AN ADVANCED APPROACH TO IDENTIFY INRUSH CURRENT AND HARMONICS USING ARTIFICIAL INTELLIGENCE FOR POWER SYSTEM PROTECTION

Tawheeda Yousouf[1] , Raguwinder Kaur[2]

[1]*Electrical engineering, AIET/PTU Jalandhar, (India*)

[2]*H.O.D, Electrical engineering, AIET, PTU Jalandhar,(India)*

ABSTRACT

Transformer is a major and important element of any power system. Normally it must be properly protected by differential relays. This protection system should be precise and reliable via implementation of strong algorithms that are able to differentiate between faulted and unfaulted condition to fully grantee of power continuity. This method presents an approach for protection of power transformers; this uses fuzzy interference system. The proposed method has been designed to make the system artificially intelligent by using fuzzy logic To estimate harmonics up to 5th order rather than giving thresholding values manually, we will trigger it by using fuzzy rules that are created using fuzzy tool box in Matlab. The performance of this simulated model is demonstrated by simulation on a power transformer using Matlab.

Index Terms - *DC component, Harmonics, Inrush phenomenon, MATLAB, Power Transformer, fuzzy logic*

I. INTRODUCTION

Transformer is expensive primary plant equipment within a power system network which needs to be isolated quickly and reliably in the event of a fault. Utilities have a responsibility towards the consumer to provide reliable and continuous power in the network without causing a large blackout or cascade power failure. Inrush and fault currents consist of DC component and harmonics and it is a challenging task to estimate and eliminate DC component which occur during transients. A decaying DC component is a non-periodic signal with a wide spectrum band. It has a significant effect on the relay operation and challenges protection engineers to estimate accurately the magnitude and the time constant of the current wave form. The value of DC component also depends on the fault resistance, fault location and fault inception angle. The implemented algorithm and estimated time constant usually helps the decaying DC component to converge to a final value otherwise it may lead to oscillation and initial overshoot.

Further, transients arising due to opening or closing of circuit breaker or due to lightning strikes HV transmission line or switching surges could create large amplitude in current and voltage peaks which may degrade the insulation of power transformer. It has been observed that these faults introduced environmentally or due to system problems cannot predetermine the amplitude of DC signals [1]. Hence, digital filtering algorithms such as full cycle DFT, half cycle DFT, least squares, Kalman filters has been used in the past to estimate the decaying DC offset component present in the input signal. MATLAB or EMTP computer simulation using filters described is the most preferred software tools employed in eliminating DC component and discriminating various order of harmonics. Inrush current occurring due to switching of a power transformer on no load may lead to resonance. A resonance is said to have occurred in the power system when there is a slow damping of inrush current. It has been observed that during inrush phenomenon, the magnitude of the inrush current depends on the switching angle 89and switching instance of the circuit breaker. In a typical normal operating scenario, the primary and secondary current of a power transformer maintains equilibrium but when an internal fault occurs, this balance is disturbed. The magnitude of the fault current depends upon zone of occurrence, the type of the fault (i.e. phase to phase, phase to earth etc.), vector group of transformer (i.e. star-star, star-delta, delta-star).The magnitude of an inrush phenomenon is usually 10-15 times the normal operating current and as a result of this inrush, high level of harmonics are present in the system which degrades the insulation, gives rise to temperature resulting in insulation failure. Harmonic current is always reactive and generate a voltage drop across the network leading to power system instability. Australian and IEC standards have limited the end users with respect to injection of harmonics into the network. As 2279 allows customer and industrial end user to restrict total harmonic distortion (THD) below 5%. Predominantly second harmonic contains inrush and causes nuisance tripping during power transformer energization

Inrush phenomenon occurs when a power transformer draws a non-symmetrical magnetizing current the time of energization. The severity of inrush is more pronounced depending upon the leakage impedance residual flux and the angle of applied voltage. The effect of inrush on power transformer winding is gauged from the fact that it heats up the winding causing fast aging, insulation failure and gives rise to harmonics. The mechanical effect of inrush is same like that of short circuit which lasts for 10 seconds or more. Some of the traditional strategies [1] employed to mitigate inrush and harmonics appearing on a power transformer has been enumerated hereunder:-

1. Pre-insertion of a resistor in series circuit. When the transformer is energized there is a voltage drop across this resistor and reduction in flux due large voltage drop. Although the method looks simple, the incomer circuit breaker associated with power transformer can be destroyed during switching operation.
2. Placement of an auxiliary winding within the transformer which controls the transformer reluctance but this will be challenging task if the power transformer has already been manufactured
3. Building up of a low variable frequency voltage which demagnetizes transformer.
4. Using a 12 pulse or 24 pulse bridge rectifier i.e. Converter

5. Phase by phase control of a thyristor controlled rectifier

The major disadvantages of above methods described are either it is too difficult to construct or formulate a complicated protective algorithm and requires complex installation measuring instruments often deemed non-practical and too expensive.

In this paper, a method has been designed to make the system artificially intelligent by using fuzzy logic to estimate harmonics up to 5th order rather than giving thresholding values manually, we will trigger it by using fuzzy rules that are created using fuzzy tool box in Matlab. The performance of this simulated model is demonstrated by simulation on a power transformer using Matlab.

II. SIMULATION

When the power transformer is switched on from primary side i.e. CB the magnitude of the inrush current is much smaller limiting the inrush. The inrush current phenomenon is investigated on a three phase 22KV/220KV, 250MVA transformer by using MATLAB/Simulink model. The maximum possible inrush current is first found out by switching on the power transformer. It is seen that, the peak value of inrush current is very high as compared to normal magnetizing current. Fig. 4.7 and Fig.4.8 shows a MATLAB model of power system network augmented with fuzzy logic controller Fig 4.9 having power apparatus and L-C filter for offline testing of the estimation of amplitude of inrush and short circuit. The DC component within inrush current is estimated and eliminated.

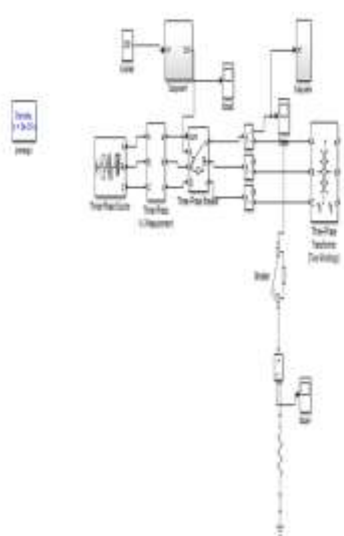

Fig.1 Simulink model with fuzzy subsyste

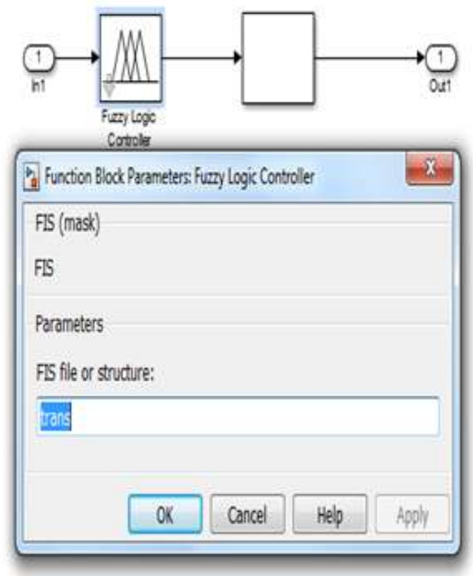

Fig. 2: Simulink model with fuzzy subsystem1

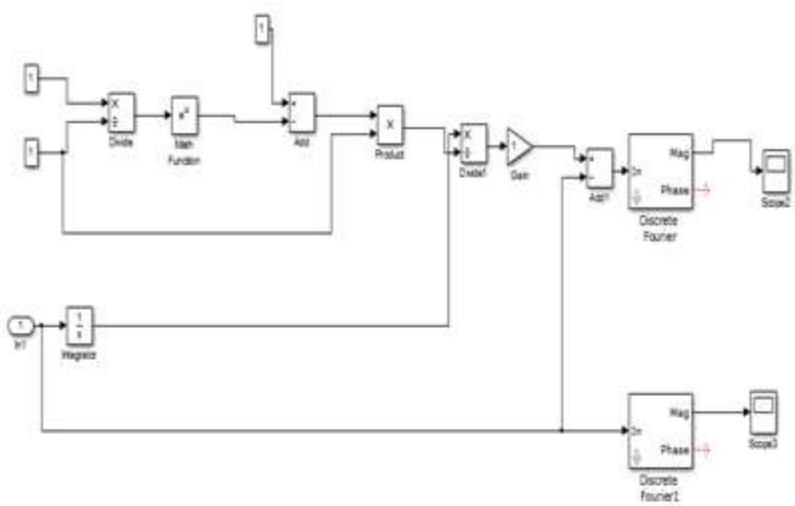

Fig.3: Simulink model subsystem

2.1 Simulation results

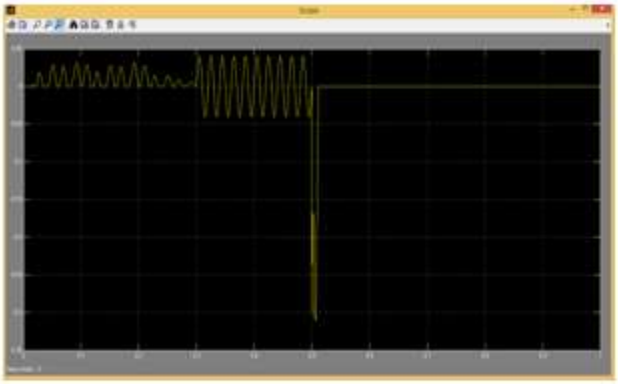

Fig.4: magnitude of inrush current at zero degree energization.

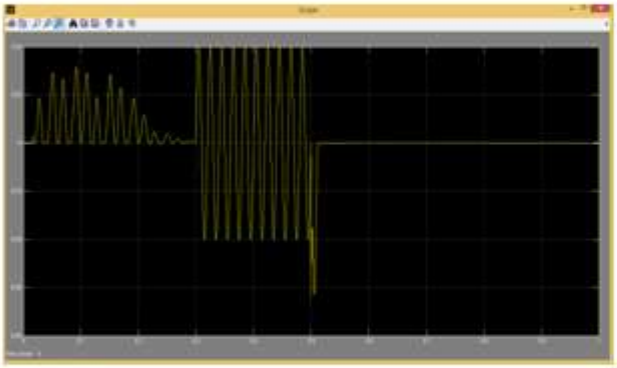

Fig.5: magnitude of inrush current at zero degree energization with fuzzy

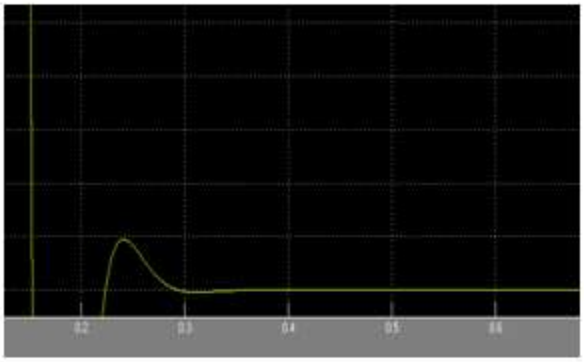

Fig.6: Dc component in inrush current

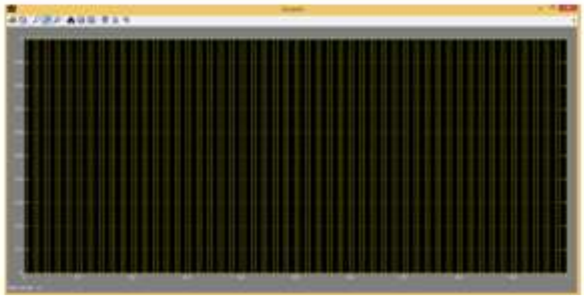

Fig.7: signal after subjected to fuzzy system

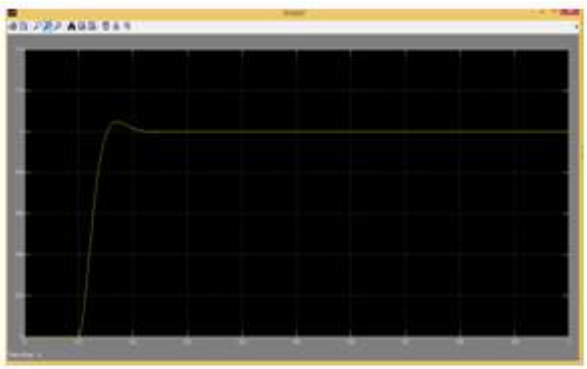

Fig.8: signal to minimize inrush current using fuzzy

III. CONCLUSION

In our technique, a methodology has been proposed for the protection of power transformer based on harmonic analysis and elimination of DC decaying component, this uses fuzzy interference system to distinguish from inrush currents to protect power system accurately and efficiently. The proposed method has been designed to make the system artificially intelligent by using fuzzy logic to estimate harmonics up to 5^{th} order rather than giving thresholding values manually and also makes signal more stable during any magnitude of disturbance, we will trigger it by using fuzzy rules that are created using fuzzy tool box in Matlab thus predicts inrush from fault thereby restraining the relay from operating during the fault. With this method we can make system artificially intelligent.

These are the simulation results and various plots. Based on the heuristics, fuzzy logic provides a general solution for a class of problems. The developed Fuzzy Logic model is robust, adaptive and intelligent as these employ artificial intelligence techniques. The obtained results indicate that the fuzzy logic model is capable of highly accurate inference. Fuzzy logic model is able to approximate a large number of nonlinear systems. The fuzzy logic model consists of representing the base rules Therefore, fuzzy model is a dynamic acoustic model, since they are especially suited for nonlinear mapping, and are able to deal with nonlinear effects such as distortion and harmonics.

The fuzzy sets in the rules serve as aninterface amongst qualitativevariables in the model, and the input and output numerical variables. A fuzzy model has been constructed entirely on the basis of systems measurements. The developed model can be simplified in order to decrease computation time in control applications. Assume that data from an unknown system is observed. The aim is to use this data to construct a deterministic function to approximate the system and to identifyinrush current for power transformer protection.

REFERENCES

[1] Douglas I. Taylor, Member, IEEE, Joseph D. Law, Brian K Jonson, Senior Member IEEE and Norman Fischer, Member IEEE, IEEE Transactions on power delivery, Vol.27.No.1.january 2012"Single phase transformer inrush current reduction using Prefluxing"

[2]Ali Abdollahi, Student member, Peng Zhang, Senior member IEEE "Precise removal of decaying DC in DFT algorithm for power measurement", Power and Energy meeting 201 IEEE.

[3] Abdollahi, A, Peng Zhang, "Precise removal of decaying dc in DFT algorithm for power system measurement", Power and Energy Society General Meeting, 2012 IEEE.

[4] Abdulah Aksamovic, ''Algorithm for Elimination of DC Component from Fault Current", 01/2006; DOI: 10.1109/MELCON.2006.165 volume 3.

[5] Greenwood Allan, "Electrical Transients in Power System", Second edition, 1991.

[6] Johns A.T., Salman S.K, IEE Power series 15, 1997, "Digital Protection for power System".

[7] Degens, A.J., MSc,"Algorithm for a digital transformer differential protection based on a least-squares curve-fitting" Generation, Transmission and Distribution, IEE Proceedings C
Volume: 128, Issue: 3.

[8] Huang C-L, Lin C.E., Cheng C.L and Yeh J.C. ''Investigation of magnetization inrush current in transformer. (i) Numerical Simulation. IEEE Transactions on Power Delivery", 8(1):246-254, Jan 1993.

[9] Yoon-Sung, Member IEEE, Chul-Kyun Lee.Gillsoo Jang, Senior Member IEEE and Heung Jae Lee, Member IEEE "An innovative decaying dc component estimation algorithm for digital relaying", IEEE transaction on power delivery Vol 24, No.1, January2009.