# Effective speed controller in island operation

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**Abstract**
In the UCTE Operational Handbook an island is defined as a portion of the UCTE power system that is electrically separated from the interconnected UCTE system. The main condition for the island successful functioning is to ensure the stability and quality defined by the frequency and the voltage in the island bus-bars. The aim of the paper is to propose the structure and the parameters of the turbine speed controller, which has the stabilizing effect in the island operation.

**Keywords:** Power System, Power Oscillation Damping, Speed Controller, Island Operation, PSS, Lead Controller

## Introduction

The problems of island operation result from the following facts. The creation of island can be followed by transient processes of the operating variables that can destabilize the island operation even in the case of wellbalanced power balance in the island (Murgaš et all, 2007). The control abilities of the turbine controllers need not be sufficient to ensure the constant frequency at the required level. The reactive power deficit can cause the voltage collapse of the island. The stability of the island can be influenced very unfavorably also by the system of the frequency load shedding, which is set up to the UCTE operation conditions when the frequency of the whole interconnected power system descends. In island operation even a relatively small disturbance as a synchronous generator failure can activate the frequency load shedding, which can initiate a sequential disconnection of other supply sources in effort to not step over the frequency 50,2 Hz.

The analysis of the island operation, either the island of the Slovak power system or smaller islands should provide the grounds for the training of dispatchers for the emergency situations. The necessary condition for the successful island operation is also to ensure the proper operation of turbine controllers in the island, which must dispose of the sufficient stabilizing properties in the mode of the speed controller. The issue of the turbine controllers functioning in island operation has not been sufficiently investigated mainly from the point of view of ensuring the stability of transient processes emerging during the break of the power system into the island operation as well as ensuring the required control abilities in island operation at different power balances.

The aim of the paper is to analyze the transient processes during the break of the Slovak power system into the island operation at various conditions. To find out the effectiveness of the transient processes damping when the proportional speed controllers are used at the turbines. To analyze the effects of the implementation of new structures to controllers or optionally the implementation of stabilizing feedbacks to the excitation controllers and also to the turbine speed controllers.

## 1. Turbine speed controller

The turbine speed controller provides synchronous operation of synchronous machine at island operation or when the frequency moved from the permitted range of 50 ± 0.2 Hz. The controller has a proportional character, so when the machines are switched to speed control the control error remains. The integration part of the controller can't be used, because of the angle of static P/f characteristic. If the integration part of the controller has been used, one synchronous machine should produce all of the deficit power. While switching the machine into speed control the turbine valve must stay at the position when it was before the switching. The power controller is turned off by disconnection of the control error from the input of the PI- controller. Then the speed controller keeps the synchronous machine nearby nominal speed. The gain of the speed controller is specified by the P/f characteristic. The schematic diagram of the power and speed controller is shown on fig. 1.

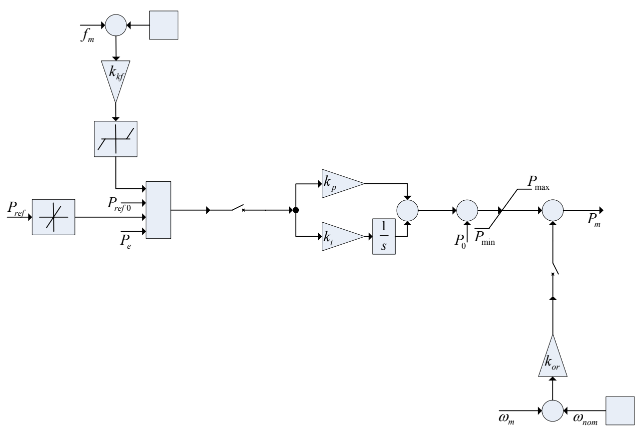


**Fig.1 Schematic diagram of the power and speed controller**

$\omega_m$ synchronous machine speed

$\omega_{nom}$ nominal speed of the synchronous machine , in p.u. $\omega_{nom} = 1$

$k_{or}$ gain of the speed controller

By the following experiments is shown response of the synchronous machine while they are at the speed control. First experiment shows the response of the EGABC1, while it is switched to the island operation. The recorded values of active, reactive power and frequency and they are shown on the fig. 2.

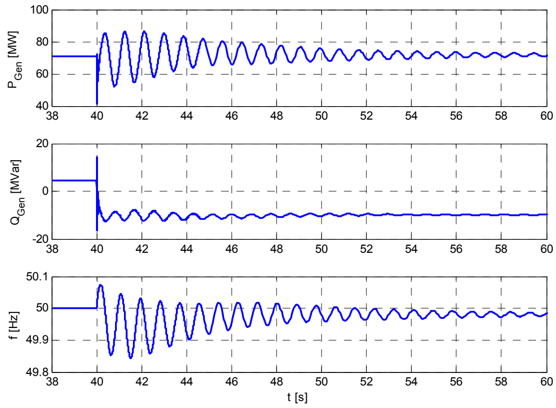


**Fig.2 The recorded values of active, reactive power and frequency**

For damping of the oscillations, in time response shown in fig. 2, should be used the power system stabilizer. The control error still remains the same. The experiment is shown on the fig. 3.

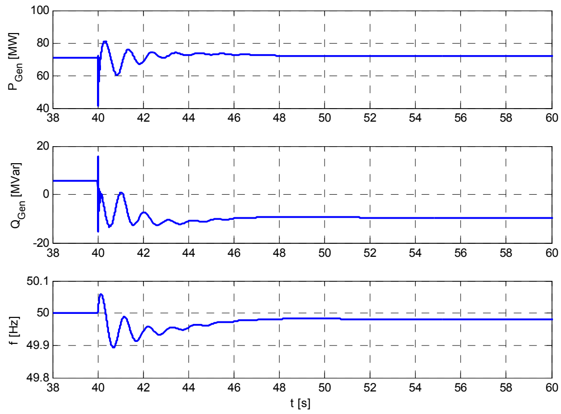


**Fig.3 The recorded values of active, reactive power and frequency, while the machine is switched into the speed control and PSS is on**

The alternative of the speed controller, which is not used in the controllers, is possible to use the structure of Lead controller with transfer function:

$$G_R(s) - = \frac{1 + saT}{1 + sT}, \qquad a > 1 \tag{1}$$

Parameters a, T should be obtained from the frequency characteristics providing the correction of the phase frequency response at frequency of amplitude intersection. For estimating the Lead controller should been used the following equations:

$$a = \frac{1 + \sin\varphi_m}{1 - \sin\varphi_m} \tag{2}$$

$$T = \frac{1}{\omega_m \sqrt{a}} \tag{3}$$

where

$\varphi_m$ is maximum rise of frequency characterstic, which obtains the controller

$\omega_m$ is frequency, where the maximum rise is obtained

At fig. 4 is shown the response of active, reactive power and frequency, while switching to the island operation of PSSR using the Lead controller of speed.

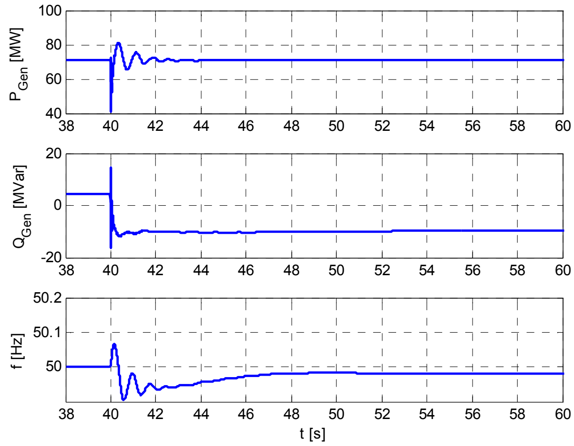


**Fig.4 The recorded values of active, reactive power and frequency, while the machine is switched into the speed control with Lead controller**

## 2. Turbine speed controller IN PS SR Island operation

Speed controllers of turbines operating in the island created in a part of PS have a great effect on stability of the island. The most important is certainly the power balance of the island, but important for the response are also turbine speed controllers. Different types of failures should affect the PS in UCTE so much, that the phase angle between the neighbors should be different against the phase angle in PS. This case will cause the disconnection of PS from the synchronous area of UCTE. In the case of PSSR are disconnected lines V497, V424 and V280 lead out from Sokolnice in Czech republic, line V404 lead out from Nošovice in Czech republic, doubled line V477, V478 lead out from Krosno-Iskrzynia in Poland, line V440 lead out from Mukačevo in Ukraine, V449 lead out from Göd in Magyar republic and line V448 lead out from Gyor in Magyar republic. The high oscillations in the PS should been observed while these lines are disconnected. After the disconnection of neighbors lines from the PS a changes of the power flows should been observed. Switching to the speed control from the power control is done without changing the valve position on the turbines but we could observe oscillations right after the switching. The responses had shown us, that the synchronous machines with PSS have a more quality response then these which haven't. Oscillations are damped to 8 s from begin of the island operation. We can also observe that the frequency didn't fail to the level of the first frequency load shedding. The responses of this experiment are shown at the fig. 5 and 6. In the experiment the neighbor lines are disconnected in the 40 second and also at this time the power controllers are switched to speed controllers. The minimum of the frequency in this experiment is 49.92 Hz at 42 second and the new steady value is 49.98 Hz.

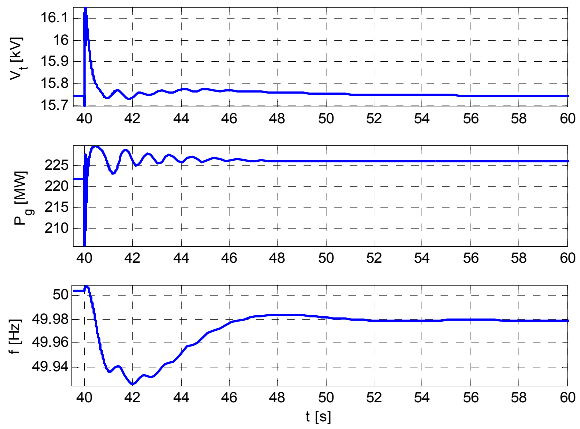


**Fig.5 Switching to the Island operation observed on EMO11**

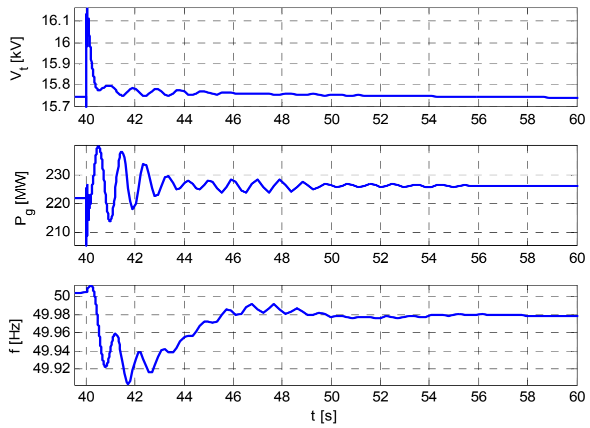


**Fig.6 Switching to the Island operation observed on EMO11, while the PSS is off**

## 3. Conclusion

Automatic switching part of PS to the island operation should be followed by the low damped oscillations of active power, which could cause activation of frequency load shedding relays that should lower the power balance of the island or cause instability. Effective controller for damping the oscillations of active power when switching to the island operation are PSS installed on synchronous machines. By this opinion is also effective changing the proportional controllers for the Lead controllers, which have derivation character and don't contain the integration part.

## References


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