

# DEVELOPMENT OF SMART UNDERFREQUENCY LOAD SHEDDING SYSTEM

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## **Annotation**

*Paper describes possibility to apply innovation technology of Smart Grid for power system emergency automation. Operational characteristics of existing emergency automation and new suggested one are compared in the paper. The method for liquidation of drawback of existing automation is suggested. Paper describes developed mathematical model of intellectual underfrequency load shedding system and its operational algorithms.*

## **Keywords**

*Smart Grid, optimization of emergency automation, underfrequency load shedding system*

## **1 INTRODUCTION**

During emergency situation in the power system caused by generating power deficiency frequency decline takes place. To restore frequency load shedding or spinning reserve involvement may be activated. If governor action cannot activate spinning reserve quickly enough to restore the system to its normal operating frequency, frequency actuated automatic load shedding (UFLS – under-frequency load shedding) serves as a last-resort tool to prevent the system from collapse [1-3]. The drawback of traditional UFLS is that value of shedded load sometimes does not coincide with the value of active power deficiency. As consequence of this imbalance overfrequency or frequency hovering situation can occur.

During last few years the term Smart Grid is constantly used in different engineering fields. There are many papers describing application of Smart Grid technology in the fields of distribution, information and communication technologies, transmission and generation [7-10].

The aim of this paper is illustration of integration of Smart Grid technology into emergency automation and investigation of control process of such automation. Considered emergency automation (Load shedding system) reacts to the presence of deficiency in the power system. Knowing the precise value of deficiency can optimize operation of UFLS system. Transformed rotor swing equation can be used for calculation of deficiency [4-6]:

$$\Delta P = T_J \cdot \frac{df}{dt} + \frac{\Delta f}{k_{stat}} + \Delta f \cdot k_{reg} , \quad (1)$$

$$\text{where } \Delta f = \frac{2 \cdot \pi \cdot f - 2 \cdot \pi \cdot f_0}{2 \cdot \pi \cdot f_0} .$$

$T_J$  – rotor's inertia constant;  $k_{stat}$  – governor speed droop;  $k_{reg}$  – load-damping constant;  $f$  – frequency.

Automation's operational process (let's call it Smart Underfrequency Load Shedding - SUFLS) can be presented by few calculation cycles: determination of deficiency value, memorization of deficiency value and its location, calculation of number of power districts to compensate deficiency, calculation of optimal variant for disconnection of load and disconnection of load feeders. Paper presents an operational algorithm for suggested new automation system.

The advantages of SUFLS automation are: suggested load shedding system is more effective emergency automation system than traditional underfrequency load shedding system; new emergency automation allows to prevent deep frequency drop during generated deficiency condition; for large united power system suggested frequency control algorithm can be implemented for different power system districts separately. In additional, paper deals with load restoration automation possibility.

To compare results of UFLS and SUFLS automation operation the mathematical model has been constructed using Matlab Simulink software [11]. Paper describes developed mathematical model of intellectual underfrequency load shedding system. Behaviour of frequency during emergency situation is presented for different values of deficiency. Considered power system consists of five energy districts. Figure 1 illustrates

frequency behavior at emergency situation. Emergency situation for power instant deficiency  $\Delta P = 0.7$  (p. u.) at the first power district at the time moment  $t = 0.0$  (sec) was simulated. Comparison of UFLS system and SUFLS system shows advantage of new suggested automation system. During operation of UFLS system frequency hovering takes place at the level of 49.66Hz. During operation of SUFLS system short decline of frequency to 49.85 Hz level is observed. Authors have got results of frequency behavior at cascade emergency situation. As in previous experiment developed automation is more effective than traditional load shedding automation.

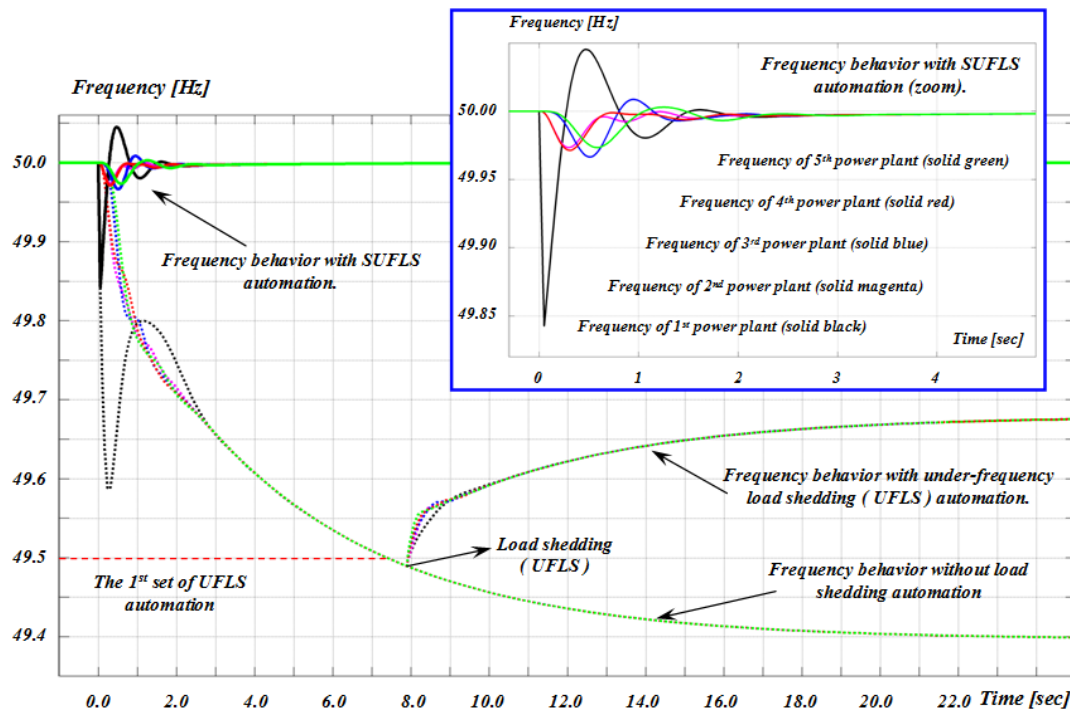


Fig.1 Frequency behavior without load shedding automation, with UFLS automation and with SUFLS automation

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