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FAULT ANALYSIS OF SINGLE PHASE INDUCTION MOTOR USING MLI BY NEURAL NETWORK AND RECONFIGURATION TECHNIQUE

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Abstract:
Growing industrial need makes the choice of fast response, accurate and efficient systems. The Multilevel inverter based induction drives (MLID) are the best solution for the industrial drive needs, which reduces the harmonics and increases the efficiency of the system. And also the need for hybrid electric vehicles increases the need of an efficient traction system with the use of multilevel inverters. As multilevel inverter has many semi-conductor switches, it is difficult to identify the fault in it. In this paper a new fault diagnosis method by using the total harmonic distortion (THD) of the voltage waveform and to classify the fault, neural network (NN) trained with back propagation, genetic algorithm (GA) and also with particle swarm optimization (PSO) is applied and the results are compared. Results shows that NN trained with PSO gives fast response in training algorithm when compared to BP and GA. Here a cascaded multi-level inverter based three-phase induction motor drive is taken as the test system. Mat-lab software is used to analyse the effectiveness of the test system and results are tabulated.

Keywords : Fault diagnosis, neural network, Particle Swarm Optimization, Genetic Algorithm, Cascaded multi-level inverter, Total Harmonic Distortion.

1. INTRODUCTON

The multi-level inverters (MLI) are essential in the efficient operation of the hybrid electric vehicles, Flexible AC Transmission System (FACTS), Motor Drives etc.. The problem with the MLI is the number of switches present in it. Increase in number of level increases the number of switching devices. And for three-phase multilevel inverter still has more switches and if in any switch fault happens, that stops the entire process and also makes the change in the output voltage wave shape. Use of more number of power semiconductors are the main drawback of MLI's and due to this reason MLI may be considered as reliable. But as MLI are used in high power applications, the reliability of the power electronics equipment is more significant. The conventional protection systems used in drives are passive devices such as fuses, overload and circuit breakers to protect the inverter systems and the induction motors. These conventional protection devices will detach the power sources from the multilevel inverter system each time a fault occurs, stopping the operated process and stopping the entire process will affect the economic growth of the industry. Therefore the fault detection and diagnosis is very important to a company's bottom line. Multilevel inverters provide more potential in the power circuit to operate under faulty conditions; yet, faults should be detected as soon as possible after they occur, because if a motor drive runs continuously under abnormal conditions, the drive or motor may quickly fail. Thus, knowledge of fault behaviors, fault prediction, and fault diagnosis are necessary. So the neural network is used for classifying the fault [7]. More recently model based approaches, fuzzy logic, Artificial Neural Networks (ANN), Case Based Reasoning (CBR) are popular techniques used in various fault diagnostics problems in electrical systems.

In particular ANN"s has been shown to be effective in many automotive fault diagnostic applications [13] [14] [15] [16]. The feature extraction using neural network takes more number of neurons. This makes the classification time consuming and increase in utilized memory. The principal component analysis is utilized in the feature extraction process to reduce the NN input size. A lower dimensional input space will also usually reduce the time necessary to train an NN, and the reduced noise can improve the mapping performance. The genetic algorithm is applied to select the valuable principal component [8]. Quick identification of fault conditions and a modulation pattern is generated according to the each single fault and it is classified without any extra sensors [3]. Classification of the fault for each MLI topology and the remedial action are described [9]. MLI can operate in faulty conditions [9]. Neutral point Coupling inverter plays main role in industrial drives, so the fault tolerant operation of this inverter is also mandatory.

2. MULTILEVEL INVERTER

For testing purposes a seven-level cascaded multi-level inverter driving induction motor shown in figure 1 is used. The closed switch faults and open switch faults are applied to the single phase of the three-phase inverter for simplicity. The fault occurs in the MLID affects the voltage level and the shape of the output voltage wave form. This waveform analysed with total harmonic distortion The layer size can be reduced by using GA [10].

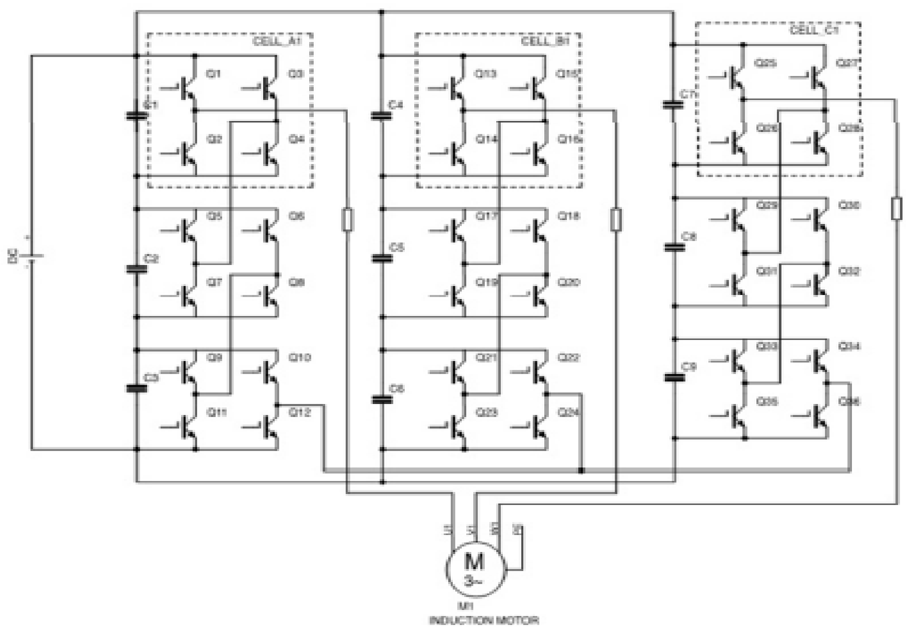

Fig.1.Multi level inverter

NN trained GA is also used for weather forecasting but it is not easy to predict [4]. Particle Swarm Optimization (PSO), which is built by swarm intelligent has also used for training the neural network. The short term-load forecasting is done using the NN trained PSO. The potential solutions flow through the problem hyperspace with accelerated movement towards the best solutions and it makes the forecasting high precision.

3. FAULT DIAGNOSIS SYSTEM

The fault diagnosis system is used to diagnose the fault location and type of the fault using the THD value. The fig. 2 shows the block diagram of the proposed Fault diagnosis system. During the operation of MLID the FFT is applied to the line voltage of the motor terminals and also THD value voltage is monitored. If the THD value is within the limit (i.e. no fault condition) then the neural network output ensures the normal operation of the system. When there is a fault THD changes, according to that the output of the NN changes which classifies the fault and TRIAC is turned on accordingly. The values, if it is in limit (i.e. no fault occurrence) then the neural network gives the output as normal condition, when the

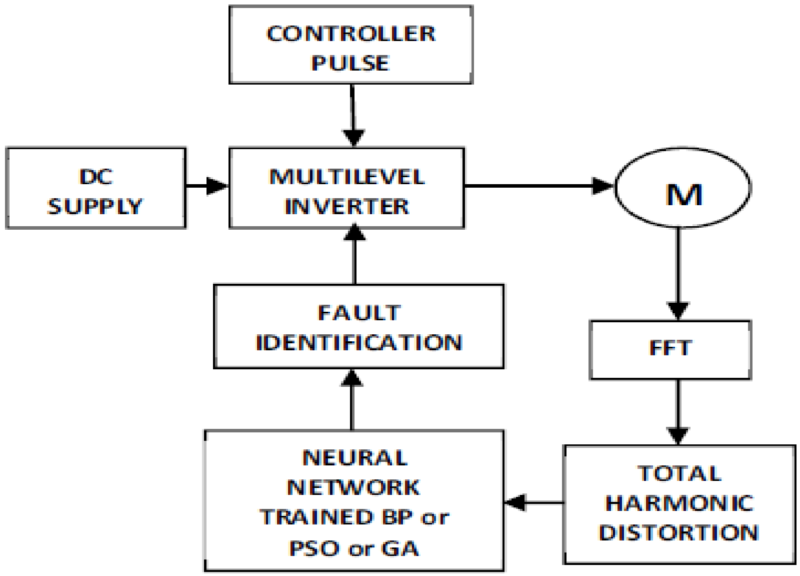

Fig.2.Fault diagnosis system

output of the THD changes, according to that neural network which is trained according to that classifies the fault and the TRAIC is turned on according to that fault. Here neural network is trained with different meta-heuristic algorithms. GA and PSO are used to select the optimal weight values. So the accurate and faster classification is achieved. A redundant leg method is proposed which compensates the fault voltage faster for PMSM [11]. That circuit is remodelled for cascaded MLI. This performs better in motor controlling operation. Here different meta- heuristic algorithms like GA and PSO are used to train the NN to select the optimal weight values which gives the accurate and faster classification of faults.

4. ANALYSIS

Generally neural network is trained by Back propagation algorithm [7]. Here the PSO algorithm and GA is applied for training the neural network [1] [4]. The Procedure is present below for BP, GA and PSO algorithms for selecting the weights, which used in the training of neural network. The objective function for GA and PSO is to minimize the mean square error. Each output computes its error term, its own weight correction term and its bias (threshold) correction term & sends it to layer below. Each hidden unit sums its delta inputs from above & multiplies by the derivative of its activation function; it also computes its own weight correction term and its bias correction term. Eventually the algorithm stops in a low point, which may just be a local minimum. The final updated weights and biases are assigned to the neural network with which network gives minimum error. Simulate the neural network with a test input pattern to check the network's performance. With a given number of layers (2), given no. of neurons & transfer functions (tansig, purelin) initialize the neural network to obtain initial weight matrices. Unwrap the weight & bias matrices in a single row vector to form first chromosome. Randomly generate the rest of the chromosomes. For every chromosome: reform into its original weight and bias matrices and simulate the neural network & obtain the Mean squared error. Form the weight & bias matrices with the obtained best

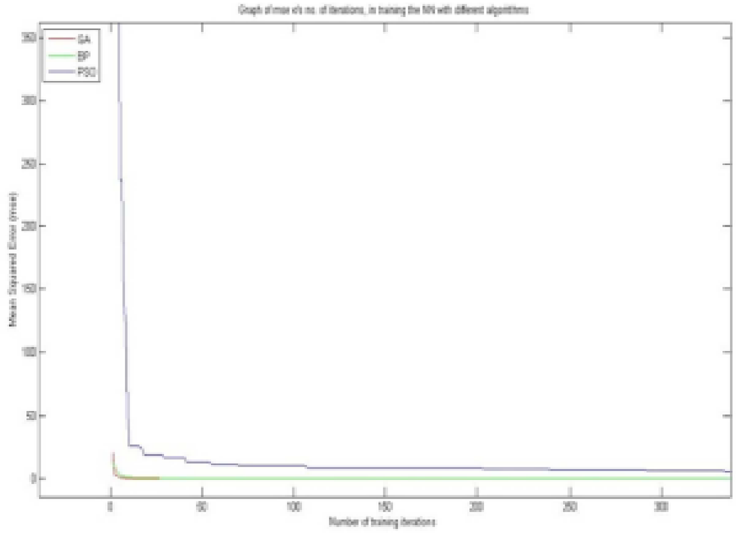

Fig.3. Analysis waveform

solution and row, column indices. Assign the obtained weight and bias matrices to the neural network. Simulate the neural network with a test input pattern to check the network's performance. With a given number of layers (2), given no. of neurons & transfer functions (tansig, purelin) initialize the neural network to obtain initial weight and bias matrices. Unwrap the weight & bias matrices in a single row vector to form first particle.

CONCLUSION

The Neural network trained by meta-heuristic algorithms is used to get optimal solutions, which makes the diagnosis system to identify the fault faster and give the control signal. The BP training is compared with GA and PSO to produce optimal solution under fault condition. The test system is tested with the mat-lab software with coding. The objective function used for this test system is the mean square error (MSE) on classification of fault and the results shows that the PSO algorithm gives fast and accurate results compared to the other methods.

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