Test for primary control capability

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This document was drawn up with the cooperation and support of industry representatives.

Contents

1 Summary

This document describes the tests used to verify the primary control capability of a generating unit and is based on the experiences of other grid operators [1-7].

2 Background

All generating units that contribute to the market-based procurement of primary control must be checked to ensure they meet the necessary technical conditions. The existing readings of power plants do not generally meet the requirements for checking the quality of control[1].

One of the following methods is used in the prequalification procedure. The activation of a test signal at the nominal frequency/rotation speed set point value or specification of the same by the turbine regulator (see Chapter 3) is the preferred test method due to its reproducibility. If this method cannot be implemented, alternative simplified tests (see Chapter 4) may be used.

3 Activation of test signals on the turbine controller

In this procedure the nominal rotation speed or grid frequency is reduced or increased from 50 Hz to 49.8 or 50.2 Hz respectively within 10 seconds, and the power deviation is recorded 30 seconds later, see Figure 1.

The generator groups of a generating unit are always tested separately. Subject to arrangement with swissgrid and confirmation from the power plant operator, identical and similarly calibrated generators do not all need to be tested.

3.1 Requirements

- Accuracy of the transformer: < 0.5 % (of the nominal value, where possible Class 0.1)
- Metering time period: 100 ms
- Recording period: ≤ 30 min
- Nominal frequency: < 5 mHz

All measurements must be provided with at least one unique time stamp for all channels/parameters and be made available as a csv file.

[1] This primarily involves the metering accuracy, the recording period, the sampling rate and the temporal synchronism of the measurements.

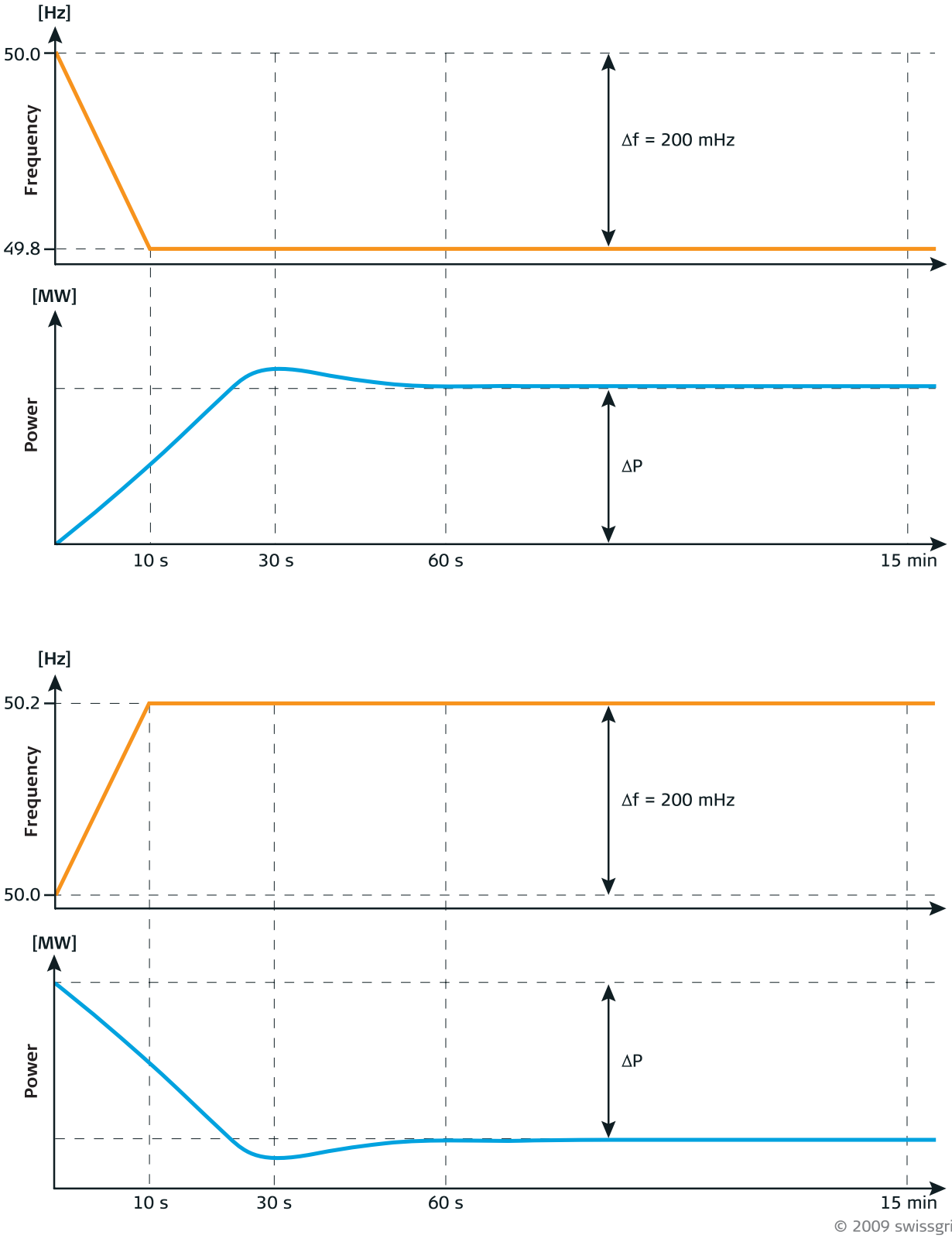

Figure 1: Idealized test signals for checking primary control capability

3.2 Recommendations

The power plant operators are solely responsible for carrying out the tests. Support from the manufacturer or experts of the grid operator or a suitably qualified consultant should be sought from time to time. The meter readings (test reports) provide the basis for a binding prequalification.

The tests must be structured in such a way that at no time is there a risk of damage to plant components and that none of the protection and control mechanisms trigger shutdowns during the tests. No protection equipment must be taken out of service for this purpose.

During the tests the entire workspace provided for control must be covered and the machines must remain in parallel operation with the interconnected grid.

3.3 Execution

The aim of the tests is to determine the deadband (see Section 3.3.1) and droop (see Section 3.3.2) inherent in the system.

3.3.1 Determining the deadband

The deadband[2] is determined with the aid of an hysterisis [1,6]. This corresponds to Δf of the total and $\Delta f/2$ of the semi-deadband. By suitably adjusting the input signal the point at which a change can be detected in the output can be determined. The nominal frequency is adjusted in steps and the output value is recorded once it has become steady, see Figure 2. Based on past experience, intervals of one to three minutes are considered appropriate depending on the type of power plant.

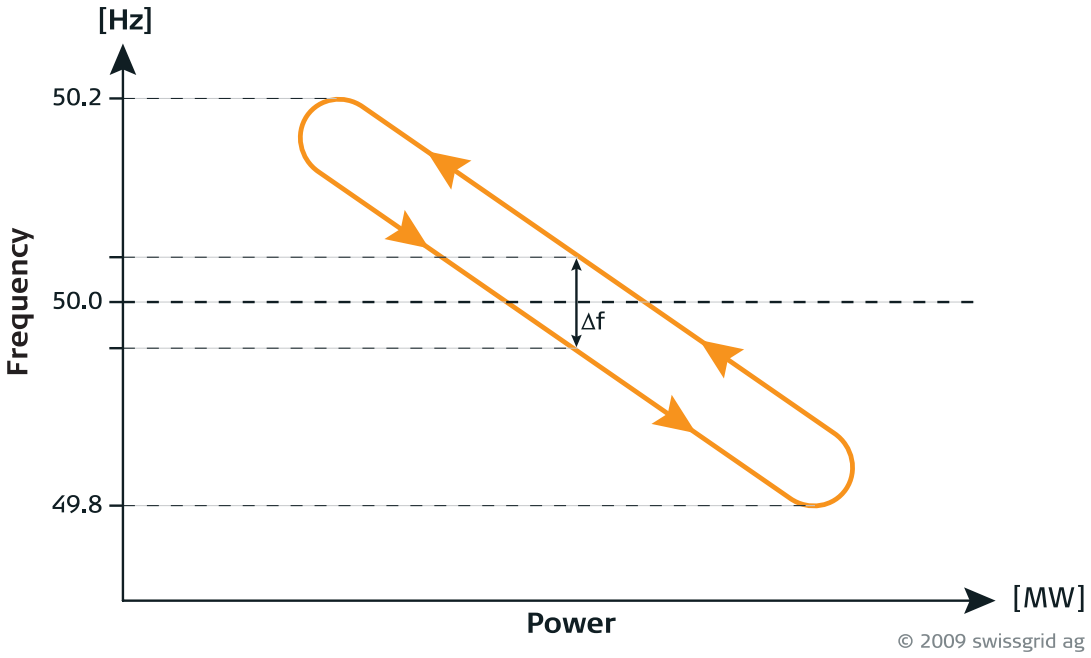

Figure 2: Determining the deadband

[2] This refers to the physically induced deadband of the entire control path (frequency/rotation input – power output) and not to the adjustable deadband on the controller.

The analysis of the deadband is based on IEC 61362 [5] and the following applies:

$$\frac{i_x}{2} \leq 2 \cdot 10^{-4} \tag{3.1}$$

After normalization this produces:

$$i_x = \frac{\Delta f}{50\ Hz} \rightarrow \Delta f \leq 20\ mHz \tag{3.2}$$

When taking readings the following two parameters must be met:

- Stepwise frequency increase: < 5 mHz
- Deadband (tolerance band): Δf/2 ≤ 10 mHz

3.3.2 Determining gain and delay times

As the frequency is gradually ramped up as shown in Figure 1 the generator output is recorded. This power characteristic is used to determine the droop and delay times. The following formula is used to calculate droop:

$$s = \frac{\Delta f / f_n}{\Delta P / P_n} \tag{3.3}$$

Where: f_n = nominal frequency (50 Hz)

P_n = nominal generator power

3.4 Reporting and evaluation

- Test arrangement, block diagrams, precise details of the test locations
- Time of the tests, list of tests carried out
- Test participants

The results of the primary control tests are examined for maximum permissible deviations – either by the grid operator or an independent third party designated by the grid operator.

The current tolerance limits are shown in Figure 3. If these limits are exceeded, the test is deemed «failed».

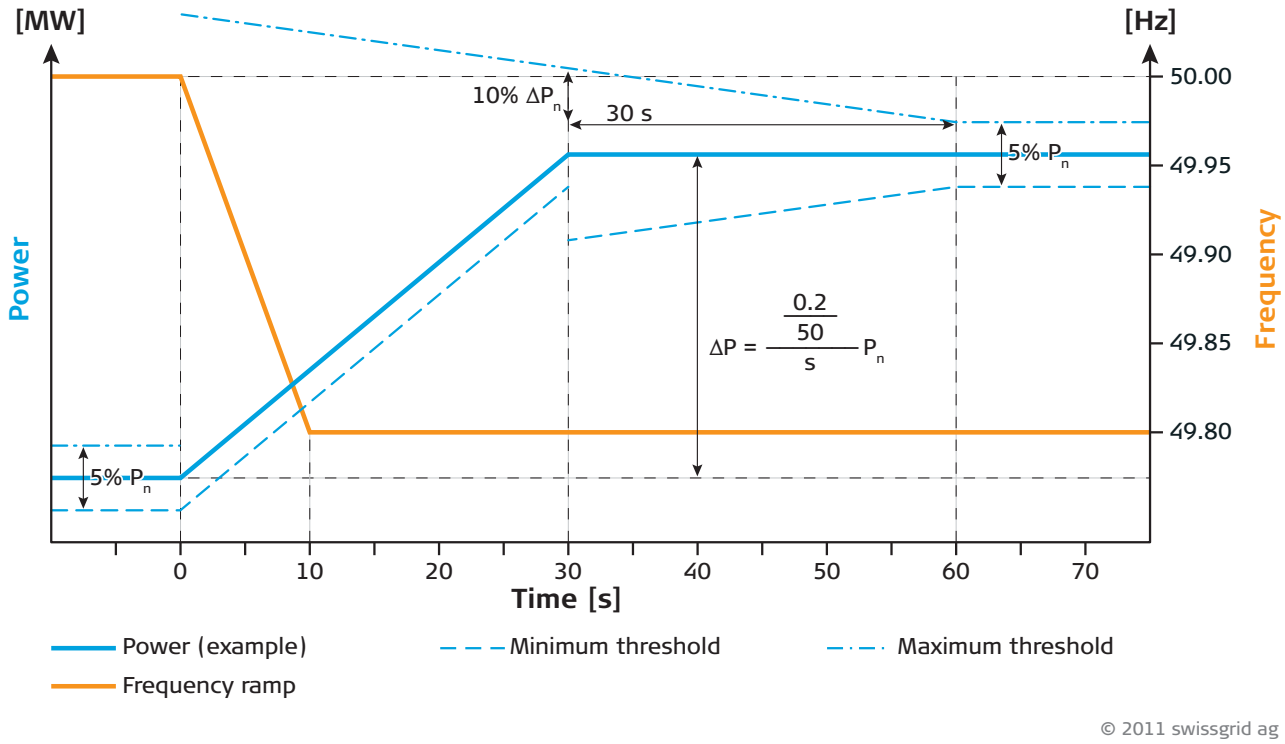

Figure 3: Performance characteristics and tolerance bands

The recorded performance characteristics must be within the tolerance limits shown in Figure 3. The tolerance limits are scaled in accordance with the generator parameters.

4 Alternative tests

If technical factors prevent the activation of test signals on the turbine regulator or if the financial burden involved is excessive, alternative (simplified) tests may be performed.

4.1 Analysis of frequency dips

This method requires no special measuring equipment. It is based on the metering sections that already exist in the power plant, most of which usually form part of the power plant's control technology. The evaluation is made under normal operating conditions and is based on events in the grid which cause the power plant to react to changes in frequency or voltage.

The quality of control capability can be determined by recording the input parameters (voltage, frequency) and the corresponding response of the individual generators (active and reactive power).

A basic requirement for this method is a time resolution of at least two seconds.

For small frequency deviations (approx. 50 mHz), the variations in power output of the different generators fall within the measurement accuracy range. The measurement of a complete group of generators at the point of in-feed is more suitable if a detailed evaluation is required.

4.2 Special tests

All other tests (coordinated with swissgrid and suitable for the prequalification procedure) are grouped together as special tests.

These methods rely on portable metering equipment connected to transformers in the power plant (existing or specially brought in for the purpose) – or high-resolution measurements made by the turbine controller itself.

The readings are subsequently taken during special tests in which targeted switching actions between the power plant and grid trigger the necessary voltage and active power in the control circuit. This includes, in particular, the tests for checking isolated grid capacity which enable the primary control capability to be inferred.

5 References

[1] **Procedura operationala, Verificarea funcţionarii grupurilor in reglaj primarschule** (procedure for checking the primary control capability of power generation units), Cod TEL – 07.VOS – DN 280, February 2008, Transelectrica.

[2] **Contrat de Participation aux Service Système**, RTE, 21.12.2007.

[3] **Participation in Frequency and Frequency-Power Regulation of Production Units**, RGTE070047 DIS-ISI, Terna, 20.07.2008.

[4] **Technische Mindestanforderungen an Kraftwerke für den Anschluss in unterlagerten 110-kV-Netzen**, RWE Transportnetze Strom, 29.03.2007.

[5] **Blockregelung von Wärmekraftwerken**, VDI/VDE 3508, September 2003.

[6] **Guide to specification of hydraulic turbine control system**, CEI/IEC 61362, March 1998.

[7] **Hydraulic turbines – Testing of control systems**, CEI/IEC 60308, January 2005.