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# DAMPING OF DYNAMIC OSCILLATIONS OF AZARBAIJAN ELECTRICAL NETWORK BY SMES SYSTEM AND FUZZY CONTROLLER

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**Abstract-** The objective of this paper is to present the modeling and design of SMES system for Azarbaijan electrical network for damping of dynamic vacillation by using SMES and fuzzy controller. In this case we well can to control of *P* & *Q* to decrease power loss. The results show that we can optimize the electrical factors of transmission line and network.

**Keywords:** Transmuting Line, SMES, Fuzzy Control, Optimize, Stability.

## I. INTRODUCTION

Attention to have a standard network with stability and reliability criteria we should control important electrical factors for example *P* & *Q*, frequency and other vacillation by new method such as SMES. In this paper the electrical parameters and damping vacillations are balanced for stability of the network. Of course by using of SMES we can increase the electrical capacity and prevent to erection of new transmission lines.

## II. APPLICATION OF SMES TO STABILITY OF POWER SYSTEM

Obviously, the response of SMES system formed by supper conductor coil and multi-phase converter (super conductor magnetic energy storage) proved before about to get of energy by SMES coil.

$$P = E_d . I_d . \text{Cas}\alpha \qquad 0 \le \alpha \le 360 \tag{1}$$

$$Q = E_d . I_d . \text{Sin}\,\alpha \qquad 0 \le \alpha \le 360 \tag{2}$$

$$P^2 + Q^2 = S^2 = (E_d . I_d)^2 \tag{3}$$

In above motioned equations $E_d$ is the output load voltage and id is SMES coil current and $\alpha$ is triggering angle of thyristor (SCR). In converters with six single phase we must be have:

$$P = 0.988 E_d . I_d \left[ \frac{\text{Cos}\alpha_1 + \text{Cos}\alpha_2}{2} \right] \tag{4}$$

$$Q = E_d . I_d \times \sqrt{022(1 - \text{Cos}\alpha_1 \text{Cos}\alpha_2) + 23(\text{Cos}\alpha_1 - \text{Cos}\alpha_2)^2} \tag{5}$$

Figure 1 shows the schematic diagram of SMES system including the inverter sub system module consists of six single-phase inverter bridges. The electric energy is stored in the form of current flowing endlessly around a super-conducting coil of wire maintained at its operating temperature. Energy released from the SMES passes through a current to voltage converter. The controller selects parameters ($\alpha_1$, $\alpha_2$) which provides the required *P* & *Q*. Figure 2 shows the transmission line and SMES system. The transmitted energy is calculated:

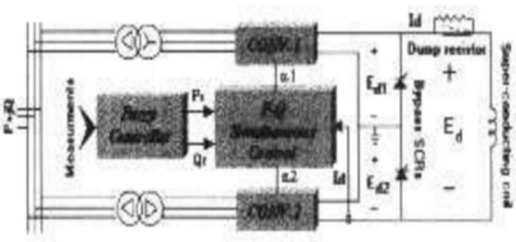


Figure 1. Structure of SMES system

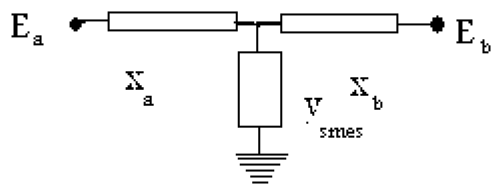


Figure 2. Diagram of transmission line with SMES

$$P_e(\theta) = \left[ \frac{E_A^2}{X_A} + \frac{E_a - E_A}{X_A - X_b} \right] . up(t) + \left[ \frac{EA.EB}{XA + XB} Sin\,\theta \right] . \left[ + u_Q(I) \right] \tag{6}$$

$$Y_{SMES}(t) = \frac{I}{|Z_{th}|} \left[ u_P(t + ju_Q(t)) \right] \tag{7}$$

## III. MODELING OF 12-PHASE CONVERTER

Figure 3 shows the model of SMES system. Using Simulink the outputs of system $P$ & $Q$ are controlled by the values of ( $\alpha_1$ , $\alpha_2$ ) to triggering of SCR’s.

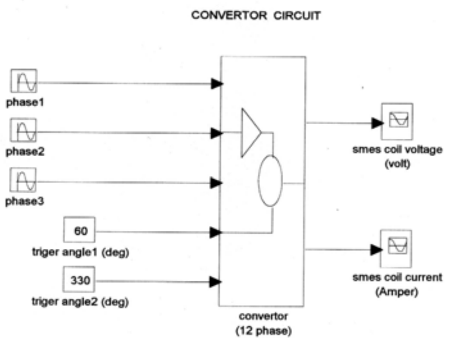


Figure 3. SMES modeling in Simulink circumference

After calculation of voltage and current in the coil the values of $P$ & $Q$ is getting by following equations:

$$P = \overline{v_{(t)}}.\overline{i_{(t)}} \quad (8)$$

$$S^2 = v_t^2 .i_t^2 \quad (9)$$

$$Q = \pm\sqrt{(S^2 - P^2)} \quad (10)$$

## IV. MODELING OF CONTROLLER FOR *P* & *Q*

Duty of this part of system for determining of ( $\alpha_1$ , $\alpha_2$ ) with attention to $P$ & $Q$ is requested.

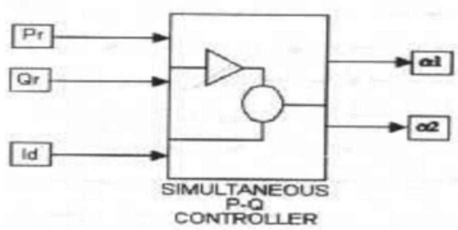


Figure 4. Controller modeling of $P$ & $Q$ in Simulink

Figure 4 shows the modeling of controller and determines $P(\alpha_1, \alpha_2) = P_r$ , $Q(\alpha_1, \alpha_2) = Q_r$ as the inputs of model are ( $P_r$ , $Q_r$ ) and the outputs are ( $\alpha_1$ , $\alpha_2$ ). Figure 5 shows that the values of ( $P_r$ , $Q_r$ ) which produce after determining of ( $\alpha_1$ , $\alpha_2$ ). Of course the values of ( $\alpha_1$ , $\alpha_2$ ) are very important for getting suitable values of ( $P_r$ , $Q_r$ ) that are requested.

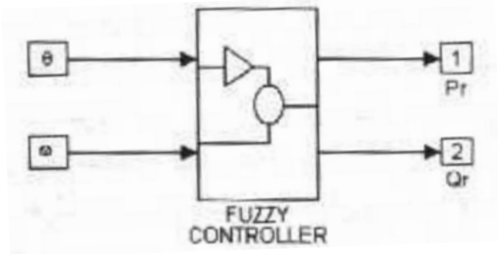


Figure 5. Modeling of fuzzy controller with determining of ( $\alpha_1$ , $\alpha_2$ )

## V. MODELING OF FUZZY CONTROL

This section of system is designed for determining of active and reactive power per moment. Determining of valuation is very important to resolve the operation of dynamic system and input values for controller selection in rate of fault of signal and desirable value. Of course by produce of fuzzy law to determine and select of values a formed classification is obtained by Table 1.

Table 1. Fuzzy law for fuzzy controller

| $\theta$ / $\omega$ | **N** | **Z** | **P** |
|---|---|---|---|
| N | NL/PL | NS/PL | ZE/PL |
| S | NL/NL | NL/PS | PL/PL |
| EQ | NL/NS | ZE/ZE | PL/PS |
| M | NL/ZE | PS/ZE | PS/PS |
| L | NS/PS | PS/ZE | PS/ZE |
| U | NL/PS | NS/NL | ZE/NS |

The fuzzy controller include the values of variations are given by the following explanation: N-negative, S-small, EQ-equilibrium, M-medium, L-large, U-unstable, Z-zero, P-positive, NL-negative large, NS-negative small, PS-positive small and PL-positive large.

The specifications of generation system in a sample plant (Tabriz power plant) are as the following:

$VS = 0.1Pu$ $\quad VERR = 0.05Pu$
$Pe = 350Mw$ $\quad Kf = 0.04$
$Pm = 387Mw$ $\quad H = 3.2MwJMVA$
$S = 445MVA$ $\quad Pnom = 400MW$
$F = 50Hz$ $\quad Xd = 1.54Pu$
$rq = 1.57Pu$ $\quad rf = 0.00062$
$Xf = 0.112Pu$ $\quad Td = 6.7\sec$
$T'd = 0.98\sec$ $\quad V = 20KV$
$Pole = 2$ $\quad rmp = 3000$
$Xq2 = 0.065\,Pu$ $\quad X'd = 0.058Pu$
$Tq = 0.27\sec$ $\quad XqI = 0.576Pu$
$rd\ \ 0.001Pu$ $\quad rS = 0.0033Pu$
$T'q = 0.04\ \sec$ $\quad Cos\phi = 0.9$
$J = 42300$

## VI. SPECIFICATION OF TRANSMISSION LINE AND LOAD

In this study information are used for network of Tabriz-Khoy diagram of electrical network containing the system with the situation of SMES and electrical relation. In Table 2 technical information of transmission line are given. Figure 6 shows the modeling of design for transmission line in Simulink circumference.

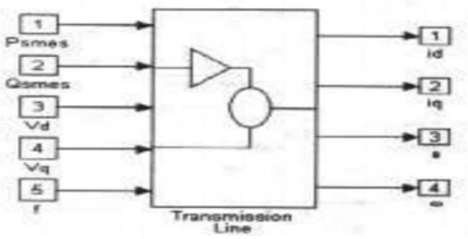


Figure 6. Modeling of transmission line in Simulink

Table 2. Specification of Tabriz-Khoy network

| | Orumieh to Khoy | Miandoab to Orumieh | Tabriz to Miandoab |
|---|---|---|---|
| *R* | 0.16 Pu | 0.124 Pu | 0.14 Pu |
| *X* | 0.093 Pu | 0.073 Pu | 0.083 Pu |
| *Bc* | 0.08 Pu | 0.098 Pu | 0.112 Pu |

## VII. RESULT OF NUMERICAL SIMULATION

In this study we use from a SMES with capacity of 30 MW in transmission about 360 km at Tabriz-Khoy line meanwhile the Tabriz power plant is the important factor of our study in this network.

Figure 7 shows the general diagram of power system Simulink circumference. Figure 8 shows the variation of active and reactive power after removal of electric fault without SMES and controller.

Figure 9 shows the damping of oscillations and effect of SMES system on the network after eliminate of fault with SMES and fuzzy controller.

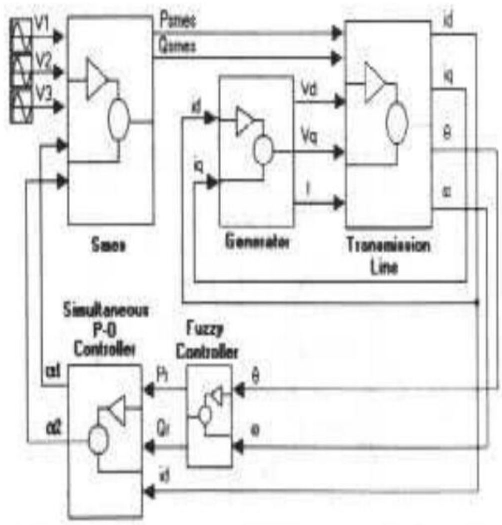


Figure 7. General diagram of power system in Simulink circumference

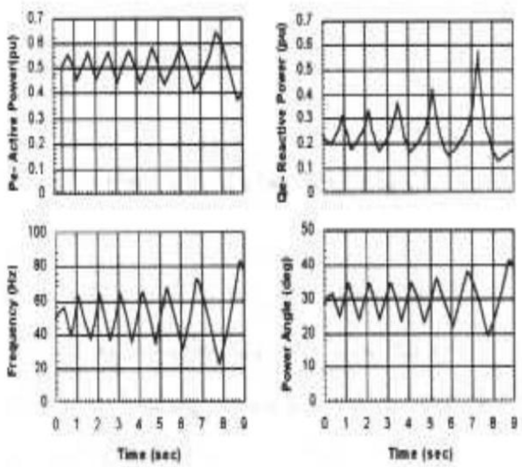


Figure 8. Diagram of varying of *P* & *Q* in SMES output

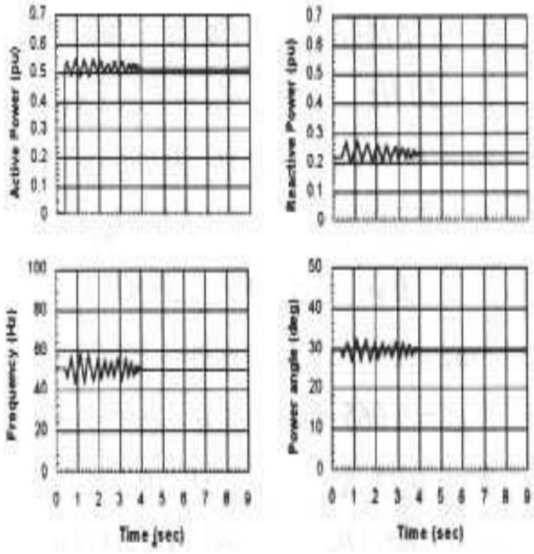


Figure 9. Diagram of varying of *P* & *Q* with SMES

## VIII. CONCLUSIONS

The maximum transmitted power in the network depends on the stability limitation especially in dynamic stability analysis. The range of dynamic stability is lower than temperature stability for accuracy controlling and simply to hold system in stability, reliability and damping of oscillations in fault situation. In this study we tried to explain the research options to develop Azarbaijan Electric Network operation and prepared system to exchange energy with SMES especially from Orumieh to Tabriz power plant with power loss decreasing and reliability rising.

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