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Vol. 32, No. 4. \ 2024 ISSN: 2616 - 9916

A New Adaptive Neuro-Fuzzy Inference System with Turbine Governor and Automatic Voltage Regulator to Control the Power Grid System

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Received:	28/4/2024	Accepted:	31/7/2024	Published:	13/8/2024

ABSTRACT

This paper introduces the turbine governor (TG) and automatic voltage regulator (AVR) and new Adaptive Neuro-Fuzzy Inference System (ANFIS) to search for improvement and the stability. MATLAB use on 3bus system and 3-phase faults between B1 and B2 systems with and without (TG), (AVR) and (ANFIS) at t_f = 5 sec. and t_c = 5.2 sec. From the results obtained from the simulations, conclude that the voltage is in a stable state whether the rotor angle is stable or unstable. (TG), (AVR) and (ANFIS) use in the grid have a role in the transient stability of the system and the voltage is improved.

Keywords: Turbine Governor, Automatic Voltage Regulator ANFIS, Voltage Stability.

1. Introduction

Stability is the ability to reach a stable state after eliminating an error or malfunction in the system [1]. The voltage breakdown in the network causes loss of synchronization, stability and affects the integrity is in the stability analysis [2]. The frequencies of the machine can return the synchronous frequency first, through which the transient stability is determined [3]. A control algorithm can be used to store and boost the energy of two microgrids with a single system and maintain the state of charge [4]. Voltage fluctuations due to angular instability led to voltage breakdown, and the cause of the breakdown is a catastrophic fault, in transient cases, which may not always cause the loss of angular stability [5]. The power was optimized using a machine learning algorithm and a combination of bio-inspired optimization and neural network was suggesting [6]. Fuzzy logic Controller was used in PV systems by simulating the monitoring of the maximum power [7], [8]. PI with FLC use for power control and optimization [9]- [11]. Using an IEEE 13 Node and a PDS device to locate the error located with the FLC [12], [13]. In the Iraqi network, to produce 100 KW using PV, the best site is chosen by studying the high temperature [14]. Stress analysis maintains acceptable levels of response in the event of sudden or gradual disturbances to obtain stability [15]. ANFIS and PI achieved by Static Var

Compensator and small wind turbines and for voltage regulation SVC was controlled by Enhanced PI By Genetic Algorithm on Single Machine Infinite Bus to enhance voltage and transient stability [16]. AC7B and PSS with AVR were useing to study power, frequency, voltage and rotor angle stability of 9 bus system [17]. Newton-Raphson method and FACTS used to enhancement of power I IEEE 9 bus network. [18]. To boost the stability, the real power flow interface indicator was using on the 30-bus network [19]. To improve the voltage on SMIB, HSVC was applied with AVR and PSS, and the results showed the work of HSVC when the system was exposed to disturbances [20], [21]. Frequency Division Multiple Access and Time Division Multiple Access are used to adjust parameters of secondary transmitters and improved [22]- [25].

Unified Power Flow Controller with Teaching-Learning-Based Optimization technology are used to control the parameters and boost of power stability [26], [27]. Enhanced Dynamic Voltage Restorer is used to increase reliability and voltage swell free load supply. VSC of DVR is conducted to perform its stability with FLC used to detect voltage sag [28], [29]. HSA and TLBO th set the parameters of PI of POD with PSS which controller SVC device on IEEE 9 bus system.

The results show the effectiveness in transient stability, damping oscillation [30]. A neural network use to investigate the error between the ANN outputs and CFANN has the best performance to solve the MLR problem [31]-[34]. Three simulation methods are applied to the neural network and two types of layers. In the first layer he found two neurons and a pure line function. Use three neurons and a positive line function in the second layer [35]. To use ANN, solve MLR be follow to define the input and target data and create the ANN. [39].

This paper shows the angle and voltage stability control. The results when TG and AVR were applied and they were effectively optimized when exposed to perturbation and maintain the terminal voltage, it is placed in the excitation system.

2. Excitation System Description Of Power System

Fig. (1) shows exciter control system. To make the terminal voltage stable, the excitation current field should be operated for rapid and continuous control [40]. AVR controls the generator terminal voltage. The amplifier increases the strength of the regulation signal to that required by the exciter [41]. The voltage of the synchronous generator is disturbed by the disturbance in the network so the exciter will respond to maintain the voltage. In order not to caused excessive heating of the rotor sets the maximum excitatory, to prevent possible loss of excitation minimum [41]. Dynamic behavior of the excitatory system at rates in [41], [42].

$$T_{Ri}\frac{dV_{si}}{dt} = -V_{si} + (V_{refi} - V_i) \qquad i = 1, 2, \ldots, m \tag{1}$$

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Vol. 32, No. 4. \ 2024 ISSN: 2616 - 9916

$$T_{Ai}\frac{dV_{Ri}}{dt} = -V_{Ri} + K_{Ai}R_{f\,i} - \frac{K_{Ai}K_{Fi}}{T_{Fi}}E_{fdi} + K_{Ai}V_{si} \quad i = 1, 2, \ldots, m \qquad (2)$$

$$T_{Ei}\frac{dE_{fdi}}{dt} = -\left(K_{Ei} + S_{Ei}(E_{fdi})\right)E_{fdi} + V_{Ri} \qquad i = 1, 2, \ldots, m \qquad (3)$$

$$T_{Fi}\frac{dR_{f\,i}}{dt} = -R_{f\,i} + \frac{K_{Fi}}{T_{Fi}}E_{fdi} \qquad i = 1, 2, \ldots, m \qquad (4)$$

There is generally a limit constraint on the regulator output is:

$$V_{Ri}^{min} \le V_{Ri} \le V_{Ri}^{max} \qquad i = 1, 2, \ldots, m$$

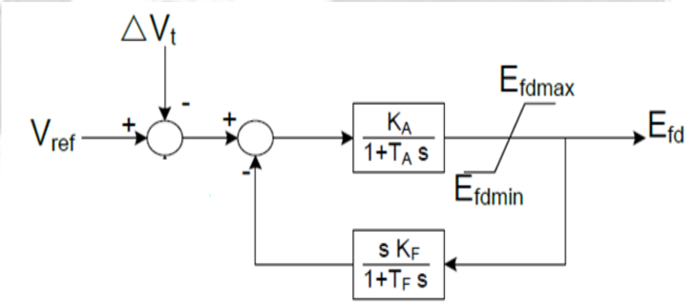

Figure 1. Exciter control system [43]

3. Turbine Governor System

Fig. (2) shows the turbine governor system [43].

Kt- single gain

Tt- time constant

Kg- speed governor is considered with single gain

Tg- single time-constant

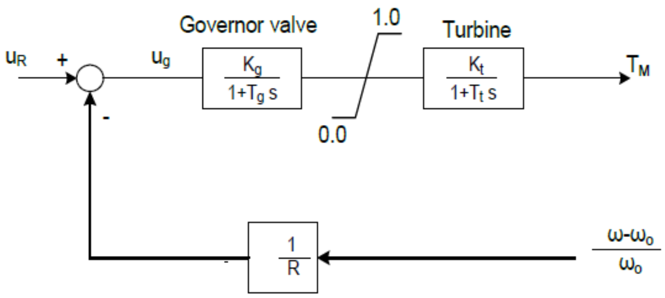

Figure 2. turbine governor system [43]

$$T_G\frac{dt_g}{dt} = \frac{1}{R_i}\left(1 - \frac{T_T}{T_G}\right)\left(\omega_{ref} - \omega_i\right) - t_g \qquad i = 1, 2, \ldots, m \quad (5)$$

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$$T_{Mi} = t_g + \frac{1}{R_i}\frac{T_T}{T_G}\left(\omega_{ref} - \omega_i\right) + T_{Moi} \qquad i = 1, 2, \ldots, m \quad (6)$$

With the limit constraint

$$T_{min} \leq T_{Mi} \leq T_{max} \qquad i = 1, 2, \ldots, m$$

4. Methodology

In Fig. (3), Transfer function of excitation system [16]. ANFIS controller dampens the rotor oscillations of the synchronous generator, input signal of the rotor speed deviation of the generator ω. ANFIS controller is moderate in phase at significant frequencies to make up for the inherent difference between the field excitation and electric torque induced by ANFIS and getting to damping oscillation. ANFIS represents the combination of neural networks and fuzzy inference that works on finding optimization. Its excitation system used a circuit containing KF and TF.

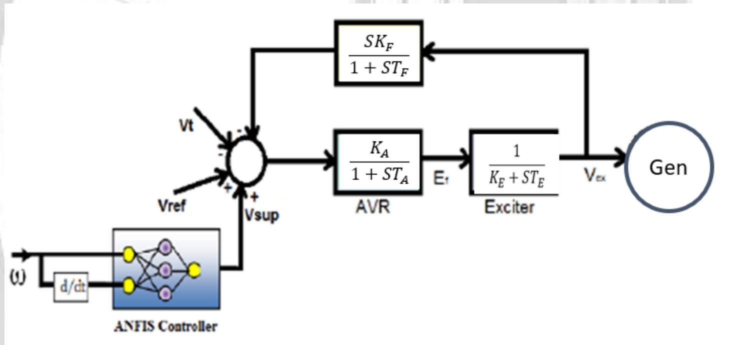

Figure 3. Transfer function of excitation system [16].

The function of the excitation system is:

$$\frac{V_{ex}}{E_f} = \frac{1}{K_E + ST_E} \quad (7)$$

K_E − constant gain

T_E − time constant of exciter

The control strategy consists of an ANFIS controller which is an integration of neural networks and a fuzzy inference system from oscillation inputs ω and error to solve problems. The voltage has been improved by ANFIS.

5. Results And Discussion

Fig. (4) shows 3 bus system when the fault between 1B and 2B. Figures (5) and (6) represent the angle 1-2 with and without (TG), (AVR) and ANFIS at a fault occurs t_f = 5 sec.

and the fault is removed by opening the breakers of the faulted line t_c = 5.2 sec., respectively. In Fig. (5) the angle with (TG), (AVR) and ANFIS stable and damping oscillation. In Figure (6), fault is cleared by opening one of the two lines between B1 and B2. The voltage of B1, B2 and B3 with and without (TG), (AVR) and ANFIS at t_f = 5 sec. and t_c = 5.2 sec., in Figures (7) and (8) respectively. In Figure (7), voltage without (TG), (AVR) and ANFIS is stable. In Figure (8), voltage with (TG), (AVR) and ANFIS is stable. The error has been removed and the original system has been restored. ANFIS suppresses all oscillations, damping oscillations, stabilizing and improving the voltage regulation of the system.

Fault is cleared by opening one of the two lines between B1 and B2. Compared with [20], HSVC used with AVR and PSS when SMIB system was exposed to disturbances to improve voltage stability.

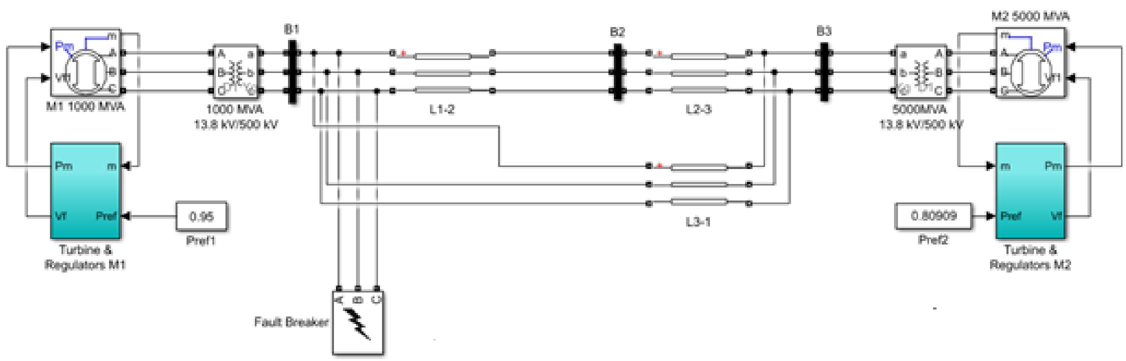

Figure 4. MATLAB of 3bus system.

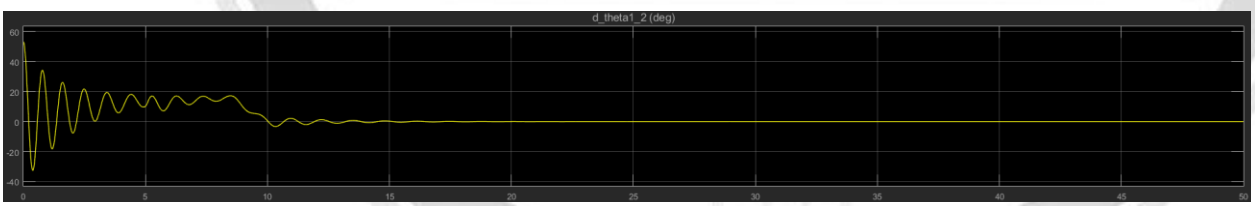

Figure 5. DEL 1-2 without (TG), (AVR) and ANFIS.

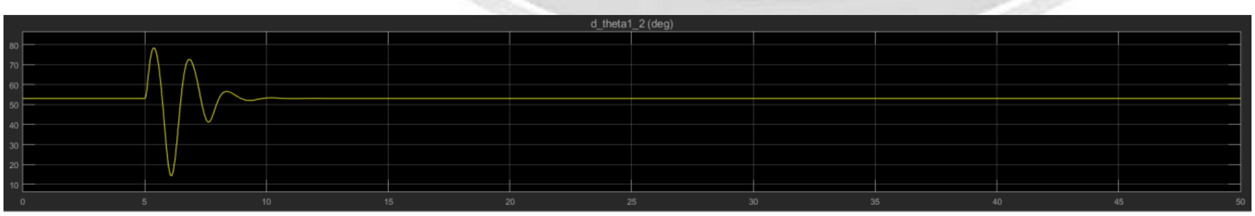

Figure 6. DEL 1-2 with (TG), (AVR) and ANFIS.

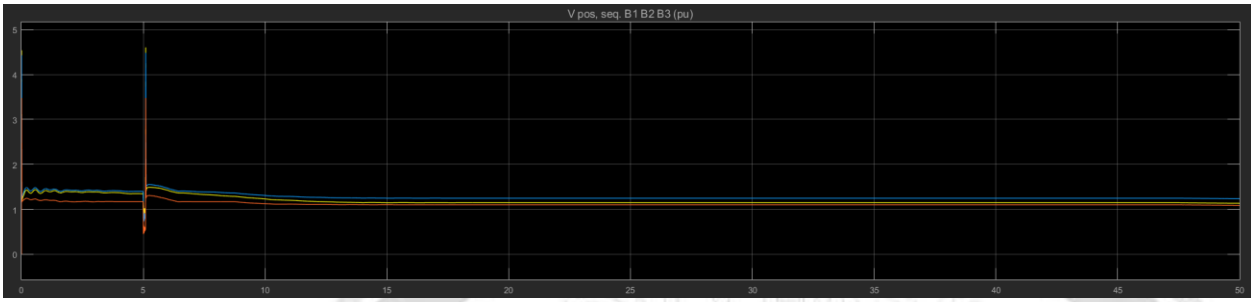

Figure 7. Voltage (B1___, B2___ and B3___) without (TG), (AVR) and ANFIS.

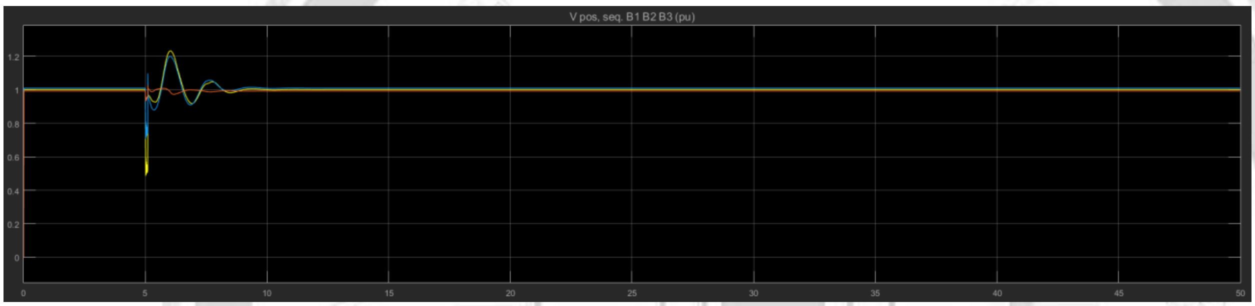

Figure 8. Voltage (B1___, B2___ and B3___) with (TG), (AVR) and ANFIS.

6. Conclusion

In 3-bus system, the tripartite fault between 1B and 2B were that if the rotating angle, whether it was stable or unstable, then the voltage is stable and damping increase. If the inertia value becomes large, it will interfere with TG and AVR and the system becomes more stable. The addition of AVR and TG with ANFIS of the synchronous generator reduces unwanted disturbances, parameters tuning and improve the dynamical response. The results show the performance of the proposed technique in terms of low fluctuation, ripple, accuracy and speed. The system is transiently stable s because the maximum value at which the defect is removed is after these disturbances and the error is removed. ANFIS can suppress all oscillations better.

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Vol. 32, No. 4. \ 2024 ISSN: 2616 - 9916

نظام استدلال عصبي ضبابي جديد متكيف مع منظم توربيني ومنظم جهد أوتوماتيكي للتحكم في نظام شبكة الطاقة

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خلاصة:-

يقدم هذا البحث منظم التوربينات (TG) ومنظم الجهد الأوتوماتيكي (AVR) ونظام الاستدلال العصبي الضبابي التكيفي الجديد (ANFIS) للبحث عن التحسين والاستقرار. استخدام MATLAB على نظام 3 باص والأعطال ثلاثية الطور بين أنظمة B1 وB2 مع وبدون (TG) و (AVR) و (ANFIS) عند t_f = 5 sec و t_c = 5.2 sec. من النتائج التي تم الحصول عليها من عمليات المحاكاة، استنتج أن الجهد في حالة مستقرة سواء كانت زاوية الدوار مستقرة أو غير مستقرة. استخدام (TG) و (AVR) و (ANFIS) في الشبكة لها دور في الاستقرار المؤقت للنظام وتحسين الجهد.

الكلمات الدالة:- منظم التوربينات، منظم الجهد الأوتوماتيكي ANFIS، استقرار الجهد.