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AN ANN BASED FAULT DETECTION ON ALTERNATOR

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ABSTRACT: *Synchronous generators are important elements of a power system. Its reliability and proper functioning are crucial in maintaining an uninterrupted power supply to the customers. Their reliability not only affects the electric energy availability of the supplied area, but also affects the economical operation of a utility. Hence the alternator protection is critical issue in power system as issue lies in the accurate and rapid discrimination of healthy condition from different faults. Artificial neural network has been proposed and has demonstrated the capability of solving the fault detection problem using an inexpensive, reliable, and noninvasive procedure. This project describes a novel and simple artificial neural-nets (ANNs) technique without using rigorous mathematics. A laboratory alternator was used to collect the data from controlled experiments. After capturing the three phase currents of alternator with data acquisition system some of the samples are used as an input to a designed neural network models Multi Layer Perceptron and Principle Component Analysis. The network is then trained rigorously and tested. The results so obtained are finally compared.*

Keywords: *Alternator, current, Artificial Neural Network, Normal and Faulty waveforms.*

I. INTRODUCTION

Power systems are the largest and most complex human made systems, where faults always occurred, in the world. Faults can cause personnel and equipment safety problems, and can result in substantial economic losses. In order to solve the problems, faults automatic detection, location and isolation must be employed. Most faults can cause large currents or voltages changing, and they are often detected by traditional protective relay. Whereas, some faults, such as high impedance faults, grounding faults of ineffectively earthed distribution systems, cause small currents and voltages changing and they are difficult to be detect using traditional protective relay.

Synchronous generators are important elements of a power system. Its reliability and proper functioning are crucial in maintaining an uninterrupted power supply to the customers.

Some of the Important Faults which may occur on Alternator are Overvoltage, Overspeed, Overcurrent, Failure of Prime mover, Unbalanced Loading, Failure of Field and Stator winding fault (which includes Line to Ground Fault, Line to Line Fault, Double Line to Ground Fault, Three phase Fault and Inter turn Fault.)

A lot of attention has been focused on generator's single phase to ground fault which is one of the main causes for shutting down a generator. Stator's winding fault must be avoided since the amount of time wasted and the cost for repairing a generator is enormous. Hence, it is necessary to prevent such occurrences by incorporating reliable protection and monitoring schemes.

The Literature based on the algorithm which detects and discriminate the Faults on the basis of magnitude and direction of reactive power. More recently two ANN based differential protection schemes [An artificial neural network based digital differential protection for synchronous generator stator winding protection] and [ANN-based novel fault detector for generator stator winding protection] have also been introduced to provide protection for generator stator windings. While the first technique uses samples taken from the line-side, neutral-end and field currents of the generator, the second one uses the difference and average of the currents entering and leaving the generator windings.

This project describes a simple technique based on artificial neural network to discriminate various types of faults in alternator Three phase current of alternator for normal and faulty condition are captured with the help of data acquisition system (DSO) with 100 MHz bandwidth and adjustable sampling rate of 1 GHz is used to capture the currents. These currents are then fed as input to artificial neural network which then discriminate healthy and faulty condition.

II. ALTERNATOR AND FAULTS ON IT

2.1 Operating principle:

When the rotor rotates, stator conductor are cut by magnetic flux, hence they have induced e.m.f. produced in them. Because the magnetic poles are alternately N and S, they induce an e.m.f. and hence current in armature conductors.

2.2 Definition of Fault:

A Fault in a line is any failure which interferes with the normal flow of current in the line.

2.3 Faults – Types:

a) Active Faults
b) Passive Faults
c)Transient & Permanent Faults
d) Symmetrical & Asymmetrical Faults

2.4 Effects Of Faults:

The faults in a power system have the following harmful effects on the system:

1. Faults generally give rise to large currents which may damage the equipment in the line of the system.
2. Large fault current overheats the system equipment.
3. Some faults block the flow of power
4. Faults can cause the system to become unstable.
5. Faults can cause the three phase system to become unbalanced and this affects the operation of 3-phase equipment.

2.5: Severity of Faults:

The occurrence of different kinds of faults in a power system in order of decreasing severity is as follows:

LLL fault = 5%
LLG fault =10%
LL fault =15%
LG fault =70%

2.6: Conventional methods for fault detection:

1. Negative-sequence over-current relay:

   The negative sequence overcurrent relay is mostly utilized to provide protection against unbalanced conditions. However, it is very slow and mainly used to provide backup protection for system faults.

2. Current differential scheme:

   Current differential scheme is the most common type of protection method used to provide protection for stator windings. Since this protection scheme cannot provide a 100% coverage of the stator windings for especially single –phase to ground faults, a supplemental protection scheme, which is usually based on the injection of a low frequency voltage to the neutral or measuring of the third harmonic voltage, is required. Utilising the combination of both the primary and supplementary protection scheme is complicated and still questionable.

3. **ANN based differential protection :**

   More recently two ANN based differential protection schemes have also been introduced to provide protection for generator stator windings. While the first technique uses samples taken from the line-side, neutral-end and field

   Currents of the generator, the second one uses the difference and average of the currents entering and leaving the generator windings.

4. **A new digital relay:**

   It detects the asymmetrical faults by monitoring the sinusoidal oscillations of the three phase instantaneous power measured at the generator terminal. Once an asymmetrical fault is detected, the algorithm checks the direction of the negative sequence reactive power flow at the machine terminal to discriminate between internal and the external faults.

III. ARTIFICIAL NEURAL NETWORK

3.1 Definition of ANN:

Ann is defined as a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs.

An artificial neural network is a system based on the operation of biological neural networks, in other words, is an emulation of biological neural system. Why would be necessary the implementation of artificial neural networks? Although computing these days is truly advanced, there are certain tasks that a program made for a common microprocessor is unable to perform; even so a software implementation of a neural network can be made with their advantages and disadvantages.

Advantages:

- A Neural network can perform tasks that a linear program cannot.
- When an element of the neural network fails, it can continue without any problem by their parallel nature.
- A neural network learns and does not need to be reprogrammed.
- It can be implemented in any application.
- It can be implemented without any problem.
-

Disadvantages:

- The neural network needs training to operate.
- The architecture of a neural network is different from the architecture of microprocessors therefore needs to be emulated.
- Requires high processing time for large neural networks.

3.2 Methods to train ANN:

a) Principal Component Analysis (PCA) :

PCA is a way of identifying patterns in data, and processing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the luxury of graphical representation is not available, PCA is a powerful tool for analyzing data.
The other main advantage 0f PCA is that once you have found these patterns in the data, & you compress the data i.e. by reducing the no. of dimensions, without much loss of information.

b) Multilayer Perceptron (MLP):

MLP is a powerful system, often capable of modeling complex, relationships between variables. It allows prediction of an output object for a given input object. The architecture of MLP is a layered feed forward neural network in which the non-linear elements (neurons) are arranged in successive layers, and the information flow uni-directionally from input layer to output layer through hidden layers.
An MLP with just one hidden layer can learn to approximate virtually any function to any degree of accuracy. For this reason MLPs are known as universal approximates and can be used when we have litter prior knowledge of the relationship between input and targets. One hidden layer is always sufficient provided we have enough data.

IV. CASE STUDY

4.1 Experimentation & Data Collection:

The setup for experiments has contain an alternator with specification 1KVA, 400 V, 1.5A, 3000 rpm, 50 Hz supply with Dc shunt motor acts as a prime-mover and its ratings are 0.75 Hp, 230V, 6.8A, 1500 rpm.Also corresponds to this ammeter of rating (0-5A), Voltmeter of rating (0-300V), Rheostat in armature circuit of rating 750 ohm/1.2A, & Rheostat in field circuit of rating 1750 ohm/0.6A.

Data Acquisition card by Tektronix an instrument was used to capture the voltage & current signals. These signals were recorded at a sample 10,000 samples/sec. The Tektronix DSO, TPS 2014B, with 100 MHz bandwidth and adjustable sampling rate of 1 GHz is used to capture the currents. The Tektronix CT's of rating 100 mV/A.

4.2. Algorithm for Fault discrimination using ANN:

1. Connection as per circuit diagram.
2. Practically, readings for different faults are taken.
3. These readings are feed to ANN as an input.
4. Select proper number of hidden layer and neuron in each layer also set proper value of testing.
5. Select proper network and algorithm.
6. Train this input data with proper training function.
7. ANN trained the data and classifies the faults.

4.3. Experimental setup:

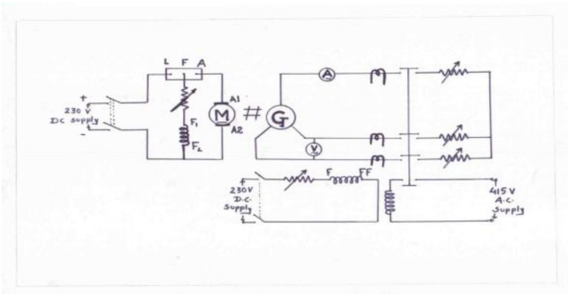


Fig. 1: Circuit Diagram

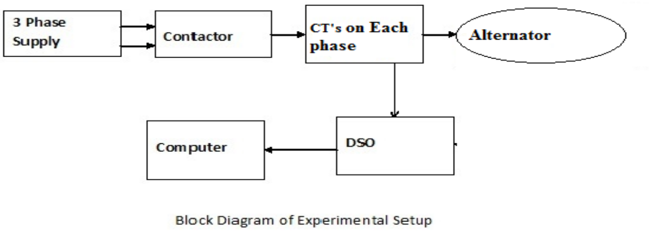


Fig. 2: Block diagram

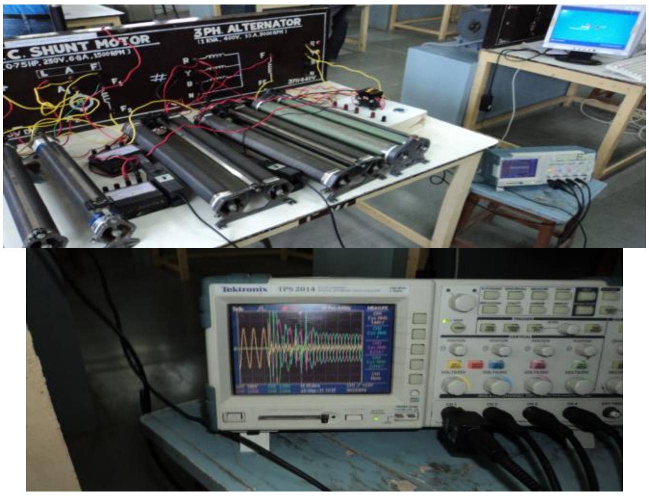


Fig. 3 : Practical Experimental Setup

4.4 RESULT ON THE BASIS OF WAVEFORM :

4.4.1 Normal Condition:

This is the smooth and healthy condition in the power system. In this condition currents in all the three phases are same in magnitude which is shown in fig.

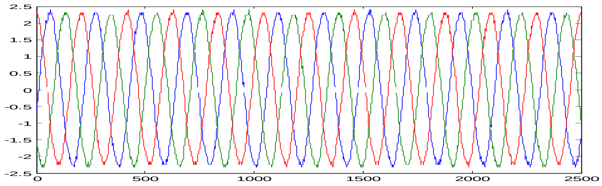


Fig 4: Graphical representation of Current Vs time for Normal Reading

4.4.2: Line-to-Ground Fault:

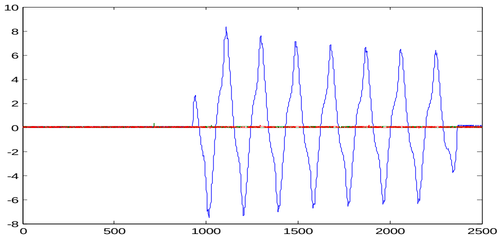


Fig 5: Graphical representation of Current Vs time for L-G fault Reading

4.4.3: Double Line-to-Ground Fault:

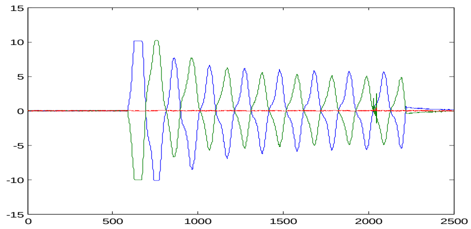


Fig 6:Graphical representation of Current Vs time LL-G fault Reading

4.4.4: Double Line Fault:

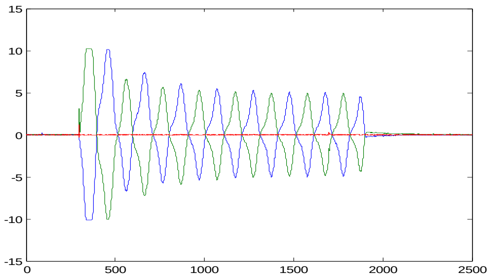


Fig.7: Graphical representation of Current Vs time fault Reading

4.4.5: LLL-fault:

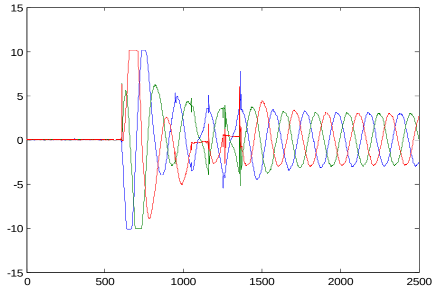


Fig 8: Graphical representation of for L-L Current Vs time for L-L-L fault Reading

4.4.6: Triple Line to Ground Fault:

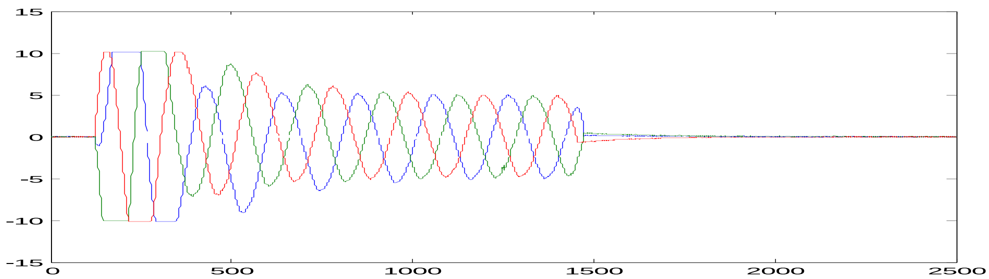
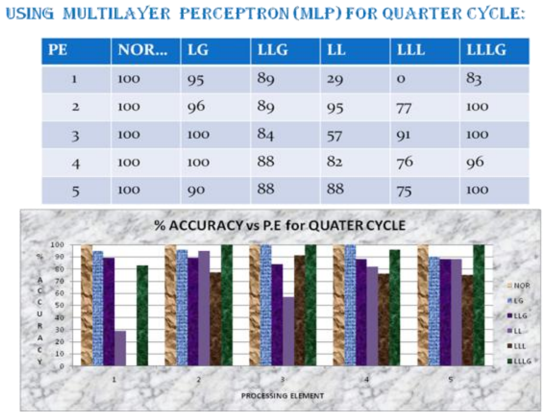


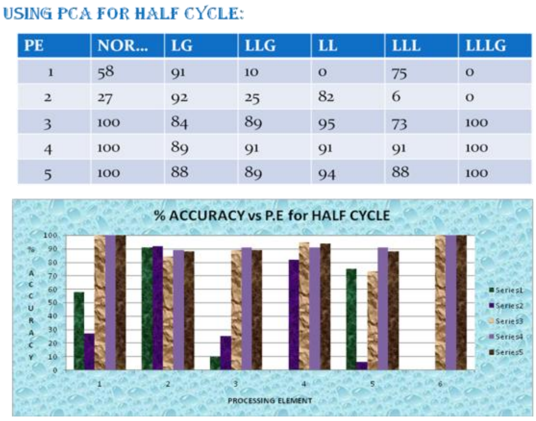
Fig 9: Graphical representation of Current Vs time for L-L-L-G fault Reading

4.5 GRAPH : Trained ANN by specific methods


USING MULTILAYER PERCEPTRON (MLP) FOR QUARTER CYCLE:

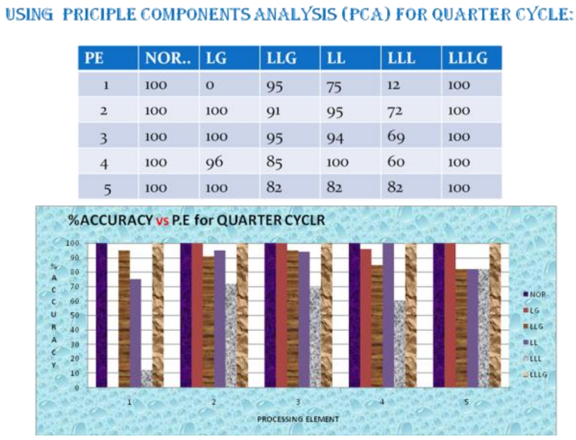
PE	NOR...	LG	LLG	LL	LLL	LLLG
1	100	95	89	29	0	83
2	100	96	89	95	77	100
3	100	100	84	57	91	100
4	100	100	88	82	76	96
5	100	90	88	88	75	100

Discription: 1) Number of hidden layer = 1.
2) For first 50 sample
3) Transfer Function
4) Result below 85%


USING PCA FOR HALF CYCLE:

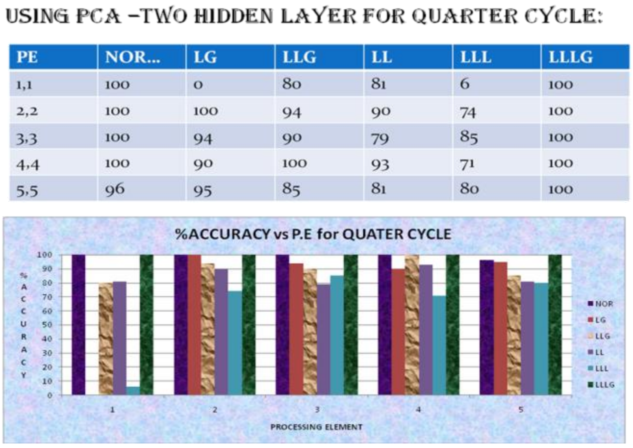
PE	NOR...	LG	LLG	LL	LLL	LLLG
1	58	91	10	0	75	0
2	27	92	25	82	6	0
3	100	84	89	95	73	100
4	100	89	91	91	91	100
5	100	88	89	94	88	100

Description: 1) Number of hidden layer = 1.
2) for first 100 sample
3) Transfer Function=
4) Result below 90%


USING PRICIPLE COMPONENTS ANALYSIS (PCA) FOR QUARTER CYCLE:

PE	NOR..	LG	LLG	LL	LLL	LLLG
1	100	0	95	75	12	100
2	100	100	91	95	72	100
3	100	100	95	94	69	100
4	100	96	85	100	60	100
5	100	100	82	82	82	100

Discription: 1) Number of hidden layer = 1.
2) For first 50 sample
3) Transfer Function
4) Result up to 90%


USING PCA –TWO HIDDEN LAYER FOR QUARTER CYCLE:

PE	NOR...	LG	LLG	LL	LLL	LLLG
1,1	100	0	80	81	6	100
2,2	100	100	94	90	74	100
3,3	100	94	90	79	85	100
4,4	100	90	100	93	71	100
5,5	96	95	85	81	80	100

Description: 1) Number of hidden layer = 2.
2) For first 50 sample
3) Transfer Function
4) Result above 90%

Fig. 10

4.6: Comparison of result:

Table no:1

	Multilayer Perceptron(MLP)	**Principal Component Analysis(PCA)**
Testing	40%	40%
Training	60%	60%
Hidden Layer	2	2
Neuron	2,2	2,2
Accuracy	Below 90%	Above 90%

4.6: Discussion on Result:

Table no:2

Fault	% Accuracy	
	MLP	PCA
1) NORMAL	100	100
2) L-G	96	100
3) LL	71	90
4) LL-G	88	80
5) LLL	64	64
6) LLL-G	96	100
TOTAL	85.83	

V. CONCLUSION

This project describes a simple technique based on artificial neural network to discriminate various types of faults in alternator.

The time domain signals obtained by data acquisition system. Current captured for healthy and faulty condition are fed as an input to artificial neural network which classifies the various faults in alternator. MLP (multilayer perceptron) and PCA (principal component analysis) artificial neural network methods are used for fault discrimination. Experimental results obtained shows that PCA with processing elements (2,2) gives about 90% accuracy for all faults. So PCA is found to be best network for classifying alternator faults.

VI. FUTURE SCOPE

The time required for processing is near about 1.1 minute. Thus time can be minimised if current signal are in frequency domain form. These are fed as input to ANN. Future scope includes application of Fourier transform to time domain current signals and calculating its slant parameter such as minima, maxima, energy, power of signal, mean deviation, median. This slant parameter will then form as an input to ANN (artificial neural network) which will make the scheme generalised. That is scheme will not restrict its application to specific KVA rating.

The method proposed in present thesis is offline which can be implemented online by using high speed data acquisition and microprocessor.

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