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Synchronization Options in the Transmission System in Case of the Reconfiguration

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Abstract: The purpose of reconfiguration in the power system of Slovak Republic is to decrease the power flow of the critical elements in the system. Therefore, in practice, the effect of the reconfiguration on the power loading of the individual elements in the system is monitored. On the other hand, less attention is paid to some additional negative impacts on the system, which may cause more problems in unexpected emergency conditions. Secondary, the non-fulfilment security criterion N-1 on other elements or limitation of the synchronization possibilities and restoration of basic grid topology are in terms of dispatch control the most critical. The article presents the problem of restoration of the basic grid topology during the violation of the synchronization conditions. The problem was measured by WAMS during the real-time operation in case of reconfiguration in 400 kV substation Lemešany and Varín during switching in the field of combined busbar coupler.

Keywords**:** reconfiguration; synchronization; phase; restoration grid topology; WAMS.

1. INTRODUCTION

The reconfiguration in the power system of Slovakia represents a change in the grid topology to restore/keep the system to a state of N-1 criterion fulfilment, respectively to decrease loading of grid elements. It is a modification of the grid topology and as every similar modification this has to be carried out only in justified cases and for a limited time. During realisation of this kind of action it is possible to observe how the phase angle is changing. It cases the problem of restoration of the base grid topology. The phase angles are measured with WAMS equipments, which have been installed in the power system of Slovakia since 2015.

1.1 Grid topology after reconfiguration

The conditions for realizing the reconfiguration in substation 400 kV Lemešany and Varín results from the grid topology and the actual power flow, which occurs after the reconfiguration. Grid topology and resultant power flow after the reconfiguration in substation Lemešany is shown in Fig. 1 and in substation Varín is shown in Fig. 2.

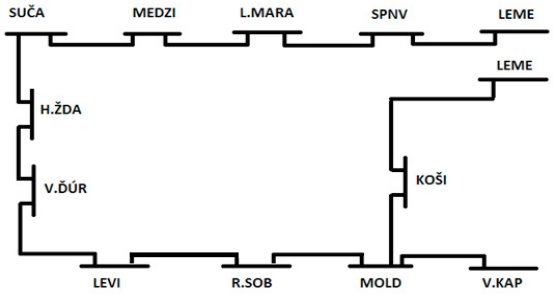

Fig. 1. Grid topology after reconfiguration in substation Lemešany

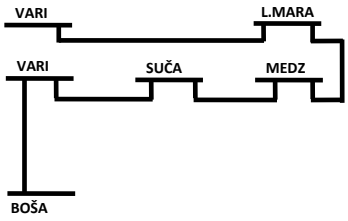

Fig. 2. Grid topology after reconfiguration in substation Varín

The most important grid elements, which have to be in operation for the reconfiguration Lemešany to be performed in real time operation are:

- 400 kV lines: V426, V427, V407, V408, V409, V492, V493,
- both busbars in 400 kV substation Lemešany have to be operational,
- operational busbar coupler in 400 kV substation Lemešany (field No.10.). [1]

The most important grid elements for the reconfiguration Varín to be possible in real time operation are:

- 400 kV lines: V404, V405, V406, V494, have to be in operation,
- both busbars in 400 kV substation Lemešany have to be operational,
- operational busbar coupler in 400 kV substation Varín.

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It is possible to use reconfiguration in only one or both substations at the same time.

2. APPLICATION OF THE PMU/WAMS IN THE SEPS

2.1 Current state

The implementation of WAMS in SEPS started in 2011 with a pilot project in which 4 internal lines were monitored with 8 PMUs. After, to the year 2015, totally 18 PMUs were installed. One on each interconnector in each border substation (V404, V270, V424, V280, V497, V448, V449, V440, V478, V477) and on both ends of 4 internal lines (V427, V492, V407, V439) Fig. 3.

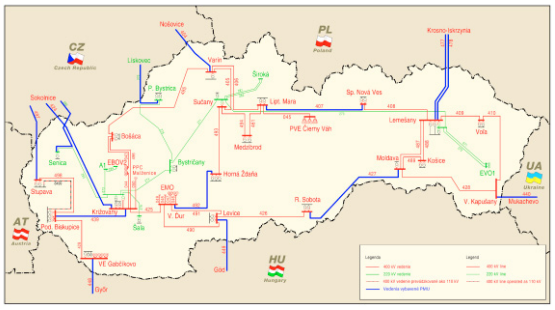

Fig. 3. Lines of SR TS equipped with PMUs

For measurement Elcom ENA406 PMUs are used. Their output values are Û, Î, P, Q, f, df/dt with a total vector error (TVE) <0,5%. It samples the electric wave with a sampling rate 12 kSa/s which are used to calculate the vectors. Output values are sent to PDC every 20ms i.e. 50/s.

In every substation equipped with PMUs is one PDC that groups PMUs in the substation and packs and temporarily backups the data from them for 30 days. These data can be recovered by central server after its outage. From PDC the data are transferred to two central servers with a high availability.

The servers are exact copies of each other, therefore, high availability of data is ensured. They receive, analyse and store the data from PMUs and PDCs in 3 different storage archives:

- Short term archive – data are stored for 93 days in the highest resolution i.e. 50 Sa/S
- Long term archive – data are stored for 365 days in downgraded resolution i.e. 10 Sa/S
- Snapshot archive – 4,5 TB for time-wise unlimited archive of data in the highest resolution i.e. 50 Sa/s. These snapshots are generated either automatically based on defined conditions or manually.

They can also communicate with control system, generate alarms, calculate user defined formulas with real time data and host user application.

For data processing, calculation and communication with a user, PhasorPoint as a software solutions is used. Its main task is data acquisition and storage. Besides that, it can process the data, detect unwanted states of power system, generate alarms and transfer them further.

3. REAL MEASUREMENTS

The voltage deviation is possible to see in the following diagrams. They describe the real situations during the operation in the year 2015. In Fig. 4 is displayed phase angle difference after the start of reconfiguration in substation Lemešany. The phase angle difference between two busbar in substation Lemešany is about 28 °.

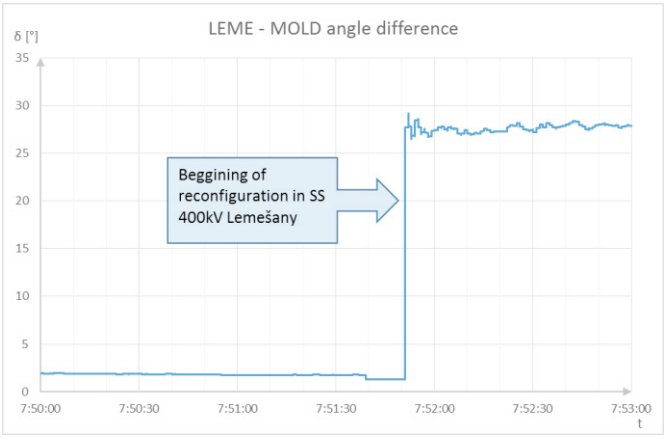

Fig. 4. The phase angle difference after the start of reconfiguration in substation Lemešany

In Fig. 5 is displayed the phase angle difference between two busbar in substation Lemešany after the reconfiguration in substation Varín. The phase angle difference increases by the value about 4°.

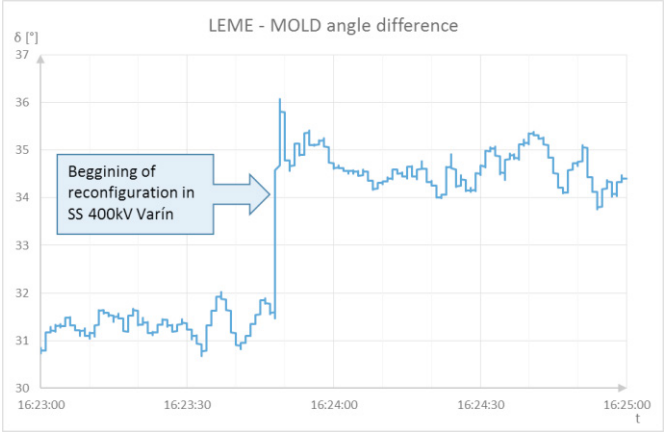

Fig. 5. Start of reconfiguration in substation Varín (during reconfiguration Lemešany)