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An Excitation Failure Detection Scheme for Alternators Using Fuzzy Inference System

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ABSTRACT
A novel fuzzy based Excitation Failure detection scheme for alternators is being attempted in this work. This work uses voltage-impedance trajectory and reactive power to clearly identify Excitation Failure from Stable Power Swing. For making a decision between Excitation Failure and Stable Power Swing the parametric values are not considered as actual (crisp) but taken as a fuzzy set. The attempted work in this paper results in a safe and reliable fast mechanism which clearly indentifies Excitation Failure and Stable Power Swing without misinterpretation.
Keywords: Excitation Failure, Stable Power Swing

I. INTRODUCTION

Fundamental protection requirements for smooth and reliable operation of a generator are elaborately discussed in [1] with particular priority to Excitation Failure situations and its detection. The evolution of Excitation-Failure relays is briefly discussed. Also some situations where Stable Power Swings have been interpreted as Excitation Failures due to lack of a fool proof mechanism has been reported in [1],[6]. Researchers have tried out providing a time delay to the Excitation Failure protection and it was inferred as is not an apt solution [1]. Further developments and wide range of approaches for LOE detection and protection are available in literature of which some are based on soft computing technique. [1] Presents an elaborate overview of various approaches and problems pertaining to LOE detection. Also to overcome these issues an innovative approach implementing a fuzzy base algorithm has been tried in [1]. In this work, as an attempt to enhance the reliability of LOE detection, the authors have tried a fuzzy inference system by including reactive power as a third parameter in addition to the traditional voltage and impedance.

II. FUZZY INFERENCE BASED EXCITATION FAILURE DETECTION SCHEME

Excitation Failure is a major issue as far as reliable operation of alternators is concerned Main reasons pertaining to Excitation Failure and its effects are elaborately discussed in [1].

During Excitation Failure of a synchronous generator feeding active power to a system, the reactive power supplied by the generator gradually decays and there is a reversal of reactive power flow. The alternator in an attempt to maintain synchronism starts absorbing reactive power from the system or in other words will try to work as a line excited induction generator. The above statement can be understood by analyzing the waveform (Fig 1) pertaining to reactive power value changing to negative region after the occurrence Excitation Failure. Further analysis of Fig 2 and Fig 3 pertaining to normal condition and Stable Power Swing respectively infers that monitoring reactive power flow in an alternator can be a useful parameter for Excitation Failure detection. Hence in the proposed scheme, the objective is that the mechanism should trip the generator for negative reactive power flow pertaining to Fig1 as Excitation Failure and should give an alarm pertaining to Fig3 that is SPS and should not do anything pertaining to Fig2 that is normal operating condition.

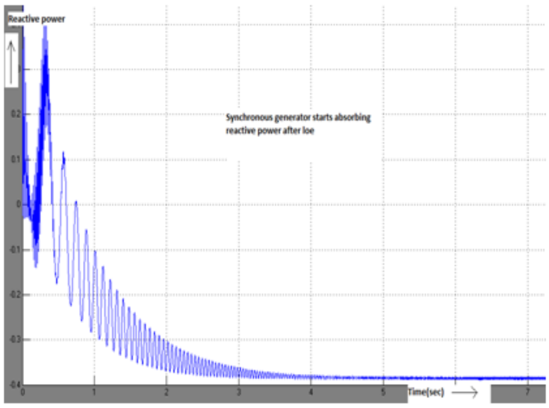

Figure 1 Typical behavior of Reactive power of a generator after LOE

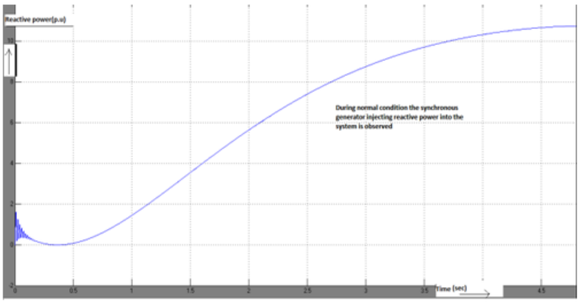

Figure 2 Typical behavior of Reactive power of a generator During Normal operating condition.

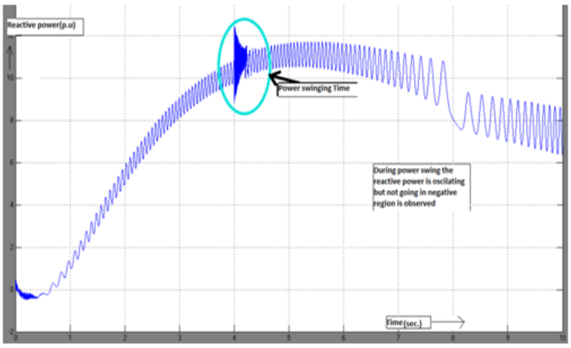

Figure 3 Typical behavior of Reactive power of a generator during SPS.

The authors of this work have referred [1] for selection of voltage and impedance values. As an enhancement the authors have included reactive power as third input to clearly differentiate LOE and SPS. When the generator looses excitation the reactive power will reduce below 0 (i.e. in negative (absorbs reactive power).

The fuzzy inference mechanism and information for LOE protection are discussed in [1]. The conventional LOE protection methods are discussed in [1]. The selection of voltage and impedance values for LOE protection based on fuzzy inference system is referred from [1]. Along with the voltage and impedance author of this paper includes reactive power as third input to Differentiate LOE and SPS. When the generator losses excitation the reactive power will reduce below 0 i.e in negative (absorbs reactive power).

The authors of [1] have use mamdani type fuzzy inference system. In this work the authors have tried Takagi-Sugeno-Kang (TSK) type Fuzzy inference system and the output membership functions are created. Instead of linear type output membership function, in this work the authors tried constant as output membership function. 0, 1, 0.5 are chosen as output membership function values as trip, no trip and alarm respectively.

Based on the characteristics of input and output membership functions and it's characteristics the following rules have been made.

1) *If Z* Low *and Vt* Medium and Q low, *then* Trip (1);
2) *If Z* Medium *and Vt* Medium and Q low, *then* Trip (1);
3) *If Z* High *and Vt* High and Q High, *then* No Trip (1);
4) *If* Q High, *then* No Trip (1);
5) *If* Q medium, *then* Alarm (1);
6) *If* Q Low, *then* Trip (1);

During starting of Synchronous Generators the reactive power will be nearer to zero so the rule 5 gets alarm as output. When breaker contact is open we can connect alarm there to give signal to the operator.

III. SIMULATION AND RESULTS

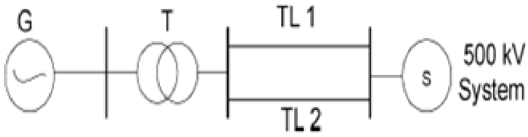

Figure 4

Figure 4 shows the test system taken for LOE protection. IEEE type 1 Excitation system and Hydro turbine is taken for simulation. For simulating the proposed LOE protection SMIB system has been taken. Transmission lines and transformer ratings are referred from [1]. The simulations are made using MATLAB. For Verifying the effectiveness three different generators and different loading conditions are chosen. The loading values for this work and generator parameters are same as used in [1].

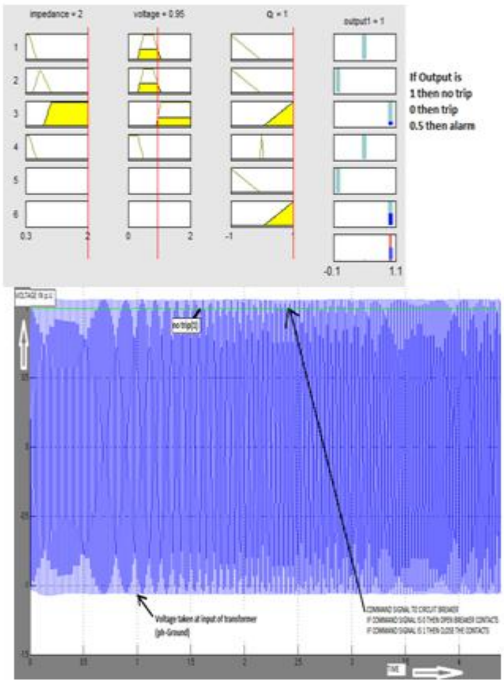

Figure 5 shows the output Rule view under normal condition and waveform taken across Line to neutral of input side of transformer. During normal condition the relay does not gives trip signal at various simulation performed.

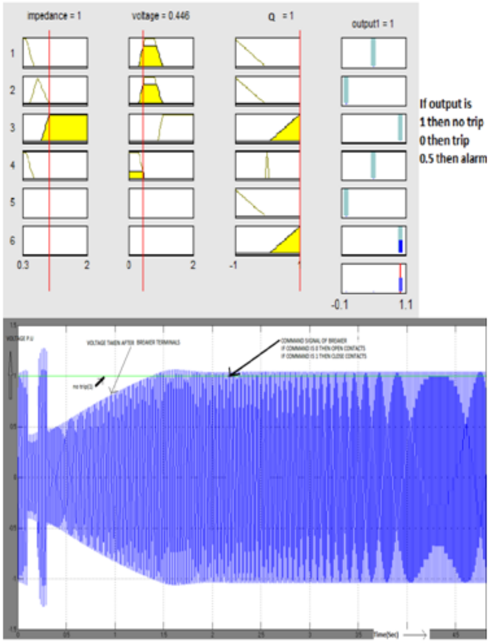

Figure 6 shows the output Rule view under Stable power swing condition and waveform taken across Line to neutral of input side of transformer. Three different generators with different loadings were tested as per the values given in [1]. Proposed method does not give trip signal during any of the SPS condition.

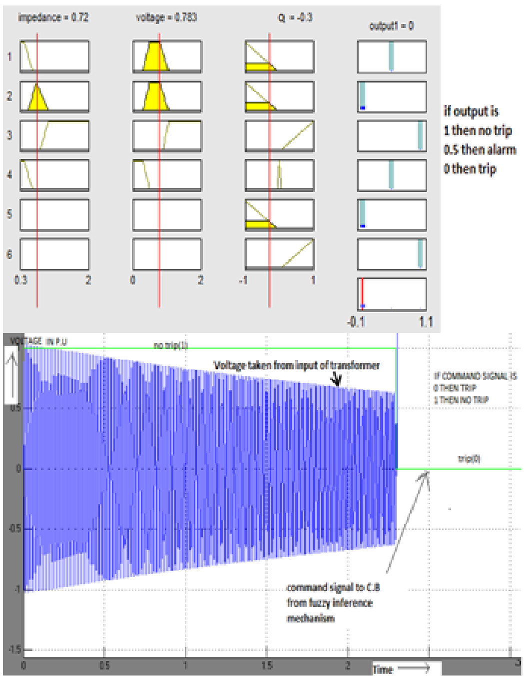

Figure 7 shows the output Rule view under Loss of excitation condition and waveform taken across Line to neutral of input side of transformer. Generator with different loading has been made during loss of excitation simulation. It gives trip signal all the times.

IV. SUMMARY AND CONCLUSION

Thus it can be inferred from this work that a reliable Excitation Failure Detection method has been developed for alternators. For different ratings of generators it is necessary to change the base value of the measurement for proper and accurate operation. The proposed protection scheme gives exact result at all the different conditions performed. The proposed scheme can be suitable for all sizes and ratings of synchronous generators.

REFERENCES

[1]. Adriano P. de Morais, Ghendy Cardoso, Jr., and L. Mariotto," An Innovative Loss-of-Excitation Protection Based on the Fuzzy Inference Mechanism IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 25, NO. 4, OCTOBER 2010.

[2]. "IEEE Committee report, "Survey of experience with generator protectionand prospects for improvement using digital computers"," *IEEETrans. Power Del.*, vol. 3, no. 4, pp. 1511–1522, Oct. 1988.

[3]. *"SIPROTEC – Multifunctional Machine Protection 7UM62 Manual,"*Siemens Ltd., 2005.

[4]. P.Kundur, *Power System Stability and Control*. New York: McGraw-Hill, 1994.