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Neural Controller for Damping Transmission Line Oscillations

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Abstract

Objective: This paper presents how a neural controller negotiates and dampen the oscillations, due to a transient fault that occurs in a power system. **Methods/ Analysis:** In this research work a transient symmetrical fault and its associated damping are analyzed, the response of the two controllers, one is the fuzzy tuned controller and the other controller is designed with neural logic for maneuvering momentary fault condition. Thyristor Controlled Reactor is a potential controller used for reactance control and for damping the oscillations in power system. **Findings:** Through this research article the effect of TCR is analyzed. In the present flexible A.C transmission system TCR is used for damping oscillations in the transmission line caused due to disturbance. Here, a symmetrical fault is simulated and the results are presented. Neural tuning of TCR improvises the result. Even without tuning TCR has the property of damping line oscillations, if tuned in a proper way by intelligent controllers definitely it has improvisation over the results. **Novelty/improvement:** The main novelty here is the use of neural controller for tuning a TCR. Generally, earlier the outputs were obtained through fuzzy controller or PID controllers. Also here the outputs are analyzed for three phases.

Keywords: Fault Analysis, Fuzzy, Mat-lab, Neural, TCR

1. Introduction

Power system in today's scenario is on the growing trend. Growing here refers to growing in all dimensions. Both structurally as well as by reliability. Many contingencies are tackled effectively by intelligent operation and control procedures.

Operation and control procedures play a vital role in today's scenario. Power system engineers and operators have to adapt themselves to the changing situations. This paper focuses on how a thyristor controlled reactor can be effectively tuned by fuzzy and neural logics and how it is suitably used as a damping device during emergency situations.

In the earlier works[1] for an IEEE14 - bus system, a symmetrical fault of momentary nature was taken, and how a fuzzy controller tunes the TCR in such a way to damp the oscillations. Here, neural controller is used to tune the TCR, and to damp the oscillations.

This work is significant for the reason that much focus is given for neural controllers. In present scenario more research works are in upswing with the effective combination of fuzzy expert systems along with neural controllers. The main strength of fuzzy controllers is that it can withstand uncertainty and non-linearity of the system to a larger extent[2].

Before proceeding further, fault and its peripheral discussions are presented.

Faults in Electrical science can be viewed in two ways, one fault is due to the shift in the line impedances, these faults are defined as series faults and the other faults are due to shorting of line conductors to ground, these faults are defined as shunt faults. Symmetrical faults are considered as most dangerous[3].

During a three phase fault, the current value profoundly rises and the voltage falls to zero3. The Fig.

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1 represents the condition for balanced three phase fault, Fault point is indicated by the letter F.

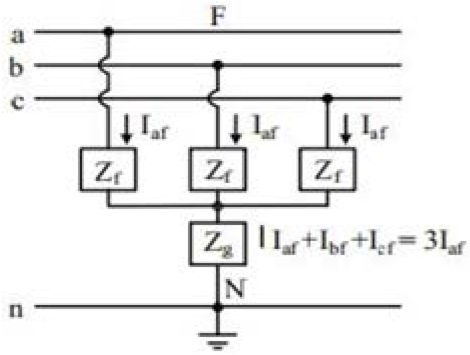

Figure 1. General representation of 3 phase fault.

$$I_{ao}=0$$
$$I_{a1}=1.0\angle 0^0/Z1+Zf$$
$$I_{a2}=0$$

$$V_{af}=0$$
$$V_{bf}=0$$
$$V_{cf}=0$$

And line voltages $V_{a0}=0$

$$V_{a1}=0$$
$$V_{a2}=0$$

Mat lab was selected for its flexibility and it is well adapted for a specific problem. Fig. 2 explains the generalized diagram of thyristor controlled reactor. The reactance of the reactor is controlled by proper gate pulses. It is also to be underscored here that reactive power is also governed and controlled as per the requirements of the power system[4]. In this work, the dynamics of the thyristor controlled reactor to damp the oscillations are analyzed. In power systems, it is a imperative FACTS controller with two way thyristor valve[3].

TCR and Thyristor Switched Reactor (TSR) are made up of parallel connected reactors elements. These reactor elements are controlled by thyristors. For TSR the functionality depends on step variation of reactance. SVC typically consists of TCR, a TCS. This configuration can be tuned to minimize the losses at the most operating point[27].

Based on the above introduction a literature survey has been carried and the essentialities are cited as follows. Fuzzy logic and neural controllers in the present scenario has been applied through graphic user interface environment[4] . Based on adaptive PID CONTROLLERS many research works were done ,this is for the reason that PID controllers always have the robustness moreover if properly tuned it becomes more adaptive for the control applications[5]. Filip et al.[6] have done research in adaptive fuzzy controllers with more enhanced features. Fuzzy controllers have played a very dominant role in power systems[7]. Fuzzy has not only strong footed in power systems but also in power electronics applications[8]. Hasan et al.[9] in their works have contributed in design and implementation perspective of fuzzy controllers. Visioli et al.[10] have highlighted tuning of PID controllers with fuzzy logic. Compatability comparisions were done on TCSC device with respect to PID and fuzzy controllers[11]. Also a static var compensators were studied[12]. Ghafori et al.[13] in their contributions have dealt with STATCOM and its applications in negotiating transient stability. Radman et al.[14] in their research have modeled dynamic FACTS CONTROLLERS. Midhulananthan et al.[15] in their contributions have compared FACTS controllers for stability criteria and for damping power system oscillations. Miranda et al.[16] have developed fuzzy inference mechanism for VAR control. Athay et al.[17] have developed robust strategy for shunt and series compensation, robust strategy has been built to damp the the electromechanical oscillations. Hoang et al.[18] in their contributions have designed and developed fuzzy inference mechanism for power system stabilizer. Ibrahim[19] in their work have developed a new control mechanism for D.C motor using ant-colony algorithm technique to tune a PID controller. Chafaa et al.[20] in their research contributions have developed Type -2 Fuzzy inference systems for control applications. Singh et al.[21] in their work have compared PI and PID controllers in the parameter of active and reactive power control of two voltage source convertors connected to power structure. Saghafinia et al.[22] in their research contributions have compared Fuzzy PI and PI controllers for induction motor drive system. Duman et al.[23] in their research contributions have designed a robust proportional controller for power engineering stabilization using RCGA. Banaei et al.[24] in their research work have analysed controller using dynamic swarm optimization logic for static compensator applications. Abedinia et al[25] in their works have developed a new combined method GA – PSO for Fuzzy controllers. Kasilingam et al.[26] in their research works have co- ordinated a power system stabilizer and proportional, integral and derivative controllers for enhancing stability of the power system. Sujatha et al.[27]

in their contributions have analysed the impact of VAR compensators in mitigation of harmonics.

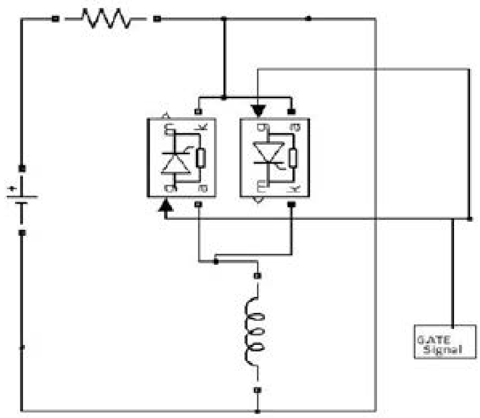

Figure 2. Generalized block diagram of TCR.

2. Fuzzy and Neural Controllers

Fuzzy logic is an intelligent approach[7]. Linguistic rules are framed for it. The fundamental model of fuzzy incorporates fuzzification, knowledge base, fuzzy inference, defuzzification.

3. Neuro-fuzzy Controllers

Neural networks have the ability to read the source data. The tuned network behaves like a complete information kit.To tap the informations from it is difficult. Also, it is equally difficult to add special information's. If to be put in another way it is not as flexible as fuzzy. Fuzzy controllers work with a set of linguistic rules, it is easy to edit and correct it. Fuzzy controllers are flexible for it and it will adapt to the new set of rules. The following Figures 3,4,5,6 represents the basic neural network structure. Part of layer 1 in neural networks, part of layer 2 in neural networks respectively.

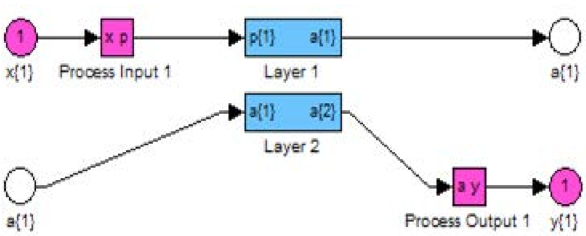

Figure 3. Neural network structure in Matlab.

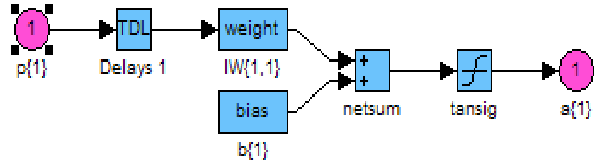

Figure 4. Part of layer 1..

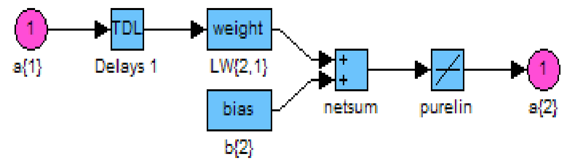

Figure 5. Part of layer 2.

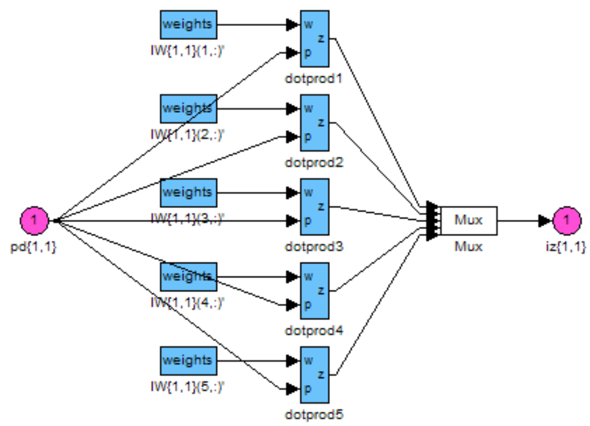

Figure 6. Description block of weight in layer 1.

4. Problem Description

In this research work a momentary fault of 0.02-0.03 seconds is taken. Due to this highly transient nature the transmission system has electro-mechanical oscillations. This is counter-acted by properly tuning of TCR. In the earlier work[1] PID with tunned fuzzy is taken for tuning the TCR. Here neural-networks is applied. Here IEEE-14 bus system is the test case. Symmetrical fault is simulated across 3 and 4. For the purpose of damping TCR is attached with the test case.

In this case the fault sustains for a very short time period of 0.02 seconds. This causes electro-mechanical oscillations in the line segment.The line variables are also disturbed. This work analysis how TCR is successful in damping the same.

5. Control Methodology

Neuro-fuzzy tuning consists of process of neural networks has fuzzification and defuzzification with a membership function.

- Inputs are X {1} is a variable transformed and processed to **X P** (process input 1). In process input the variables are sent into **Fix Unknowns**, processing function is not yet supported in Simulink. It currently returns its input without any change.
- After conversion into linguistic variables, it goes to Remove constant rows, i.e., Removes rows from a vector in positions where the values are always constant.
- From Remove constant rows, input goes to **Mapminmax**, Maps each element of x from its respective [minimum, maximum] interval to a common [minimum, maximum] interval.
- Then, converted input variable is sent into P. It is then processed based on certain conditions.
- In Layer 1, **TDL** the primary signal passes through the delay sector. The weights play a major role in this case.
- In Weight, it functions according to Neural network rules and similar to Fuzzy-Weight.
- Each of the variables in sets is processed with many goes to Dot Product Weight Function. And to multiplexer, where a set of variables is combined to give one output goes to summation .
- A block called **Bias** is also given to **Netsum**. Both are added to purelin (a linear transfer function) proceeds to initial output port **a1**.
- From **a1 to Layer 2,** same elements TDL, Weight, Bias, Netsum to **a2**. From a2 to Process output where output variables are subjected to defuzzification and passes to output **Y.**

5.1 Explanation of the Neural Process

It's a dynamic state is obtained by an adaptive learning process or self correcting mechanism. Back propagation algorithm is the fundamental process. In this research article a Thyristor Controlled Reactor (TCR) is tuned by neural controller. In the Figure 7, the IEEE 14 bus system designed with Matlab- Simulink is shown, in that it has to be observed that the control input for the TCR gate pulse is provided by neural logic. This has been incorporated in the simulink model. The input for the TCR is fed from neural block. Here, the neural block is assigned with weights from (0 to 5). It applies the weight suitably depending on the control magnitude required for the fault. The TCR 'S effective reactance is controlled by the triggering pulse angle that in turn is controlled by neural output. The objective by which it is designed is that the damping of oscillations must be quick and effective.

The results are quite encouraging.

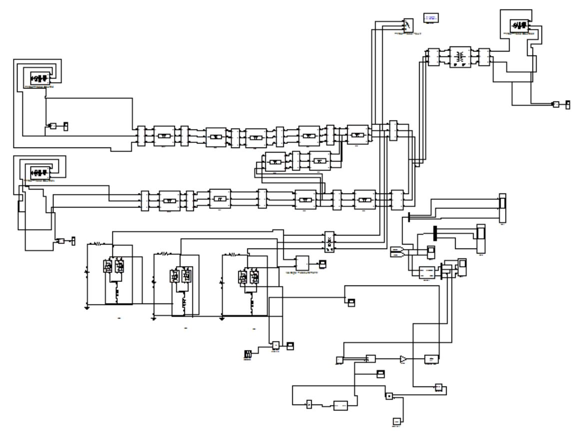

Figure 7. IEEE- 14 bus systems with neuro tuned TCR.

6. Results and Discussion

From the result, it's very clear that there is a sudden upsurge of current during the fault condition. It is to be observed here that the damping process is also successful. The oscillations (travelling wave surges are controlled by the TCR controller tuned by neural controller. Also, it is to be understood here that after the duration of transient fault, the settling of current parameter is also smooth. In the earlier work standard 14 bus system with the same symmetrical fault is controlled by the fuzzy controller as shown below

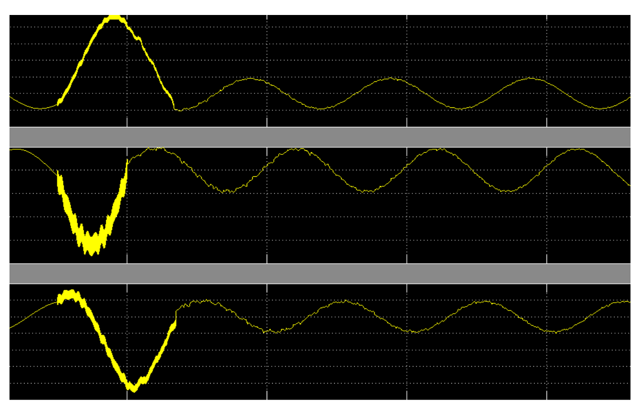

Figure 8. Waveforms of current of all the three phases during the symmetrical fault between bus 3 and 4.

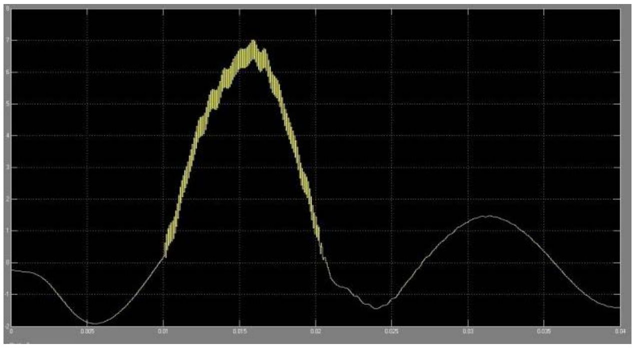

Figure 9.

But in the earlier study one phase was analyzed and presented. Here, all the three phases are presented. From the two research studies made on TCR regarding it's tuning with intelligent controllers fuzzy and neural process. Both have control abilities on TCR also TCR is compatible for the tuning process. Based on this even an embedded hardware control can be built and supported with TCR. This further smoothens the control methodology.

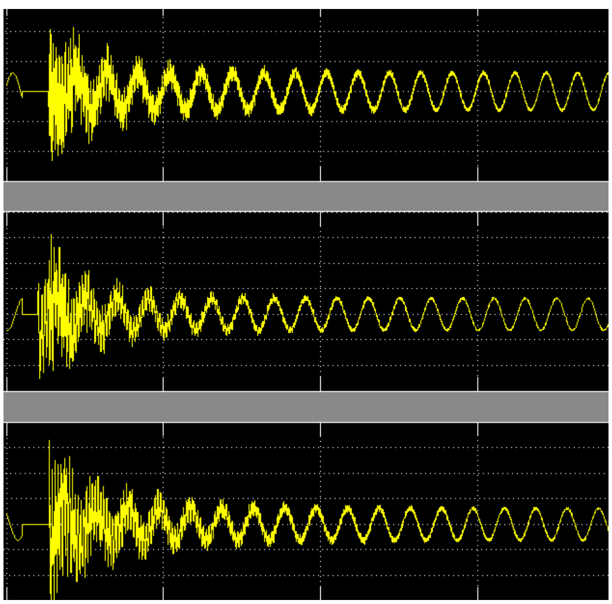

Figure 10. Waveforms of voltage of all the three phases during the symmetrical fault between bus 3 and 4.

From the above results it is vivident that, during transient symmetrical fault condition the voltage in all the phases becomes zero. After the recovery of fault since the breaker is in auto re-close mode, it closes the circuit. During this process voltage wave cannot reach to normalcy immediately, and that is represented as a surge of oscillations in voltage component for few seconds say.002 seconds. This surge of oscillations immediately settles down to normalcy by the action of neural controlled TCR.

7. Conclusion

Through this research article the effect of TCR is analyzed. In the present flexible A.C transmission system TCR is used for damping oscillations in the transmission line caused due to disturbance. Here, a symmetrical fault is simulated and the results are presented. Neural tuning of TCR improvises the result. Even without tuning TCR has the property of damping line oscillations, if tuned in a proper way by intelligent controllers definitely it has improvisation over the results.

8. References

1. Ashokkumar N, Rathinakumar M. Intelligent solution for transmission line management for three phase to ground fault problems. International Review of Automatic Control. 2014 Sep; 7(5).
2. Santamaria J. Analysis of power systems under fault conditions. B. S. Universidad Centroamericana, Elsalvador; 2006.
3. Available from: http://en.wikipedia.org/wiki/Thyristor_controlled_reactor.
4. Giri PD, Shah SK. Fuzzy logic controller and neural network controller as a power system regulator implemented on GUI. Proceedings of the International Conference on Soft Computing for Problem Solving (SocProS 2011), 2011 Dec 20–22, Vol 30 of the series Advances in Intelligent and Soft Computing; 2011. p. 243–56.
5. Dash K, Liew AC, Mirshra BR. An adaptive PID stabilizer for power systems using fuzzy logic control. Electric Power Systems Research. 1998 Mar; 44(3):213–22.
6. Filip I, Prostean O, Vasar C, Szeidert I. Adaptive fuzzy controller for synchronous generator. 3rd Romanian Hungarian Joint Symposium on Applied Computational Intelligence (SACI), Timisoara Romania; 2006 May.
7. El-Hawary, Mohamed E. Electric power applications of fuzzy systems. Wiley-IEEE Press; 1988.
8. Tomescu B. On the use of fuzzy logic to control paralleled dc-dc converters. Dissertation Virginia Polytechnic Institute and State University Blacksburg, Virginia; 2001 Oct.
9. Hasan AR, Martis TS, SadralUla AHM. Design and implementation of a fuzzy controller based automatic voltage regulator for synchronous generator. IEEE Transactions on Energy Conversion. 1994; 9(3):451–9.
10. Visioli A, Nagrath IJ, Gopal M. Tuning of PID controllers with fuzzy logic. Control Systems Engineering; 1999.
11. Yolac U, Yalcinoz T. Comparison of fuzzy logic and PID controllers for TCSC using MATLAB. 39th International

Conference on Universities Power Engineering. 2004 Sep; 1:438–42.
12. Static VAR Compensator. Available from: http://en.wikipedia.org/wiki/static_VAR_Compensator.
13. Ghafori A, Zolghadri MR, Ehsan M. Fuzzy controlled STATCOM for improving the power system transient stability. IEEE International Conference on Power System; 2001. p. 1178–85.
14. Radman G, Raje RS. Dynamic model for power systems with multiple FACTS controllers. Electric Power Systems Research; 2008. p. 361–71.
15. Midhulananthan N. Canizares CA. Comparison of PSS, SVC and STATCOM controllers for damping power system oscillations. IEEE Transactions on Power Systems. 2003 May; 18(2).
16. Miranda V. An improved fuzzy inference system for voltage / VAR control. IEEE Transactions on Power Systems. 2007 Nov; 22(4).
17. Athay T, Podmore R, Virmani S. A robust control strategy for shunt and series reactive compensators to damp electromechanical oscillations. IEEE Transactions on Power Delivery. 2001 Oct; 16(4):812–17.
18. Hoang P, Tomsovic K. Design and analysis an adaptive fuzzy power system stabilizer. IEEE Transactions on Energy Conversion. 1996 Jun; 11(2).
19. Ibrahim HEA, Mahmoud AAH. DC motor control using PID controller based on improved ant colony algorithm. International Review of Automatic Control (IREACO). 2014; 7(1):1–6.
20. Chafaa K, Benzid R, Slimane N, Ghanai M, Blanco D, Moreno L. Type-2 fuzzy basis functions for adaptive control. International Review of Automatic Control (IREACO). 2013; 6(1):14–18.
21. Singh R, Singh AK. Design and comparison of a PI and PID controller for effective active and reactive power control in a grid connected two level VSC. International Review of Automatic Control. 2013; 6(6):759–66.
22. Saghafinia A, Ping HW, Rahman MA. High performance induction motor drive using hybrid fuzzy-PI and PI controllers. A International Review of Electrical Engineering. 2010; 5(5):2000–2011.
23. Duman S, Ozturk A. Robust design of PID controller for power system stabilization by using real coded genetic algorithm. International Review of Electrical Engineering. 2010 Sep; 5(5).
24. Banaei MR. Tuning of damping controller parameters using multi-objective PSO algorithm for STATCOM. International Review of Electrical Engineering. 2011; 6(1):300–8.
25. Abedinia O, Naderi MS, Jalili A, Mokhtarpour A. A novel hybrid GA-PSO technique for optimal tuning of fuzzy controller to improve multi-machine power system stability. International Review of Electrical Engineering. 2011; 6(2).
26. Kasilingam G, Pasupuleti J. Coordination of PSS and PID controller for power system stability enhancement – overview. Indian Journal of Science and Technology. 2015 Jan; 8(2):142–51. DOI: 10.17485/ijst/2015/v8i2/58441.
27. Sujatha S, Anita R, Selvan P, Selvakumar S. Impact of static VAR compensator in stability and harmonics mitigation for real time system with cogeneration. Indian Journal of Science and Technology. 2015 Jun; 8(12). DOI: 10.17485/ijst/2015/v8i12/54007.