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Research Article

Particle Swarm Optimization Recurrent Neural Network Based Z-source Inverter Fed Induction Motor Drive

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Abstract: In this study, the proposal is made for Particle Swarm Optimization (PSO) Recurrent Neural Network (RNN) based Z-Source Inverter Fed Induction Motor Drive. The proposed method is used to enhance the performance of the induction motor while reducing the Total Harmonic Distortion (THD), eliminating the oscillation period of the stator current, torque and speed. Here, the PSO technique uses the induction motor speed and reference speed as the input parameters. From the input parameters, it optimizes the gain of the PI controller and generates the reference quadrature axis current. By using the RNN, the reference three phase current for accurate control pulses of the voltage source inverter is predicted. The RNN is trained by the input motor actual quadrature axis current and the reference quadrature axis current with the corresponding target reference three phase current. The training process utilized the supervised learning process. Then the proposed technique is implemented in the MATLAB/SIMULINK platform and the effectiveness is analyzed by comparing with the other techniques such as PSO-Radial Biased Neural Network (RBNN) and PSO-Artificial Neural Network (ANN). The comparison results demonstrate the superiority of the proposed approach and confirm its potential to solve the problem.

Keywords: ANN, PSO, RBNN, RNN, Z-source inverter

INTRODUCTION

In power conversion methods, power inverters with both simple two-level and relatively complex multilevel topologies have so far been largely used for dc-ac power inversions such as ac motor drive, renewable energy interfacing and uninterruptable power supply (Gao *et al*., 2008). The power inverters can be broadly categorized either as Voltage-Source Inverter (VSI) or Current Source Inverter (CSI) (Ali and Kamaraj, 2011). The output voltage is for all time less than the input DC voltage in conventional voltage source inverters. In addition, firing the thyristors in the similar leg is limited as it short circuits the DC source (Meenakshi and Rajambal, 2010). In conventional voltage-source inverter, the two switches of the same-phase leg can in no way be gated on at the similar time since doing so would cause a short circuit (shoot through) to happen, which would demolish the inverter (Shen *et al*., 2006). Z source inverter rises above the problems in the Traditional VSI and CSI (Thangaprakash and Krishnan, 2009).

The Z-source inverter is a dc voltage source which sustained by a comparatively large capacitor supplies the main circuit of the inverter bridge (Peng, 2003). Z-source inverter can enhance dc input voltage with no necessity of dc-dc boost converter or step up transformer, therefore overcoming output voltage limitation of traditional voltage source inverter with lower its cost (Husodo *et al*., 2010). To take the isolated load, it is applied to change variable magnitude, variable frequency voltage into dependable constant voltage and steady frequency supply (Sasikumar and Pandian, 2010). For both voltage-boosting and inversion with an attractive inverter topology it presents a different choice (Yu *et al*., 2011). The Z-source inverters can be planned with their maximum modulation ratio set to the prevailing nominal case. Any flow in energy demand is next supervised by fluctuating the inverter shoot-through time duration, which in result is a third state introduced for gaining voltage boosting in Z-source inverter (Loh *et al*., 2010).

The induction motor drive system fed by z-source inverter may have the benefits of both of them and be appropriate for the electric drive systems (Sutar *et al*., 2012). Induction Motor (IM) can be regarded as one of the choice of the industry and researches since of its special characteristics such as low cost, high dependability, low inertia, simplicity and ruggedness (Raghu *et al*., 2012; Tripura and Babu, 2011). Habitually, variable speed operation of a single- phase induction motor is undergo from large harmonic

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injection into the supply and low power factor, besides the restricted speed (Bashi *et al*., 2005). The invention of modern solid state power electronics tools, the variable speed drives are managed by dissimilar kinds of PWM control methods (Abdelsalam *et al*., 2011).

This study proposed a PSO and RNN based Z-source inverter fed induction motor, which is used to improve the performance of the induction motor while decreasing the Total Harmonic Distortion (THD), eradicating the oscillation period of the stator current, torque and speed. Here, the PSO technique uses the induction motor speed and reference speed as the input parameters. From the input parameters, it optimizes the gain of the PI controller and generates the reference quadrature axis current. By using the RNN, the reference three phase current for accurate control pulses of the voltage source inverter is predicted. The RNN is trained by the input motor actual quadrature axis current and the reference quadrature axis current with the corresponding target reference three phase current. The training process utilized the supervised learning process. Other report organized as follows: the suggested function quick description is usually described with part 2; the proposed process achievement benefits as well as the associated discussions pick up with part 3; in addition to part 4 ends your report.

LITERATURE REVIEW

Several associated works are previously existed in literature which based on Z-source inverter. A few of them assessed here. An enhanced Z-source inverter topology has been suggested by Tang *et al*. (2009). Compared to the traditional Z-source inverter, it could be decreased the Z-source capacitor voltage stress considerably to execute the same voltage boost and has intrinsic restriction to inrush current at startup. The control approach of the suggested Z-source inverter was precisely the similar as the traditional one, so all the existing control approach could be applied directly. To hold back the inrush surge, a soft-start approach was moreover suggested and the resonance of Z-source capacitors and inductors. The operation code of the suggested topology and comparison with the traditional topology were examined in detail. To show the novel characteristics of the enhanced topology, Simulation and experimental results were specified.

For Z-Source Inverter (ZSI) fed induction motor drives, by means of an adapted voltage Space Vector Modulation (MSVM) a Current Mode Integrated Control method (CM-ICT) has been suggested by Thangaprakash and Krishnan (2010). MSVM offers an enhanced DC voltage boost in the dc-link, a broad range of AC output voltage controllability and a better line harmonic profile. The outer voltage feedback loop only was planned in a Voltage Mode ICT (VM-ICT) and it implements the desired line voltage to the motor drive. An Integrated Control Technique (ICT), the intention of line current limiting and soft operation of the drive. The current command produced by the PI controller and limiter in the outer voltage feedback loop, was compared with the actual line current and the fault was processed through the PI controller and a limiter. This limiter makes certain that, the voltage control signal to the Z-source inverter was restrained to a safe level. The rise and fall of the control signal voltage were made to be slow, so as to guard the induction motor drive and the Z-source inverter from transients.

A configuration of parallel UPSs based on Z-Source Inverters (ZSIs) has been suggested by Shahparasti *et al*. (2012). This system offers a general AC load with DC sources of dissimilar voltages and power ratings. Control of the suggested system contains the ZSI and the current sharing control. Dual-loop control method was executed to control the ZSI output voltage. For ZSI DC link voltage control, direct and indirect techniques were conversed and their results on circulating current and system characteristic equation were learned. Additionally, two approaches were suggested for current sharing: Equal Current Sharing (ECS) and proportional DC source nominal Power rating Current Sharing (PCS). A current sharing algorithm based on 3C method was improved for executing these approaches. The system operation with these techniques was compared from the perspective of Z-source network response and maximum power supply duration. The presentation of the suggested system was checked by simulation and was authenticated via experimental effects.

The study of switched inductor/capacitor Z Source inverter topologies with/without quasi Z Source network has been suggested by Saravanan *et al*. (2012). The widened topologies with the addition of a little passive component networks. The presentation of a SL Z Source Inverter, SL quasi Z Source Inverter and SL embedded Z Source inverters were in the simulation atmosphere. The topologies such as SC quasi Z Source Inverter, SC embedded Z Source Inverter which displays suitable presentation. Both SL and SC topologies were expanded by increasing the number of SL and SC cells correspondingly and the increasing capability was compared. The SC Z Source Inverters could be applied for both boost and buck operations and have been decreased stress on the capacitors in start conditions and that could be employed to the complete spectrum of power conversion and it was clear that many Z Source conversion circuits could be derived. Consequently, these inverters were rationally aggressive for buck-boost applications with their good presentations proved by simulation.

A direct dual-loop peak dc-link voltage control approach has been suggested by Ellabban *et al*. (2012) with outer voltage loop and inner cur-rent loop, of the

Z-Source Inverter (ZSI). By measuring both the input and capacitor voltages, the peak dc-link voltage was calculated approximately. With this suggested method, a high-performance output voltage control could be attained with an outstanding transient performance together with input voltage and load current deviations with minimized non minimum phase attributes caused by the right half-plane zero in the control to peak dc-link voltage transfer function. Based on a third-order small-signal model of the ZSI, both controllers were planned by means of the direct digital control technique. By simulation and experimental, the presentation of the suggested control strategy was checked.

A novel family of high boost voltage inverters that develop upon the conventional trans-Z-source and trans-quasi-Z-source inverters has been suggested by Nguyen *et al*. (2013). The enhanced trans-Z-source inverter offers nonstop input current and a higher boost voltage inversion capability. Besides, the enhanced inverter could hold back resonant current at startup, which might demolish the tool. In comparison to the conventional trans-Z-source/-trans-quasi-Z-source inverters, for the similar transformer turn ratio and input and output voltages, the enhanced inverter has a higher modulation index with decreased voltage stress on the dc link, lower current stress flow on the transformer windings and diode and lower input current ripple. The enhanced inverter employs a lower transformer turn ratio compared to the conventional inverters in order to generate the similar input and output voltage with the similar modulation index. As a result, the size and weight of the transformer in the enhanced inverter could be decreased.

Dehghan *et al*. (2010) have offered a novel z-source inverter with two AC outputs and two DC inputs. This inverter was supported on the z-source inverter and nine-switch inverter. The offered inverter could control amplitude, frequency and phase of both AC outputs and furthermore control current of both DC inputs. Input dc voltages were boosted to the necessary level. In addition, both outputs prolong their operation, still if one of the input voltages was zero.

A lot of PWM control plans have also been accounted with some attaining a lower switching loss and others recognizing an optimized harmonic presentation for controlling the Z-source inverters. Although these plans do have a little difference in characteristics, they are classically developed by beginning shoot through states to the classical VSI state chains with more states feasible to surface below low load small inductance conditions. The extra states are made known to control the produced voltage gain, which is now load reliant and, for that reason, harder to control. Appropriate parametric regulation should be accomplished for decreasing this load influence, to diminish the total of high frequency current ripple inside the circuit while assessed with the accomplished load level. While competent in firming the gain, parametric tuning can never eradicate the chopping current flow into the dc source which strength degrade the source feature response. A high competence Z-source inverter is applied to overcome the problem of this traditional power inverter topology. Due to its new voltage buck/boost ability and it is low-priced, the Z-source inverter is extremely promising for the systems. However, the only disadvantage of Z-source inverter is the current issue happened in the output current of the inverter. In order that, dissimilar control approaches are accessible such as simple, maximum boost control of z-source inverter and etc. The specified clarification about the suggested technique is given in the subsequent section below.

MATERIALS AND METHODS

Z-source inverter fed induction motor with proposed control scheme: This section describes the z-source inverter fed induction motor with proposed control scheme. Here, the Z-source inverter is very promising for the systems due to its novel voltage buck/boost ability and it is low-priced. For controlling the Z-source inverters, many PWM control schemes have been reported with some achieving a lower switching loss and others recognizing an optimized harmonic presentation. Even though these schemes do have a few differences in features, they are typically developed by beginning shoot through states to the classical VSI state chains with further possible states to surface below low load small inductance conditions. The added states are revealed to control the produced voltage gain, which is now load dependent and, for that reason, harder to control. To overcome these drawbacks, the proposed suitable parametric regulation should be utilized to minimize the total high frequency current ripple within the circuit while evaluated with the completed load level. The proposed control scheme is described in the following Fig. 1.

The above figure explains the controlling process of the proposed method. Here, the dc supply (V_d) is applied for the z-source inverter, which converts the dc voltage into the required level three phase ac voltage. The outcome of the inverter is utilized for the induction motor operation. The proposed control scheme occupies the input parameters from the induction motor speed (W_m) and the input three phase current (I_{abc}) of the induction motor. For optimizing the PI controller gain parameters using the PSO technique with the help of the input parameters like actual induction motor speed (W_m) and the reference speed (W_{ref}). The output of the PI controller is reference quadrature axis current (I^*_q); the reference quadrature axis current (I^*_q) and the actual quadrature axis current (I^*_q) is preferred to train the RNN. The reference three phase current (I^*_{abc}) has been developed from the RNN. Finally the control pulses are developed depending on the actual and

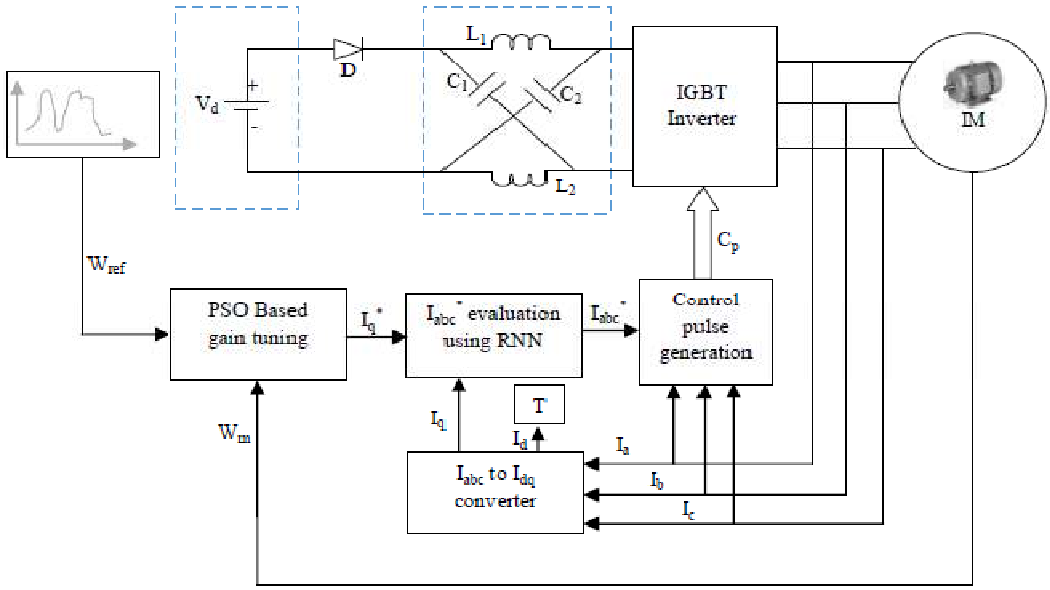
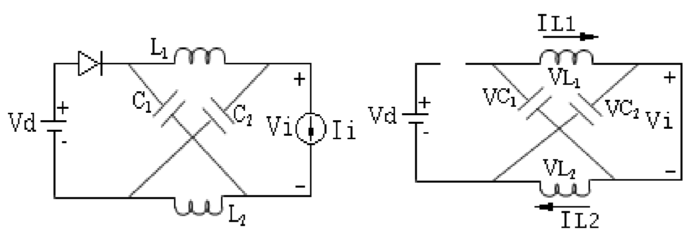


Fig. 1: Structure of the proposed method



(a) (b)

Fig. 2: Modes of operation, (a) non-shoot through mode, (b) shoot through mode

reference three phase current. These control pulses are utilized to operate the Insulated Gate Bi-polar Transistor inverter. Then the z-source network modes of operation are briefly illustrated in the following section.

Z-source network modes of operations: The z-source inverter contains two important modes of operations, i.e., non-shoot through mode of operation and shoot through mode of operation. The operation modes are explained in the following Fig. 2. In non-shoot through mode, the diode switch is forward biased; the flow of current directly goes to the inverter bridge. The inverter bridge act as a current source in which the presented inductor and capacitor is assumed as symmetry. So the inductor and capacitor voltage is given by:

$$V_{L1} = V_{L2} = V_L$$

and,

$$V_{C1} = V_{C2} = V_C$$

The shoot through voltage inductor voltage is given by the following Eq. (1) and (2):

$$V_L = V_d - V_C \qquad (1)$$

$$V_i = V_C - V_i = 2V_C - V_d \qquad (2)$$

where,

V_C = The capacitor voltage
V_L = The inductor voltage, is the inverter voltage
V_d = The input dc voltage

In the shoot through mode of operation the inverter upper leg positive switches and the lower leg negative switches are short circuited. During this time the diode switch is reverse biased, so the components energy is released and the output is boost voltage. The shoot through state inverter voltage is described in the following Eq. (3):

$$V_i = V_C - V_L = 2V_C - V_d = B.V_d \qquad (3)$$

where, $B = \frac{1}{1-2D_0}$ is the boost factor, D_0 is the shoot through time duty ratio. The proposed control method is used to control the IGBT inverter switches. Here, the proposed method contains two algorithms, i.e., PSO based gain optimization and RNN based control pulse generation. The PSO based gain optimization is briefly described in the following section.

PSO based gain optimization: The PSO as an optimization tool provides a population-based search procedure in which individuals called particles change their position (state) with time (2013). In a PSO system, particles change their positions by flying around in a multidimensional search space until a relatively unchanged position has been encountered or until computational limitations are exceeded (2012). Here, the PSO technique optimizes the minimum error function of the induction motor speed. From the minimized error, the optimum proportional (k_p) and integral (k_i) gain parameters has been predicted. By using the optimized gain parameters the PI controller has been tuned correctly. The output of the PI controller is reference quadrature axis current. Initially the gain parameters of the controller are selected randomly and the fitness function is calculated using the following relation (4):

$$Fitness = \Psi = Min\left\{K_p e(t) + K_i \int_0^t e(\tau)\, d\tau\right\} \tag{4}$$

where,

Ψ	= The objective function value to be added to the actual objective function
K_p and K_i	= The proportional and integral gain, respectively
t	= The time
τ	= The integration variable
e	= The error

Then the current particle position is modified, i.e., updating the change in voltage and change in current, which is described in the following Eq. (5):

$$x^{k+1} = x^k + v_{k+1}, \quad k = 1,2\ldots n \tag{5}$$

Here the particle and the velocity modification are described in the following Eq. (6) and (7):

$$x^k = [x^1, x^2, x^3 \ldots x^n] \tag{6}$$

$$v_{k+1} = w.v_k + c_1 rand^*(P_{best} - x^k) + c_2 rand^*(G_{best} - x^k) \tag{7}$$

where, x^k is the error speed between the actual motor speed W_m and the reference speed W_{ref}, w is the weight function for velocity of agent k, c_1 and c_2 positive constants, rand is the random numbers (0, 1) and the inertia weight w is defined by the following Eq. (8):

$$w(k) = \frac{w_{\max}(w_{\max} - w_{\min})}{\max.Iter} k \tag{8}$$

where, max.*Iter* is the maximum number of iteration, the steps to find the optimum parameters prediction, which is given in the following section:

Steps to optimize the gain parameters:

Step 1: In the first step, 'N' number of initial populations is randomly generated. In the study, the gain parameters like proportional (k_p) and integral (k_i) gain parameters are selected as the initial population.

Step 2: For each particle apply to the fitness function and evaluate the fitness values of the random initial populations.

Step 3: Depending on the fitness function evaluation the particles are classified into two groups, i.e., maximum fitness and minimum fitness. From the classification, determine the P_{best} and G_{best} as per the objective function.

Step 4: For each best particle velocity and position is modified by using the Eq. (7) and (9).

Step 5: Using the updated particles, find the fitness and check the objective function.

Step 6: Check the iteration limit, if it reaches the maximum number, go to or else increase the iteration number and go back to the step 2.

Step 7: Evaluate the reference quadrature axis current (I^*_q).

Step 8: Terminate the process.

Once the above process is completed, the PSO gives optimum gain parameters, which is applied into the PI controller. The output of the PI controller is quadrature axis current (I^*_q) and the controller output is applied to the input of the RNN. The RNN can predict the reference three phase current (I^*_{abc}) using the inputs like reference and actual reference quadrature current. The brief explanation about the RNN process is described in the following section.

Control pulses generation using RNN: The RNN is the artificial training and testing algorithm, which works on the basis of a machine learning approach that models a human brain and consists of a number of artificial neurons. The presented neurons have the interior connections and each neuron in RNN receives a number of inputs, depending on the activation functions

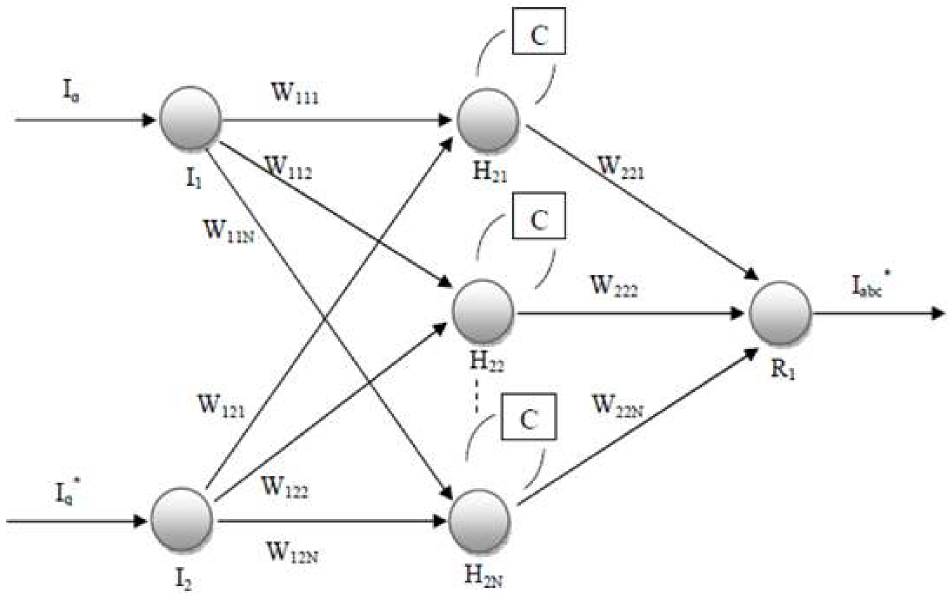


Fig. 3: Structure of the RNN

of the RNN results in the output level of the neuron. The learning task is given in the form of examples, which is known as training examples. Normally RNN has three layers like input layer, hidden layer and output layer. Here, the input layer consists of reference quadrature axis current (I^*_q) and actual quadrature axis current (I_q). The output target layer is the three phase reference current (I^*_{abc}). Also the RNN has context layer, which hold activities of the recurrent layer from previous time step. By using the target output and the corresponding input the RNN has been trained. This training process utilizes the supervised learning process. During the training process the hidden layer obtains the weight at the specific time delay from the context layer. The RNN structure is explained in the following Fig. 3. The training process is explained in the following section.

Supervised learning and training process: This section describes about the training process of the RNN. Here, the supervising learning law of the gradient descent is used to train the RNN during the end of the initialization process. The derivation is similar to the back propagation algorithm. It is used to ensure the weight adjustments w^3_{bc}, w^2_b and w^2_{ab} of the RNN by using the training datasets. By using the chain rule, each layer error speed is calculated and updated. The main purpose of the supervising learning algorithm is to minimize the error function, which is explained in the following Eq. (9):

$$E = \frac{1}{2}(W_m - W_{ref})^2 = \frac{1}{2}e_s^2 \tag{9}$$

where, W_m is the IM actual speed, W_{ref} is the reference speed and E is the error function. The error calculation and weight updating is explained in the following.

Layer 1: This layer is used to update the weight of the w^3_{bc}. Here the updated weight is given by the following Eq. (10):

$$w^3_{bc}(N+1) = w^3_{bc}(N) + \eta_{bc}\Delta w^3_{bc}(N) \tag{10}$$

where,

$$\Delta w^3_{bc} = -\frac{\partial E}{\partial R^3_c} = \left[-\frac{\partial E}{\partial R^3_c}\frac{\partial R^3_c}{\partial Net^3_c}\right] = \delta_c R_b$$

with,

$$\delta_c = \frac{\partial E}{\partial R^3_c} = \left[-\frac{\partial E}{\partial e_s}\frac{\partial e_s}{\partial R^3_c}\right]$$

is propagates the error term, η_{bc} is the learning rate for adjusting the parameter w_{bc}.

Layer 2: This layer performs multiplication operation, the updated rule for w^2_b and w^2_{ab} is given by the following Eq. (11) and (12):

$$w^2_b(N+1) = w^2_b(N) + \eta_b \Delta w^2_b(N) \tag{11}$$

$$w^2_{ab}(N+1) = w^2_{ab}(c) + \eta_{ab}\Delta w^2_{ab}(N) \tag{12}$$

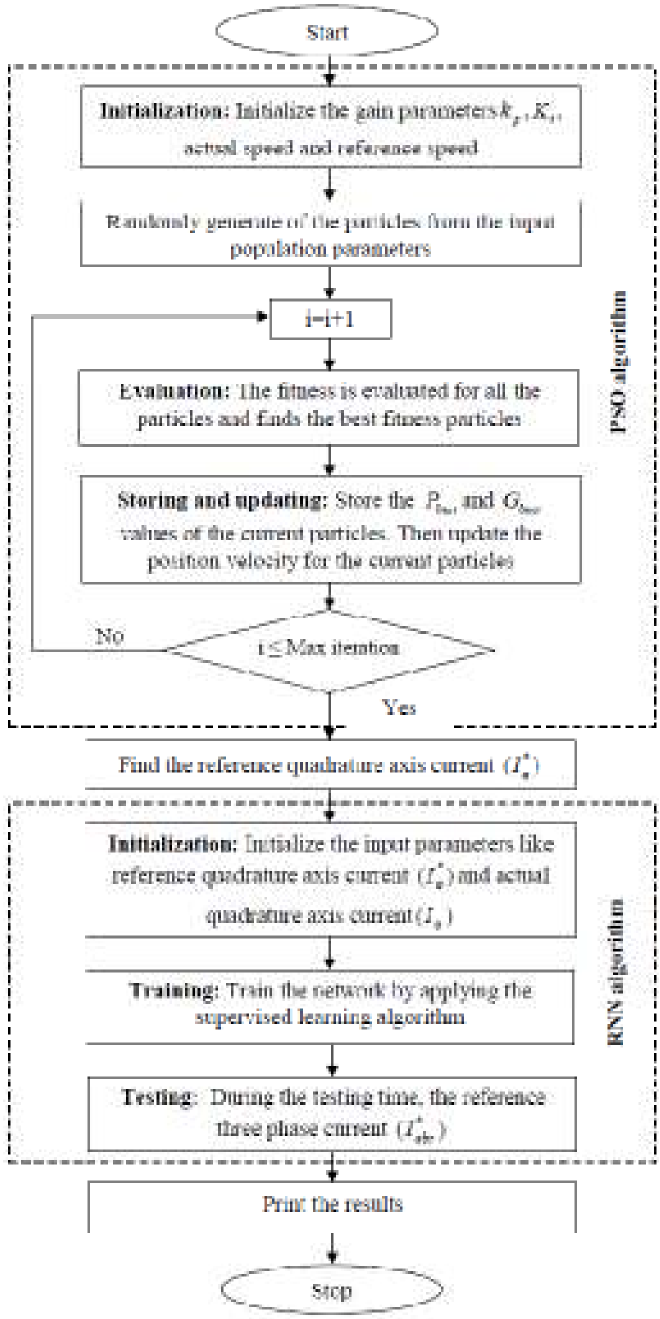


Fig. 4: Structure of the proposed method

where,

$$\Delta w_b^2 = -\frac{\partial E}{\partial w_b^2} = \left[-\frac{\partial E}{\partial R_c^3} \frac{\partial R_c^3}{\partial R_b^2} \frac{\partial R_c^3}{\partial R_b^2} \right] = \delta_c w_{bc}^2 P_b^2$$

and,

$$\Delta w_{ab}^2 = -\frac{\partial E}{\partial w_{ab}^2} = \left[-\frac{\partial E}{\partial R_c^3} \frac{\partial R_c^3}{\partial R_b^2} \frac{\partial R_b^2}{\partial w_{ab}^2} \right] = \delta_c w_{bc}^2 Q_{ab}^2$$

With η_b and η_{bc} is the learning rate for adjusting the parameter w^2_b and w^2_{ab} respectively, w^2_b, w^2_{ab} and w_{bc} are the tuning parameters. We can derive a learning algorithm that drives E to zero. Once the process is finished, the RNN is ready to give the reference three phase current. Finally the RNN output is converted into the appropriate control pulses. The proposed technique structure is described in the following Fig. 4. The mentioned process is tested under the MATLAB/SIMULINK platform and the effectiveness of the proposed methodology is analyzed through the comparison with the other techniques. The implementation results and the corresponding discussion are briefly described in the following section.

RESULTS AND DISCUSSION

The proposed method is implemented in MATLAB/SIMULINK 7.10.0 (R2012a) platform, 4 GB RAM and Intel(R) core(TM) i5. Here the proposed method gets the input parameters from the induction motor, i.e., rotor speed and three phases current. The induction motor configuration used as the implementation is given in the following Table 1. The simulation results were taken under 2 sec; the effectiveness of the proposed method is analyzed by using the comparison study between the PSO-ANN, PSO-RBNN and the proposed method. The implemented structure of the proposed method based Z-Source Inverter Fed Induction Motor Drive is described in the following Fig. 5.

Table 1: Implementation parameters of induction motor

Parameters	Values
Rated power	37.3 KW
Rated voltage	460 V
Pole pairs	2
Stator resistance	0.087 Ω
Stator inductance	0.8 mH
Rotor resistance	0.228 Ω
Rotor inductance	0.8 mH
Mutual inductance	34.7 mH
Reference speed	1200 RPM

The above figure contains z-source inverter fed induction motor with proposed control technique. Here, the actual speed (W_m) of the induction motor and reference speed (W_m) are given as the input of the PSO. The PSO optimizes the gain parameters of the PI controller (K_p and K_i) and the output of the PI controller is the reference quadrature axis current (I^*_q).

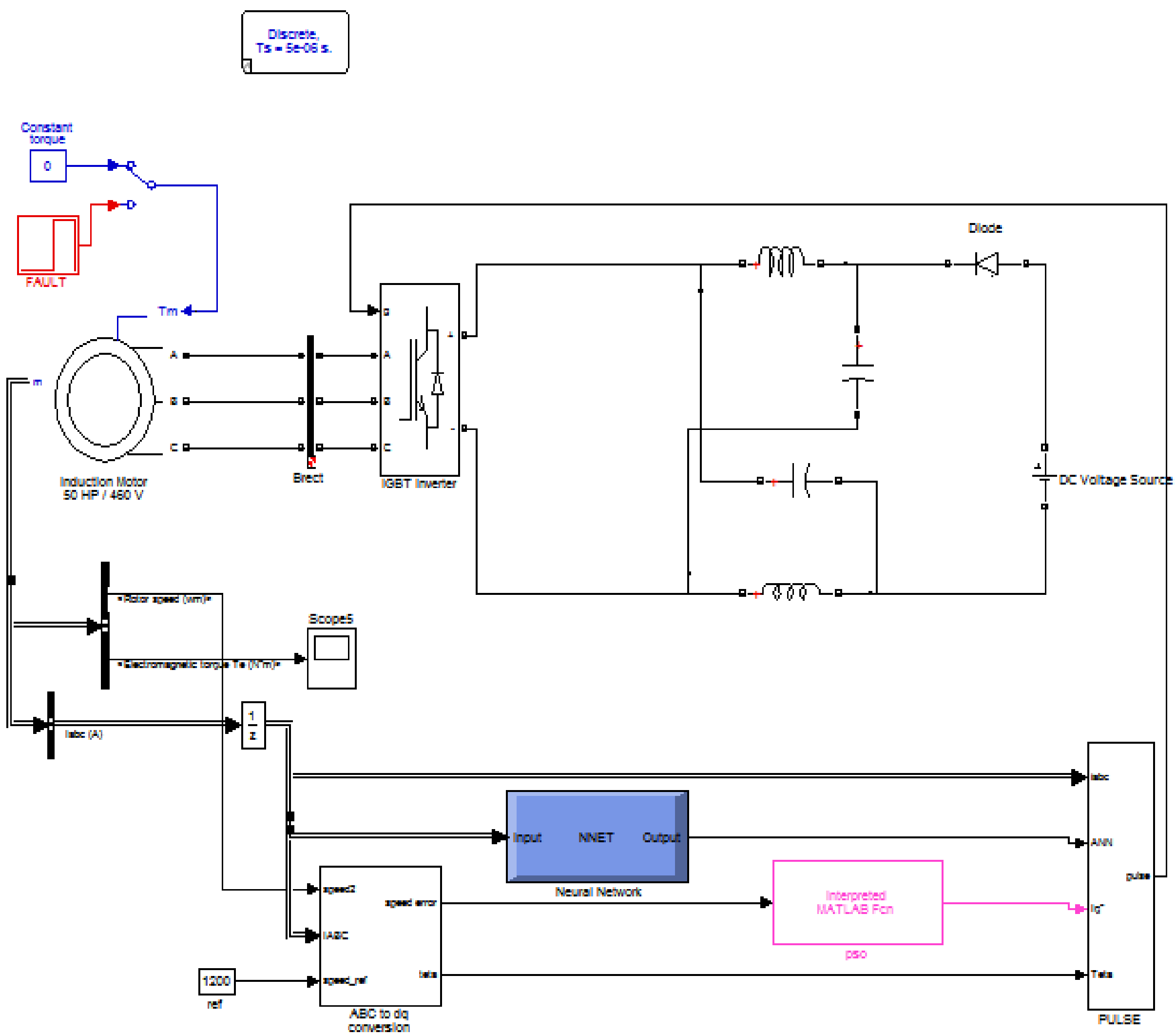


Fig. 5: Implementation model of the proposed control technique

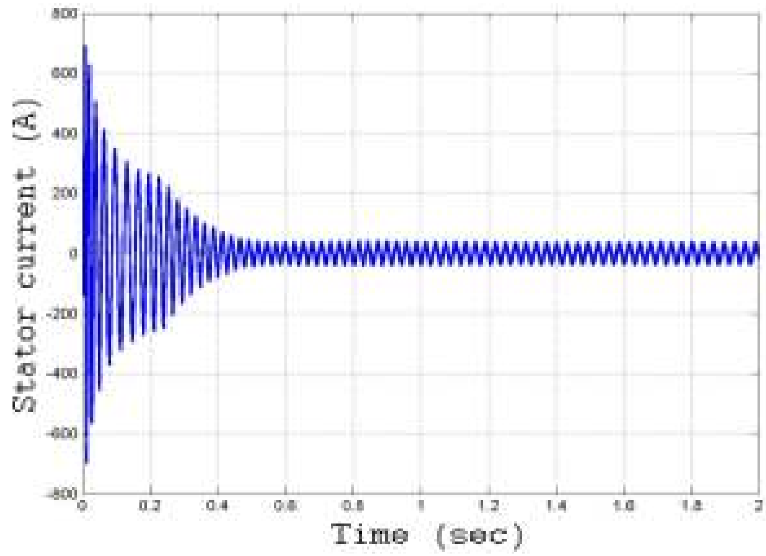


Fig. 6: Induction motor stator current using proposed method

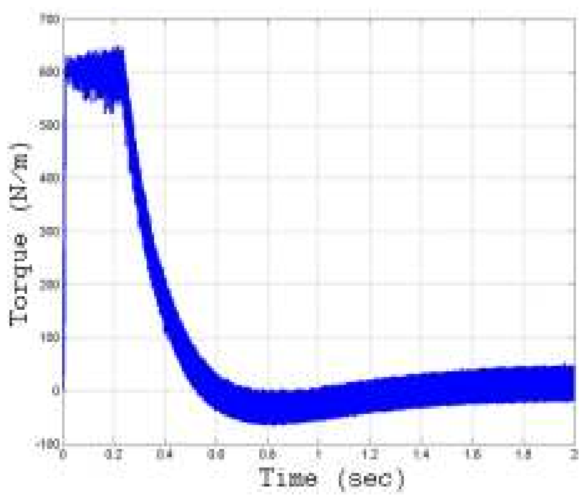


Fig. 7: Induction motor torque using proposed method

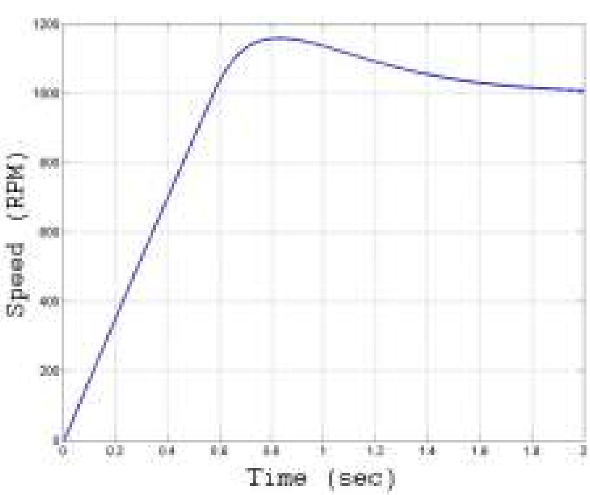


Fig. 8: Rotor speed using proposed method

It is used as one of the training parameter of the RNN, because the RNN contains I^*_q, I_q are the inputs and I^*_{abc} is the target output. Depending on the actual three phase current (I_{abc}) and the reference three phase current (I^*_{abc}), the controlling pulses are created. The results are explained in the following figures. The three phase induction motor stator current using proposed method is explained in the following Fig. 6. It clearly shows that the transient period is very short, i.e., the oscillation present in the stator current is vanished out within 0.4 sec. After the oscillation time, the stator current make a constant response till the end of simulation time. The induction motor torque response is illustrated in the following Fig. 7. From the figure we observe that the overshoot period is restricted between the period 0 to 0.23 sec, so it should not affect the performance of the system.

The induction motor speed response is illustrated in the Fig. 8. It was seen from Fig. 8, the rise time is restricted by 0.6 sec; also it eliminates the transient period or the oscillation of the speed response and reduces the settling time. The presented overshoot time is not affected by the performance of the system. The effectiveness of the proposed method is analyzed by the following Fig. 9, in which the proposed method stator current is compared with PSO-ANN and PSO-RBNN. It clearly describes that the PSO-ANN stator current contains high oscillation time, i.e., the oscillation of the stator current is between 0-0.3 sec and also it is extended during the operation time. The PSO-RBNN contains very long transient period, because it reflects 0-0.8 oscillation period. But the proposed technique reduces the oscillation period effectively compared to the other techniques. It effectively eliminates the oscillation at very short time.

The torque response of the induction motor using various techniques is explained in the following Fig. 10.

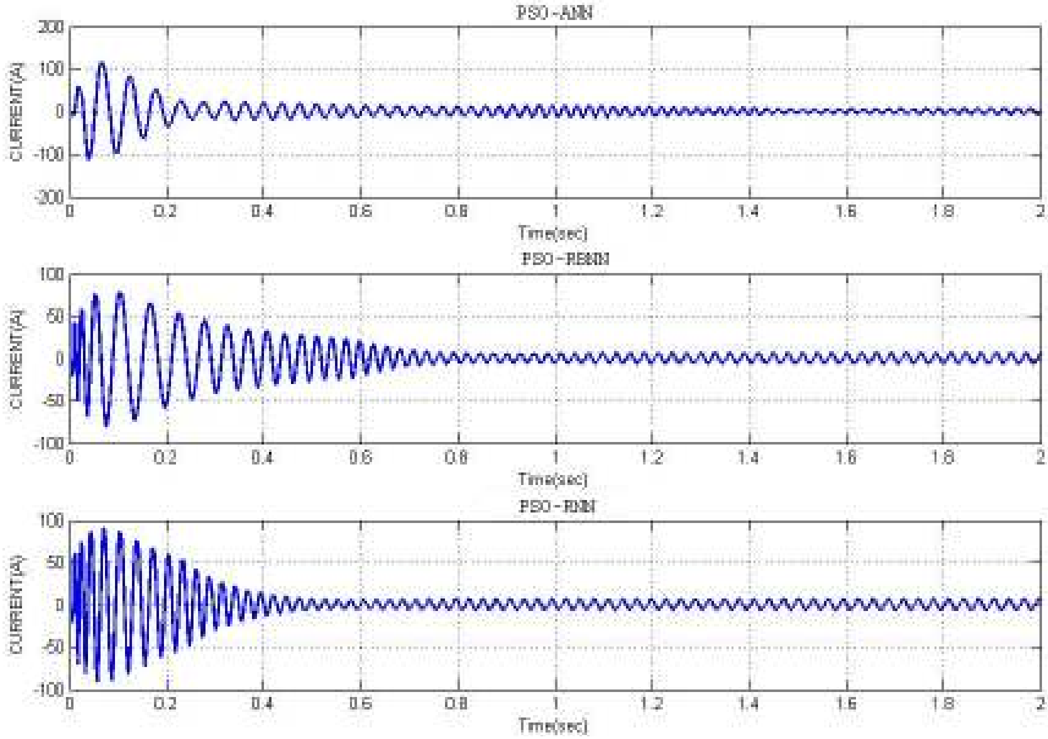


Fig. 9: Stator current comparison using different techniques

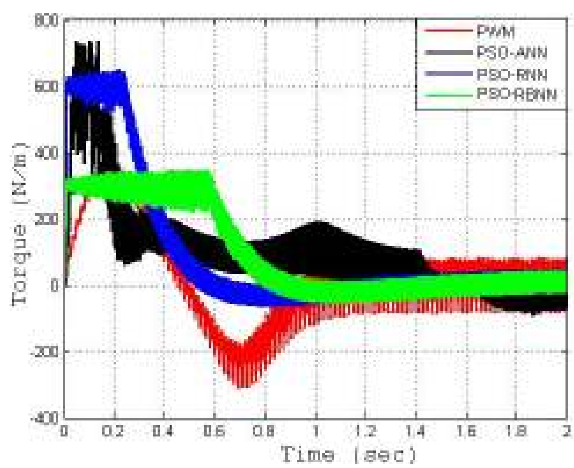


Fig. 10: Torque comparison using different techniques

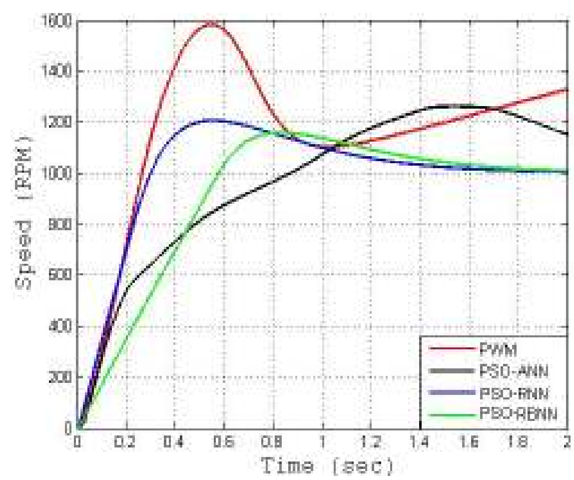


Fig. 11: Rotor speed comparison using different techniques

Here, the effectiveness is analyzed by using the comparison study between the normal PWM technique, PSO-ANN, PSO-RBNN and the proposed method. It was seen from the Fig. 10, the normal PWM technique torque response have high oscillation period. The PSO-ANN has the peak overshoot period at 0-0.3 sec and also it extends the oscillations till the end of the time. The PSO-RBNN has the overshoot time between 0-0.6 sec; after the overshoot time the oscillations are vanished. The PSO-RNN contains very short peak overshoot time at 0-0.23 sec and actively maintains the steady state time with reduced oscillations compared to the other techniques.

The speed response of the induction motor using different techniques is explained in the following Fig. 11, i.e., normal PWM, PSO-ANN, PSO-RBNN and proposed method. Here, the normal PWM method has high peak overshoot time 1 sec and it doesn't reach the settling time. The PSO-ANN speed response signal takes long time to reach the settling. The PSO-RBNN has rise time at 0.6 sec; the overshoot period is also high so it takes long time to achieve settling. The proposed method is effectively reduced the rise time (0.2 sec) and the torque early reaches the settling time at 1.6 sec compare to the other techniques.

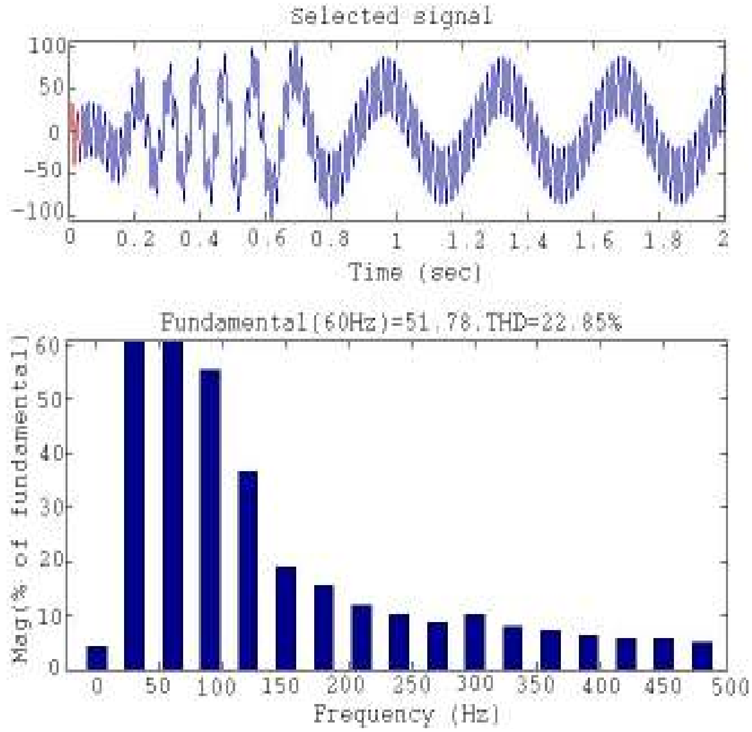


Fig. 12: Stator current THD using PSO-ANN

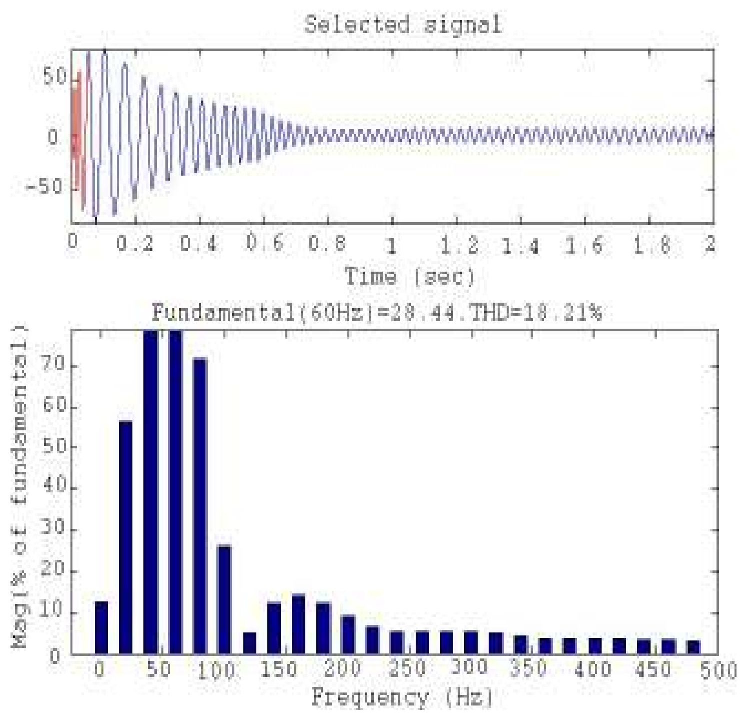


Fig. 13: Stator current THD using PSO-RBNN

The stator current THD analysis for PSO-ANN, PSO-RBNN and the proposed method is analyzed in the above Fig. 12 to 14. Here the PSO-ANN stator current has 22.85% of THD, because the stator current contains long period of oscillations. The PSO-RBNN stator current contains 18.21% of THD, i.e., the stator current has transient conditions during the period 0-0.8. But the proposed method has 11.09% THD, which is well effective technique compared to the other techniques.

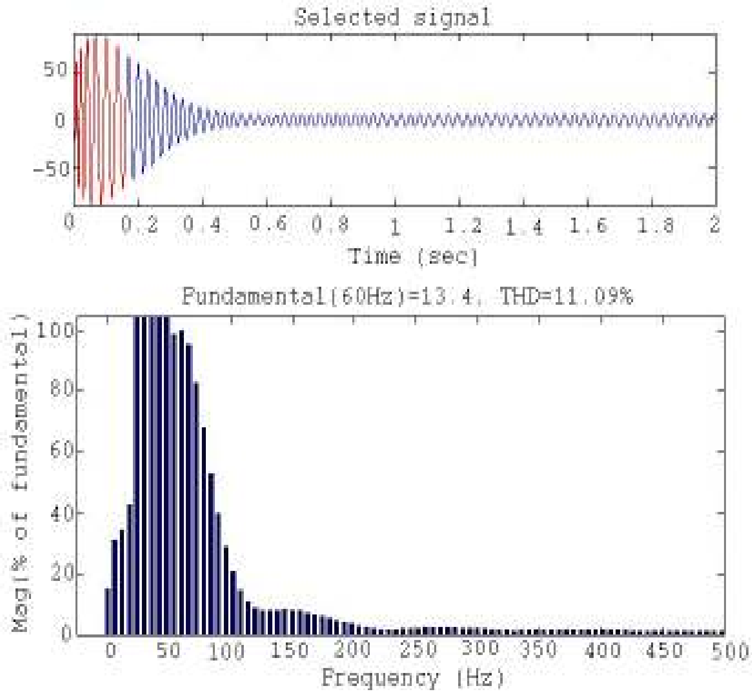


Fig. 14: Stator current THD using PSO-RNN

CONCLUSION

This study is intended to propose PSO-RNN based Z-source inverter for improving the performance of induction motor drive. In this study, the performance evaluation of the PSO-ANN, PSO-RBNN and PSO-RNN techniques also determined, based on the THD in the inverter output current. Here, the proposed method gets the input parameters from the induction motor drive with the corresponding load change and speed change. Depending on the input parameters the control pulses are generated. From the simulation results, the proposed method effectively reduced the THD of the stator current at 11.09% and eliminates the oscillations presents in the motor torque and speed response. It was observed that the proposed method is highly preferable to enhance the performance of the induction motor where not much load change is involved or not much speed change is required. Finally the comparison results have proved that the proposed method is well effective technique to the non-linear system processes, which is competent over the other techniques.

REFERENCES

Abdelsalam, A.K., M.I. Masoud, S.J. Finney and B.W. Williams, 2011. Vector control PWM-VSI induction motor drive with a long motor feeder: Performance analysis of line filter networks. IET Electr. Power App., 5(5): 443-456.

Ali, U.S. and V. Kamaraj, 2011. Double carrier pulse width modulation control of Z-source inverter. Eur. J. Sci. Res., 49(2): 168-176.

Bashi, S.M., I. Aris and S.H. Hamad, 2005. Development of single phase induction motor adjustable speed control using M68HC11E-9 microcontroller. J. Appl. Sci., 5(2): 249-252.

Dehghan, S.M., M. Mohamadian, A. Yazdian and F. Ashrafzadeh, 2010. A dual-input-dual-output Z-source inverter. IEEE T. Power Electr., 25(2): 360-368.

Ellabban, O., J.V. Mierlo and P. Lataire, 2012. A DSP-based dual-loop peak DC-link voltage control strategy of the Z-source inverter. IEEE T. Power Electr., 27(9): 4088-4097.

Gao, F., P.C. Loh, F. Blaabjerg and C.J. Gajanayake, 2008. Operational analysis and comparative evaluation of embedded Z-Source inverters. Proceeding of IEEE Power Electronics Specialists Conference (PESC, 2008), pp: 2757-2763.

Husodo, B.Y., M. Anwari, S.M. Ayob and Taufik, 2010. Analysis and simulations of Z-source inverter control methods. Proceeding of IPEC Conference 2010, pp: 699-704.

Loh, P.C., F. Gao and F. Blaabjerg, 2010. Embedded EZ-source inverters. IEEE T. Ind. Appl., 46(1): 256-267.

Meenakshi, T. and K. Rajambal, 2010. Identification of an effective control scheme for Z-source inverter. APEJ J., 4(1): 22-28.

Nguyen, M., Y. Lim and S. Park, 2013. Improved trans-Z-source inverter with continuous input current and boost inversion capability. IEEE T. Power Electr., 28(10): 4500-4510.

Peng, F.Z., 2003. Z-source inverter. IEEE T. Ind. Appl., 39(2): 504-510.

Raghu, T., J.S. Rao and S.C. Sekhar, 2012. Simulation of sensorless speed control of induction motor using APFO technique. Int. J. Comput. Electr. Eng., 4(4): 440-444.

Saravanan, V., R. Ramanujam and M. Arumugam, 2012. Switched quasi Z source inverters with extended boost capability. Eur. J. Sci. Res., 68(3): 440-452.

Sasikumar, M. and S.C. Pandian, 2010. Implementation and characteristics of induction generator fed three level ZSI for wind energy conversion scheme. Int. J. Adv. Eng. Sci. Technol., 1(1): 52-57.

Shahparasti, M., A. Yazdian, M. Mohamadian, A.S. Larijani and A. Fatemi, 2012. Parallel uninterruptible power supplies based on Z-source inverters. IET Power Electron., 5(8): 1359-1366.

Shen, M., J. Wang, A. Joseph, F.Z. Peng, L.M. Tolbert and D.J. Adams, 2006. Constant boost control of the Z-source inverter to minimize current ripple and voltage stress. IEEE T. Ind. Appl., 42(3): 770-778.

Sutar, A.R., S.R. Jagtap and J. Tamboli, 2012. Performance analysis of Z-source inverter fed induction motor drive. Int. J. Sci. Eng. Res., 3(5): 1-6.

Tang, Y., S. Xie, C. Zhang and Z. Xu, 2009. Improved Z-source inverter with reduced Z-source capacitor voltage stress and soft-start capability. IEEE T. Power Electr., 24(2): 409-415.

Thangaprakash, S. and A. Krishnan, 2009. Modified space vector pulse width modulation for Z-source inverters. Int. J. Recent Trends Eng., 2(6): 136-138.

Thangaprakash, S. and A. Krishnan, 2010. Current mode integrated control technique for Z-source inverter fed induction motor drives. J. Power Electron., 10(3): 285-292.

Tripura, P. and Y.S.K. Babu, 2011. Fuzzy logic speed control of three phase induction motor drive. World Acad. Sci. Eng. Technol., 60: 1371-1375.

Yu, Y., Q. Zhang, B. Liang and S. Cui, 2011. Single-phase Z-source inverter: Analysis and low-frequency harmonics elimination pulse width modulation. Proceeding of IEEE Energy Conversion Congress and Exposition (ECCE, 2011), pp: 2260-2267.