SIMULATION MODELLING OF ANN BASED DISCRIMINATION OF INRUSH CURRENT AND FAULT CURRENT IN POWER TRANSFORMER

Dr.T.Govindaraj[1], P.Ganapathi[2]

[1]Professor and Head of the Department, EEE
Muthayammal Engineering College,Rasipuram ,Tamil Nadu,India

[2]M.E.PSE Scholar,Department of EEE
Muthayammal Engineering College,Rasipuram,Tamil Nadu,India

Abstract- **This paper proposes the Identification of Inrush Current & Fault Current of power transformer for proper protection scheme. In the proposed algorithm, Feed Forward Back Propagation Network (FFBPN) are used as a classifier and address the challenging task of detecting magnetizing inrush from fault current. The algorithm is evaluated using MATLAB simulation. The results verify that the proposed technique is quicker, firm and more consistent recognition of transformer inrush and fault condition.**

Keywords- **Inrush current, fault current, BPNN, Transformer protection, differential protection.**

I. INTRODUCTION

In a power system, power transformer is a part of electrical equipment that needs continuous monitoring and fast protection since it is very costly and an essential element. The transformers and other electrical equipment's have to protect not only from short circuit, but also from unusual operating conditions, such as over loading, and dissimilar fault protection. The increased growth in power systems both in size and difficulty has brought the need for fast and reliable protection scheme for main equipment's like transformer. The power transformer protective relay should block the tripping during magnetizing inrush and quickly kick off the tripping during internal and external faults. The concept of magnetizing inrush current and over-excitation phenomena as they belong to causes of the protection of mal-operation. [1]

Power transformer internal faults may cause extensive damage And or power system instability. Thus, differential transformer protection schemes are used to avoid interruption of the power supply and catastrophic losses. The most common protection technique is the percentage differential protection, which provides discrimination between the fault (internal fault and external fault) or a normal operating condition. Usually, differential relays compare the currents from all terminals of the protected transformer to a predetermined threshold and, in the case of an internal fault the equipment is disconnected from the power supply. However, some operation conditions can cause differential currents and they deserve special attention. Some examples of this (with the presence of magnetizing inrush currents) are energization, over-excitation and sympathetic inrush. In order to avoid the relay mal-operation it is necessary to differentiate inrush current from fault current. [1] [2]. In the case of energization, the second harmonic component is larger than in a typical fault current. In modern transformer due to presence of high permeability core material there is presence of second harmonic content compare to fault current so based on harmonic tripping operation may become mal-operation [3].

As mentioned before, a sympathetic inrush current also cause relay mal-operation. In order to develop power transformer protection, various methods were developed for accurate and efficient discrimination. Here ANN techniques have been applied for power transformer security because of its potential of highly non-linear mapping feature. But in these proposed methods the extraction techniques are based on either time or frequency domain signals, but it becomes very important to extract both time and frequency features of the signal for accurate discrimination between an internal fault and other operating conditions [11][13].

II. INRUSH CURRENT

Transformer Inrush current is classified into three types. That is energization inrush, recovery inrush and sympathetic inrush. When a transformer is energized a transient current up to 10 to 20 times higher than the rated transformer current can last for more than a few cycles. Decay of inrush current depends on the series resistance on the transformer winding. In a transformer winding resistance will damp out the inrush. When dispersion occurs for part of half cycles only, then harmonic rich waveforms can be generated, and can cause lot of problems to other interrelated equipment.[9][10]

For large transformers by means of low winding resistance and high inductance, these inrush currents can last for several seconds until the transient has died away (decay time proportional to ~XL/R) and the regular AC equilibrium is established. Generally inrush current includes d.c. offset, odd harmonics, with even harmonics.

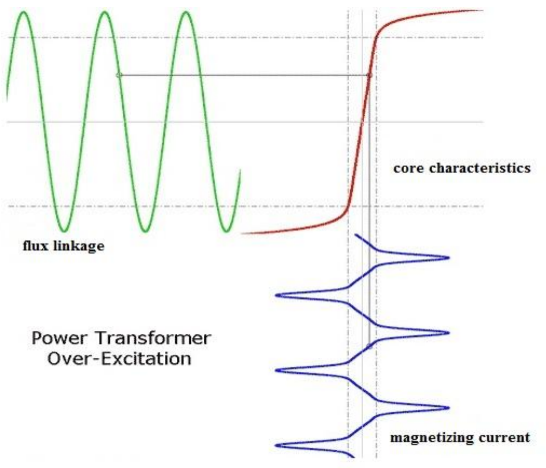

Fig.1. Generation of inrush current in transformer.

The common equation for the amplitude of inrush current as a meaning of time can be expressed as

$$i(t)=\frac{\sqrt{2}v_m}{z_t}*k_w*k_s*(\sin(wt-\varphi)-e^{-\frac{(t-t_o)}{\tau}}.\sin\alpha)\cdots \quad (1)$$

where v_m – highest applied voltage; *Zt*– whole impedance beneath inrush together with network; φ– energization angle; *t*–instant time; *t0* – point at which core saturates; τ– time constant of transformer winding beneath inrush conditions; α– function of t0; *Kw* – accounts for three phase winding connection; *Ks* –accounts for short-circuit power of system.

For [4] the use of a protective system for transformer, the maximum value of inrush current is an important issue. In [5] these cases, a basic equation can be used to determine the peak value of the first set of the inrush current. This equation is as follow

$$i_{peak}=\frac{\sqrt{2}v_m}{\sqrt{(\omega L)^2+R^2}}\left(\frac{2B_N+B_R-B_S}{B_N}\right) \quad (2)$$

Where, *Vm* – highest applied voltage; *L* – air core inductance of the transformer; *R* – whole resistance of the transformer; B_N – normal rated flux density of the transformer core; B_R – remnant flux density of the transformer core; B_S – saturation flux density of the core substance.

As seen from the equations (1) and (2), the value of inrush current is needy to the parameters of transformer and in service circumstances. So a broad analysis for finding the dealings between the inrush current personality as well as these factors is needed. Factors influencing the magnitude and duration of magnetizing current inrush are,

1. Transformer size: as size of transformer increases, the inrush current also increased.

2. Type of core: if the core is made up of material having good permeability magnetic then the inrush current routinely decreased.

3. Residual flux of transformer: presence of residual flux also increases the magnetizing current.

4. Switching at Instant: if the transformer is switched on at the instant when the voltage wave is transitory through zero value, then the magnetizing inrush current at that inrush will be high.[5]

III. ARTIFICIAL NEURAL NETWORK

A neural network is a dominant data modelling tool that is capable to capture and signify complex input / output relationships. The motivation for the progress of neural network technology came from the wish to develop an artificial system that could perform "Intelligent" tasks related to those performed by the human brains. We look, see, pay attention and then recognition. Neural network theory studies both,

- pre – attentive and attentive
- processing of stimuli

The basic unit of neural networks, the artificial neurons, stimulates the four basic functions of natural neurons. Artificial neurons are much simpler than the biological neurons [8]. The blower figure 2 shows the fundamentals of an artificial neuron

This section gives the formula used in the model of an artificial neuron: A single neuron may be written accurately as mentioned in(3).

y=f (bias+w1*x1+w2*x2+w3*x3+…+wn*xn) (3)

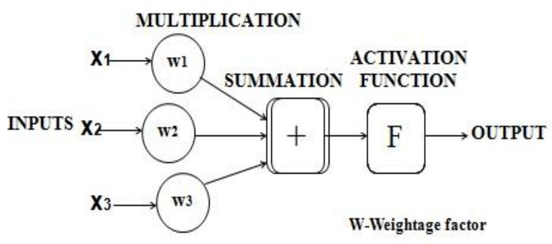

Fig.2. Artificial Neuron

Where y is output, x1, x2,…xn are the inputs and f(x) is the activation function. And the formula used for this job is called the 'sigmoid'.

$$F(x) = 1/ (1+ \exp (-x)) \quad (4)$$

IV. BACK PROPAGATION LEARNING

Neural networks are usually organized by layers. It can be prepared by number of interconnected nodes, it enclose an activation function. Parameters are offered to the system through the input layer that communicates one or more hidden layers where the real processing is done via a system of weighted links. The unseen layers after that link to an output layer where the answer is output as shown in below (Fig. 3)

This neural network is mostly trained by "Back propagation" algorithm. In Back propagation the network learns a predefined set of input – output examples pairs by using a two phase propagate adopt cycle. When a Back Propagation network is cycled, the activations of the input units are propagated forward to the output layer throughout the connecting weights. Like the perceptron, the net input to a unit is determined by the weighted sum of its inputs. After an input pattern has been applied as a motivation to the first layer of network unit, it is propagated through each upper layer until an output is generated. This output pattern is then comparing through the desired output sample and an error signal is computed for each output unit.

The error signals are then transmitted backward from the output layer to each node in the intermediate layer that contributes directly to the output. However, each unit in the intermediate layer receives only portion of the total error signal, based roughly on the relative contribution the unit made to the original output. Based on the error signal, connection weights are then updated by each unit to cause the network to converge towards a state that allows all the training patterns to be encoded [5][6][8].

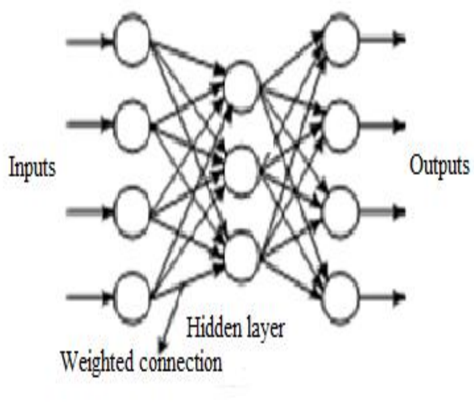

Fig.3. BPNN Architecture

The Back propagation Algorithm (BPA), also called as the Generalized Delta Rule (GDR), Which provides a way to estimate the gradient of the error function efficiently using chain rule of isolation. This paper is concerned with the delta rule. With the delta rule, as with other types of back-propagation, 'learning' is a supervised process that occurs with each cycle or 'epoch' (i.e. in every time the arrangement is presented with a new input pattern) during a forward activation flow of outputs, and the backward error propagation of weight adjustments [6][7]. Within each hidden layer node is a sigmoidal activation function which is differentiable and therefore continuous everywhere. Sigmoidal function polarizes network activity and helps stabilize it.

$$Yj=1/(1+\exp(-Si)) \quad (5)$$

Back propagation performs a gradient descent within the solution's vector space towards a 'Global Minimum' beside the steepest vector of the error space. Learning in a back propagation network is in two steps. First each pattern $\mathbf{I_p}$ is presented to the network and propagated forward to the output. Second, a method called gradient descent is used to minimize the total error on the patterns in the training set. In gradient descent, weights are malformed in proportion to the negative of an error derived regarding each weights. The global minimum is the theoretical solution with the least possible error.

V. CIRCUIT EXPLANATION & ANALYSIS

All the three circuit breakers are not blocked at the same instant rather they are closed when the relevant voltage waveforms are enchanting their maximum value in order to reduce the inrush effect. The 3−Φ fault is applied for 5 cycles i.e. from 25/60 cycles to 30/60 cycles (0.4s-0.5s). The Circuit Breakers are closed at their first switching

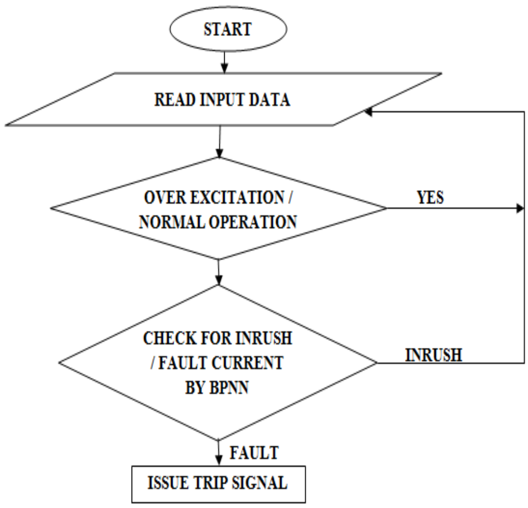

Fig.4.BPNN Flowchart

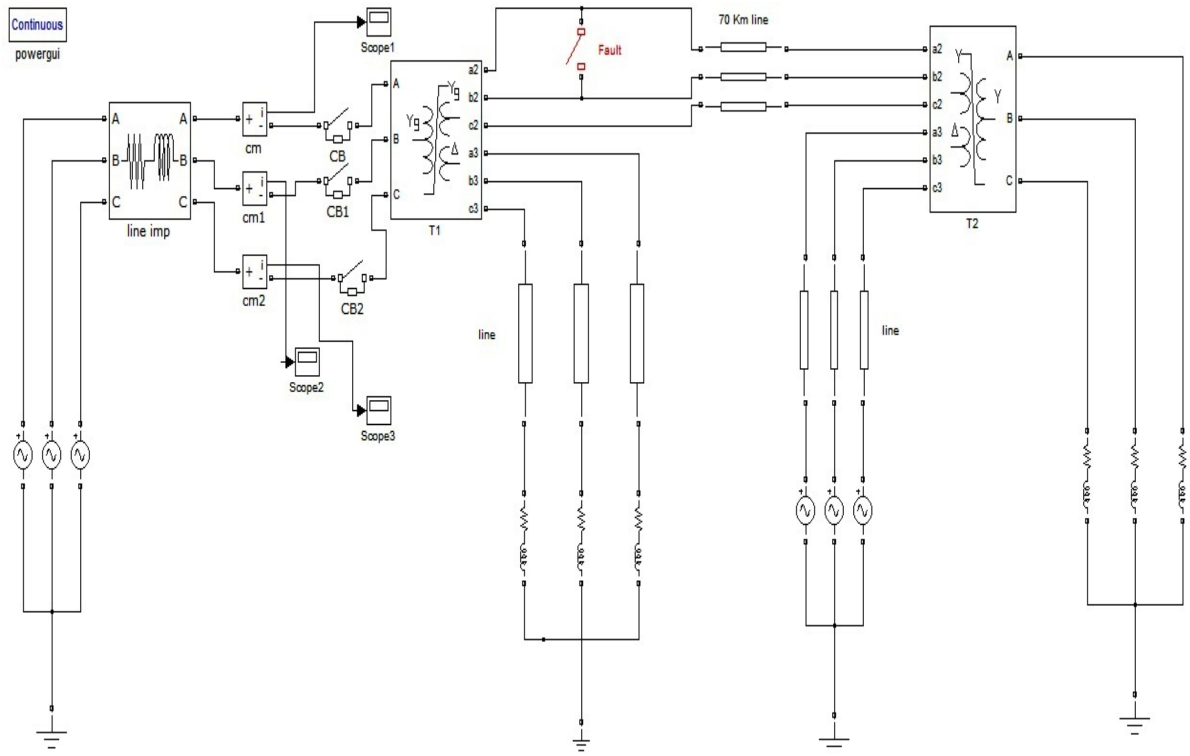

Fig.5.Simulink representation of $3\phi - Transformer$

A. TRAINING PERFORMANCE BY ANN

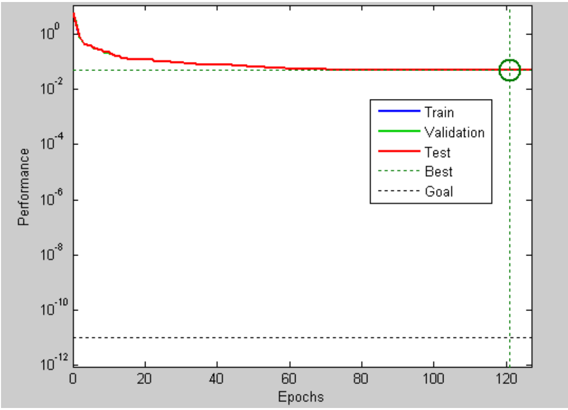

Fig.6 Normal current Training Performance

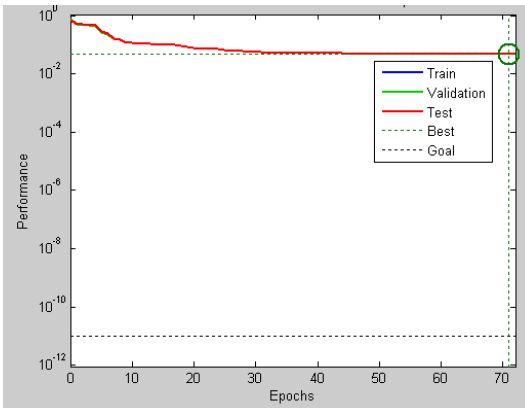

Fig.7.Inrush Current Training Performence

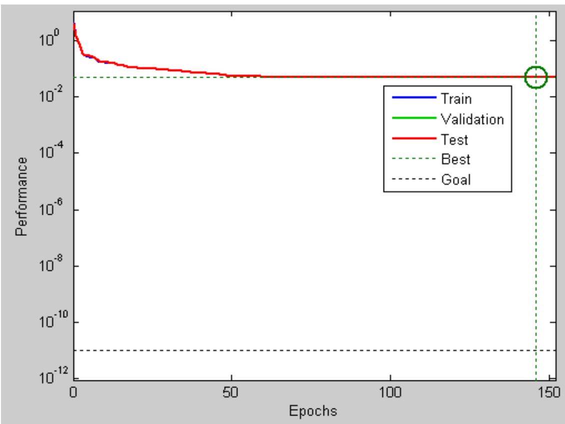

Fig.8.Line-Ground Fault Current Training Performance

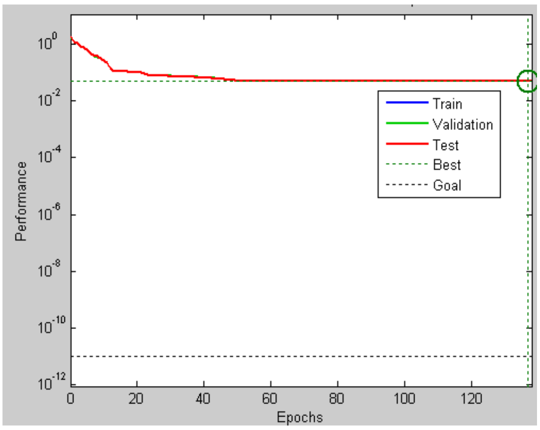

Fig.9.Line-Line Fault Current Training Performence

B. OUTPUT CURRENT DISCRIMINATION BY FFBPN TOPOLOGY WITH MATLAB

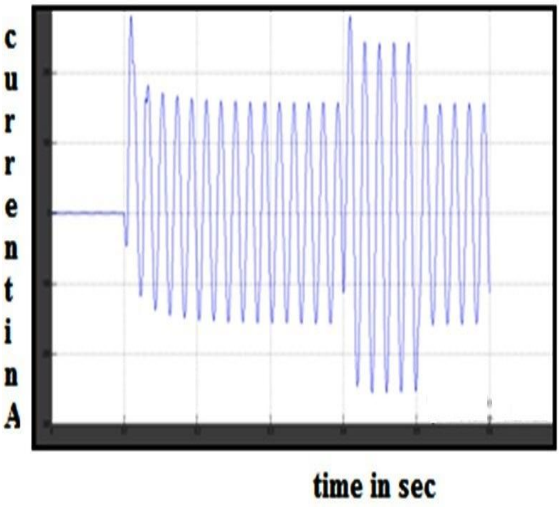

Fig.10.Waveform of Inrush & Fault current from phase a

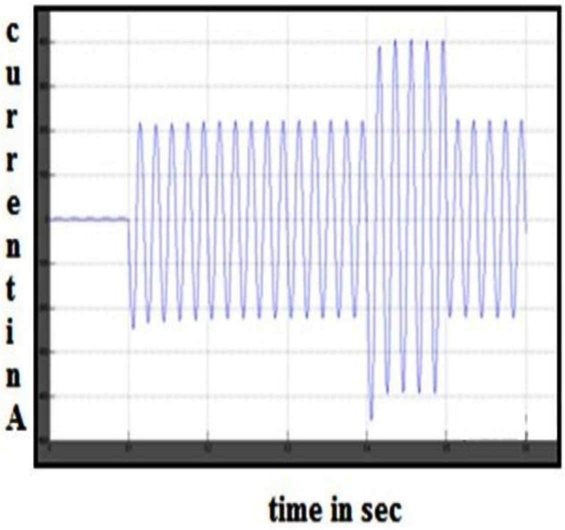

Fig.11.Waveform of Fault current from phase b

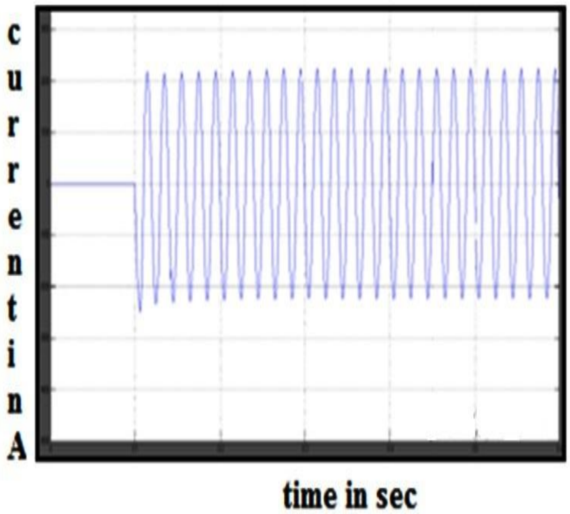

Fig.12. waveform of steady state current (after clearing fault)

timings. For the first switching timing 25/60 (phase A) the energy source is now connected to the power transformer through CB's. Now a 3−Φ fault is applied. From the current measurement, currents through all the three lines are tapped to MATLAB work space [11]-[12],[18]-[33].

VI. RESULTS DISCUSSION

From the above figures (Fig 6, 7, 8, 9) we observe the fault and inrush current. From the ANN performance (V-A),the normal current reach the best value in very few test iteration. And then faults are takes more test iterations than normal current value.

The MATLAB waveform shows (V-B) that inrush is very short period and which is so peak. And the fault current is in 0.4s-o.5s as smaller than inrush and differs from steady state current. In the fig (12) shows the steady state current wave which is appears after clearing the fault. From the section V(A,B) the classification of waves and magnitudes, duration of faults are noticeable.

VII. CONCLUSION

This work presents a new approach in differential protection for power transformer vastly enhanced performance over conventional techniques. The conventional harmonic control technique may fail because high second harmonic components are generated through faults and low second-harmonic components are generated during magnetizing inrush with such high permeability core materials of power transformer. In this paper to improve the performance & rectify error by analyzing of Mean, Standard Deviation, Maximum Norm & THD standards are taken from the inrush & fault current. The facility of the new scheme will express by simulating various cases on a distinctive power system and the proposed algorithm is also tested data collected from a simulation model. In this new algorithm is performance was very crucial. The proposed approach is considered a general tool because it can be easy implemented on the fashionable MATLAB software.

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Dr.Govindaraj Thangavel born in Tiruppur , India in 1964. He received the B.E. degree from Coimbatore Institute of Technology, M.E. degree from PSG College of Technology and Ph.D. from Jadavpur University, Kolkatta,India in 1987, 1993 and 2010 respectively. His Biography is included in Who's Who in Science and Engineering 2011-2012 (11th Edition). Scientific Award of Excellence 2011 from American Biographical Institute (ABI). Outstandin Scientist of the 21st century by International Biographical centre of Cambridge, England 2011.Since July 2009 he has been Professor and Head of the Department of Electrical and Electronics Engineering, Muthayammal Engineering College affiliated to Anna University, Chennai, India. His Current research interests includes Permanent magnet machines, Axial flux Linear oscillating Motor, Advanced Embedded power electronics controllers,finite element analysis of special electrical machines,Power system Engineering and Intelligent controllers.He is a Fellow of Institution of Engineers India(FIE) and Chartered Engineer (India).Senior Member of International Association of Computer Science and Information. Technology (IACSIT). Member of International Association of Engineers(IAENG), Life Member of Indian Society for Technical Education(MISTE). Ph.D. Recognized Research Supervisor for Anna University and Satyabama University Chennai. Editorial Board Member for journals like *International Journal of Computer and Electrical Engineering,*International Journal of Engineering and Technology,International Journal of Engineering and Advanced Technology (IJEAT).International Journal Peer Reviewer for Taylor &Francis International Journal "Electrical Power Components & System"United Kingdom,Journal of Electrical and Electronics Engineering Research,Journal of Engineering and Technology Research (JETR),International Journal of the Physical Sciences,Association for the Advancement of Modelling and Simulation Techniques in Enterprises,International Journal of Engineering & Computer Science (IJECS),Scientific Research and Essays,Journal of Engineering and Computer Innovation,E3 Journal of Energy Oil and Gas Research,World Academy of Science, Engineering and Technology,Journal of Electrical and Control Engineering (JECE),Applied Computational Electromagnetics Society etc.. He has published 167 research papers in International/National Conferences and Journals. Organized Forty National / International Conferences/Seminars/Workshops. Received Best paper award for ICEESPEEE 09 conference paper. Coordinator for AICTE Sponsored SDP on special Drives,2011.Coordinator for AICTE Sponsored National Seminar on Computational Intelligence Techniques in Green Energy, 2011.Chief Coordinator and Investigator for AICTE sponsored MODROBS - Modernization of Electrical Machines Laboratory. Coordinator for AICTE Sponsored International Seminar on "Power Quality Issues in Renewable Energy Sources and Hybrid Generating System", July 2013

P.Ganapathi born in Mettur,India,1991. He received the B.E[EEE] degree from Sasurie College of Engineering, Thirupur, 2012. Now he pursuing M.E [PSE] degree in Muthayammal Engineering College, Rasipuram, India. His area of interest was Systems Theory, Power System Operation And Control, Power System Protection.

