vector phase jumps
— Frequency   — Voltage phase jumps after filtering

Frequency as a function of RoCoF without phase jumps

UNDERSTANDING THE REQUIREMENTS

Evaluation of RoCoF and voltage phase jumps

- The voltage phase jumps (blue line) must be evaluated independently.

- RoCoF must be evaluated independently, calculated using an algorithm that filters out the impact of the voltage phase jump.

- The frequency change generated by voltage phase jumps must not contribute to exceeding the RoCoF requirement.

- With RoCof > 2 Hz/s or voltage phase jumps > 20° disconnection is allowed.

Frequency as a function of RoCoF and two 20° vector phase jumps

— Frequency   — Voltage phase jumps after filtering
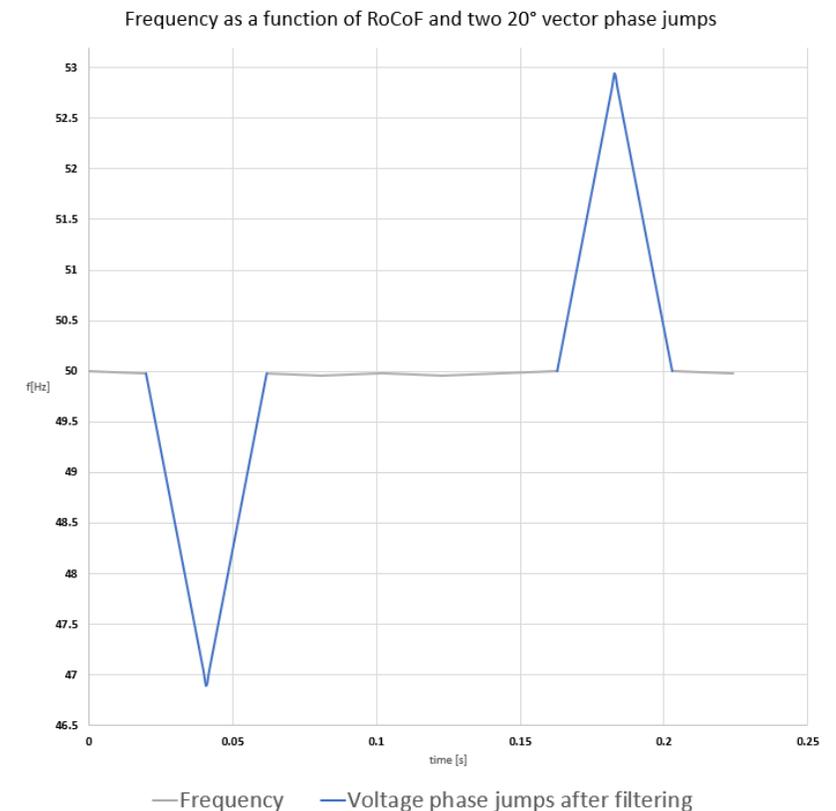
VALIDATION TEST

The following tests are used by Energinet for validation:

1. 2 Hz/s for 500 ms
2. -2 Hz/s for 500 ms
3. 0.5 Hz/s for 2000 ms
4. -0.5 Hz/s for 2000 ms
5. -4 Hz/s for 40 ms followed by -1 Hz/s for 40 ms followed by -2 HZ/s for 20 ms followed by -4Hz/s for 40 ms followed by 0 Hz/s
6. 4 Hz/s for 40 ms followed by +1 Hz/s for 40 ms followed by +2 HZ/s for 20 ms followed by +4Hz/s for 40 ms followed by 0 Hz/s
7. 4 Hz/s for 80 ms followed by 0 Hz/s for 20 ms followed by -4 HZ/s for 100 ms
8. -4 Hz/s for 80 ms followed by 0 Hz/s for 20 ms followed by +4 HZ/s for 100 ms
9. 20 Hz/s for 20 ms followed by 0 Hz/s for 20 ms followed by -8 HZ/s for 40 ms followed by + 4 Hz/s for 80 ms followed by 0 Hz/s for 20 ms followed by -20 Hz/s for 20 ms
10. -20 Hz/s for 20 ms followed by 0 Hz/s for 20 ms followed by +20 HZ/s for 20 ms followed by + 0 Hz/s for 80 ms followed by -20 Hz/s for 20 ms followed by +20 Hz/s for 20 ms followed by 0 Hz/s for 20 ms

Vector jump
11. 147 Hz/s for 20 ms
12. -147 Hz/s for 20 ms
13. 47 Hz/s for 20 ms followed by +100 Hz/s for 20 ms
14. -47 Hz/s for 20 ms followed by -100 Hz/s for 20 ms
15. 47 Hz/s for 20 ms followed by +50 Hz/s for 20 ms followed by 50Hz for 20 ms

Combined vector jump and frequency change
16. -1 Hz/s for 20 ms followed by -147 Hz/s for 20 ms followed by -1 Hz for 20 ms
17. 1 Hz/s for 20 ms followed by +147 Hz/s for 20 ms followed by +1 Hz for 20 ms
18. -1 Hz/s for 20 ms followed by +147 Hz/s for 20 ms followed by -1 Hz for 20 ms
19. -1 Hz/s for 20 ms followed by -147 Hz/s for 20 ms followed by -1 Hz for 20 ms followed by +1 Hz for 20 ms followed by -1 Hz/s for 20ms followed by +1Hz/s for 40 ms followed by +147 Hz/s for 20 ms followed by -1 Hz/s for 20 ms
20. -1 Hz/s for 20 ms followed by +147 Hz/s for 20 ms followed by -1 Hz for 20 ms followed by +1 Hz for 20 ms followed by -1 Hz/s for 20ms followed by +1Hz/s for 40 ms followed by -147 Hz/s for 20 ms followed by -1 Hz/s for 20 ms