Efficient Maximum Power Point Tracking in Grid Connected Switched Reluctance Generator in Wind Energy Conversion System: An EMATSO Approach

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Research Article

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Efficient Maximum Power Point Tracking in Grid Connected Switched Reluctance Generator in Wind Energy Conversion System: An EMATSO Approach

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Abstract

In this manuscript presents an efficient hybrid approach for fast and efficient MPPT in WECS. The system has MPPT based control of Switched Reluctance Generator (SRG) containing a hybrid Meta-heuristic algorithm. The hybrid proposed method is joint implementation of Mayfly Algorithm (MA) and Transient Search Optimization (TSO) named as enhanced MATSO (EMATSO) method. The reduction of speed error is the main aim of the proposed method. Depend on direct variation and quadrature current parameters the MA method is proposed to stimulate the maximum gain parameters of proportional integral (PI) controller with lowest error function. Here, the MA search behavior is enhanced using the efficient TSO algorithm. Based on speed variation of generator using MPPT method and loss reduction method the direct axis set point and the quadrature axis current parameters of WECS are developed. The proposed

EMATSO method has enhanced the efficiency of the WECS with this proper control. At last, the proposed model is updated on MATLAB/Simulink platform and performance is compared to other methods like GA, ALO, TSA and MA

Keywords: *Wind Energy Conversion system, Switched Reluctance Generator, Wind turbine, Maximum power point tracking, Mayfly Algorithm, Transient Search Optimization*

1. Introduction

Based on the fact that fossil fuels are working today, renewable energies have established. Fossil fuels become infinite with convertible renewable energy, clean and obtainable content (Lopez-Flores et al. 2020) Wind and solar energy are one of the most significant renewable energy factors, which researchers have taken into account on their studies for obtaining a high efficient and consistent approach (Chen et al. 2020). There have been various studies conducted on wind energy in recent years. Control and stability of various kinds of generators in grid-connected wind plants and WT and Maximal Power Point Tracking (MPPT) systems are the most popular topics (Neto et al. 2018). WT are divided into two groups (Shafiei et al. 2016):fixed speed wind turbines (FSWT) and variable speed wind turbines (VSWT). FSWT is very simple and low cost (Hasanien and Muyeen 2012). Also the VSWT are more complicated and high price, they have maximum productivity in contrast with FSWTs. In the VSWT enhancing the MPPT method is one of the main subject of recent works (Hu et al. 2019). The wind generator may occupy optimal energy as wind with MPPT stimulating higher productivity (Mishra and Singh 2020). The classic controllers consisting of PI, PD and PID controllers have few challenges like robustness and broad margin stability (Namazi et al. 2018). Moreover, such controllers consist of few drawbacks that they contain: maximum reactivity to changes on parameters and maximum sensitivity to respond with non-linear dynamic systems (Oshaba et al. 2020). Recently, fuzzy logic controller (FLC) and artificial neural network controller (ANNC) are widely used due to its advantages (Sunan et al. 2014).

Several generators have been used for wind power plants, such as induction generator (IG) (Youssef et al. 2019) doubly fed induction generator (DFIG) (Salimi et al. 2012) wound field synchronous generator (WFSG) (Shah et al. 2018), permanent magnet synchronous generator (PMSG), and SRG (Han et al. 2019). IGs are utilized to FSWT (Gan et al. 2018) DFIG is an appropriate option for VSWTs based on their advantages, especially on unstable states (Mishra et al. 2019). In recent years, the implementation of SRG for VSWT is evaluated to achieve maximal power performance. It is a clever choice as it presents powerful challenges like high efficiency, mechanical robustness, performance over a wide speed range, high power density and fault tolerance (Reddy et al. 2020). Based on SRG function on various wind speeds, this generator may be a suitable choice and work with maximum performance. Previously, on the basis of these merits in the VSWT to obtain high power, the SRG has been used. In past MPPT production, the closed-loop is one of the major components. This controller type is used for operating the SRG thyristors firing angle. SRG is evaluated on maximum velocity and single pulse mode (Mishra and Singh 2019).In recent years, examining SRG switching and high on-off angle of SRG asymmetric half-bridge is one of the famous studies for achieving high productivity at various wind speeds (Wee et al. 2013). An appropriate model can neglect the rotor position of the SRG sensor using an artificial neural network (ANN). Rotor position is most essential for operating the SRG. Recently ANNC utilized as MPPT with SRG firing angle operation. This operation method executes the SRG at maximal rotation speed (Wang et al. 2017).

This manuscript presents an efficient hybrid approach for fast and efficient MPPT in WECS. The system has Switched Reluctance Generator (SRG) MPPT-based control that contains a hybrid Meta-heuristic algorithm. The proposed hybrid method is joint implementation of Mayfly algorithm (MA) and Transient Search Optimization (TSO) named as enhanced MATSO (EMATSO) method. Remaining manuscript is expressed as follows: Section 2 delineates the literature survey and their background. Section 3 describes the modelling for the Wind energy conversion system with SRG. Section 4 delineates the proposed approach of EMATSO. Section 5 explains the results obtained by the proposed and existing techniques. Section 6 concludes the manuscript.

2. Recent Research Work: A Brief Review

Based on the monitoring of maximal power point in wind energy conversion system, recently there have been several research papers on bibliography with several methods and aspects. Some of them are examined as follows,

H. Mousa et al. (2019) have developed the MPPT variable step perturb and observe (VS-PO) algorithm. The VS-PO algorithm separates the P-ω curve addicted to modular sectors by combining a recently produced relationship with another required relationship that was associated with compelled obligated accuracy. When the power output was long distance as MPP, then the step size value was high and it decreased infinitely with power output and proceeds among MPP. The Wind Speed Estimation method calculates the wind speed to measure the integrated relationship. CM Hong and CH Chen (2018) developed an improved radial fuzzy wavelet neural network with sliding mode (RFWNNSM) and hill climb search (HCS) on MPPT method in a variable speed WECS for SRG. According to its usability and robustness, with various terms of inertia turbine the HCS approach was developed for maximum power searching.

The MPPT algorithm improves the tracking speed and the controller efficiency of MPPT. Artificial bee colony optimization method was described by D Kumar and K Chatterjee (2016) for MPPT in DFIG-based WECS. For sampling the versatility the developed approach, with two cases of wind data have described, they are randomly chosen wind speeds and real wind data. The most challenges of developed approach was high solution which individual of the preminilary stage and essential of low number of control parameters, which leads to simple and robust MPPT.

The MPPT method based on hybrid fuzzy particle swarm optimization was developed by N Priyadarshi et al. (2018) in adverse operating states to achieve high tracking efficiency and maximum MPP. The FSVPWM method produces a fixed switching pattern, low current harmonic content, over current protection, minimum switching losses is provided for accommodating the non-linearities and variables of system connected to the PV wind power grid. E Rahmanian et al. (2017) have introduced the intelligent control systems like ANN and FL controller are modify the rotation speed of WT via operating the SRG off angle. The inverter was operated through a discrete PWM generator as well as voltage regulator. The inverted power was sampled using LCL filter. Under various wind speeds for SRG new MPPT was described by N H. Saad et al. (2020) for rectifying the classic Hill Climb Searching method with ANN that was evaluated for closed loop operation to stimulate the PI controller. The artificial neural network (ANN) control was used to improve the SRG four-phase touch ripple reduction algorithm in WECS. During the accumulation times the control algorithm is produced interms of maximum cost of generator phase currents. R. Sitharthan et al. (2020) have found that PSO algorithm improves the radial basis function MPPT control based on TSR method for DFIG based wind power generation system. The enhanced hybrid MPPT control method improves the effectual wind speed and calculates maximum rotor speed of wind power production system for tracking maximal power. The enhanced approach enhances the reliability of systems and achieves an efficiency of power tracking with minimized losses of converter.

2.1. Background of the Research Work

Several researchers have been developed for the evaluation of SRG based on the WECS performance. Thus the time-varying variables related to the complex dynamic model have not been properly characterized. Moreover, the SRG back-EMF on production process was a time-varying position based on voltage source outcomes at contribution model, which cannot be rejected on MPPT method. Also the evaluation of less signal approaches generates an easy way for terminating stability on breakeven point; it may not be exploited on time-varying back-EMF dynamics presence. So, maximum power tracking was essential one for WECS. Some of the methods utilized to track the maximum power in the literature study are several-step perturb and observe (VS-PO) MPPT, Artificial Bee Colony Optimization, Particle Swarm Optimization (PSO), ANN and FL controller, HCS technique, tip speed ratio (TSR) control. ANN was used for dynamic achievements finding in WECS system and also the drawbacks of ANN hardware dependence, unexplainable actions of the network, persistence of proper network architecture and problems of showing the issues to the network. FLC was utilized to operate indoor air temperature and humidity of WECS system and but the drawbacks of FLC was not always correct, so the results are detected based on assumption, so it may not be widely established. The HCS helpful to cure pure optimization issues where the aim was to find the best state based on the aim. It requires low conditions than other search methods. HCS was a fast and effectual in spite of variables on wind speeds and inertia turbine. The TSR control was utilized for tracking the maximum power but it require speed sensors to correctly track maximal power point (MPP), and, they are not precise adequate. These examined disadvantages and issues are challenged to do this work.

3. System Modelling of Wind Energy Conversion System (WECS)

Based on the SRG, the WECS is connected with grid during multi-level voltage source inverter. Based on the proposed approach the MPPT control method has been presented to modify the rotating speed for supplying SRG to operate near to MPP without any ripple in the export torque in speed below rated speed. More than the rated speed the control method obtains the operating speed of wind turbine (2020). The intention function of the proposed approach denotes minimization of speed error. The MA is produced to create the optimal gain parameters of proportional integral (PI) controller through minimal error objective function interms of direct variation and quadrature parameters. The MA search behavior is customized by well-organized TSO algorithm. The direct axis set point and WECS quadrature axis current parameters are demonstrated by MPPT system and minimization loss strategy interms of generator speed variation. With this proper control, the proposed EMATSO technique has enhanced the WECS efficiency (Saad et al. 2018) Figure 1 portrays that SRG-based WECS architecture with the proposed method.

3.1. Wind Turbine and Maximum Power Point Tracking

The blades swept area of WT derives the kinetic energy. The power of the airflow is expressed in below equation,

$$p_{air} = \frac{1}{2}\rho a v^3 \tag{1}$$

The wind speed is expressed as v, the air density is articulated as ρ and swept area by blades is expressed. Depending on power coefficient the wind power reduces while it is forwarded to the rotor of WT and it is expressed as follows,

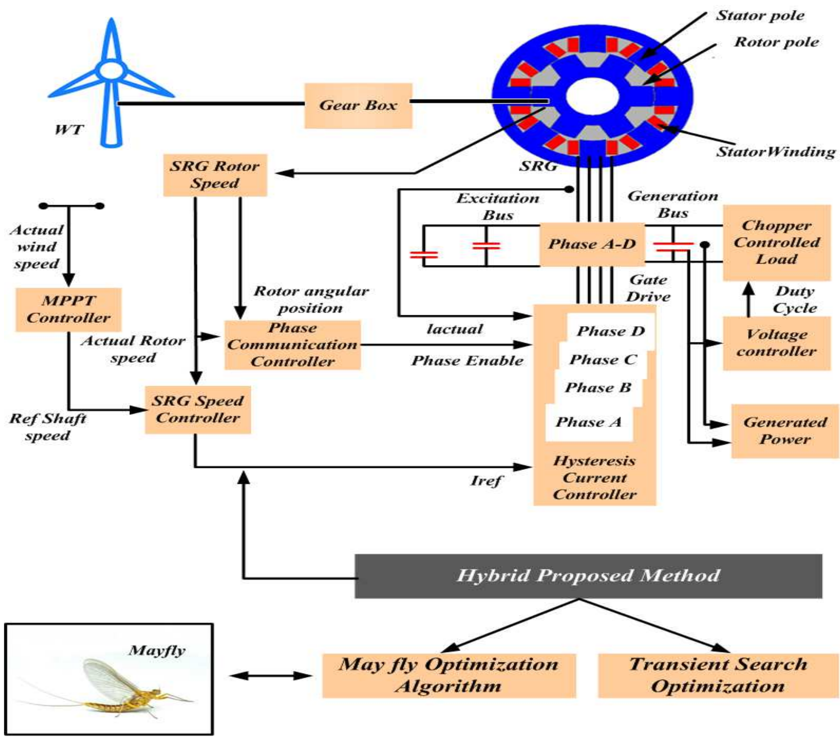

Fig 1: Architecture of WECS based on SRG with proposed method

$$c_p = \frac{p_{WT}}{P_{air}} \tag{2}$$

From the above equation, the power coefficient is expressed as c_p,

Based on the power of turbine, for obtaining the variable speed of WT in MPPT, the power coefficients of ratio of tip speed and pitch angle is restricted. For achieving the MPPT, the maximum rotational speed of WT should be circulated (Namazi et al. 2018)

3.2. Modelling of Wind Power Conversion

Based on the wind turbine obtainable amount of wind energy has been retrieved nearly the overall amount of energy from the wind (Rahmanian et al. 2017). Based on the wind turbine the mechanical power produced which is articulated as follows,

$$P_W = \frac{1}{2}\pi\rho\, c_P(\lambda, \beta) r^2 V^3{}_W \tag{3}$$

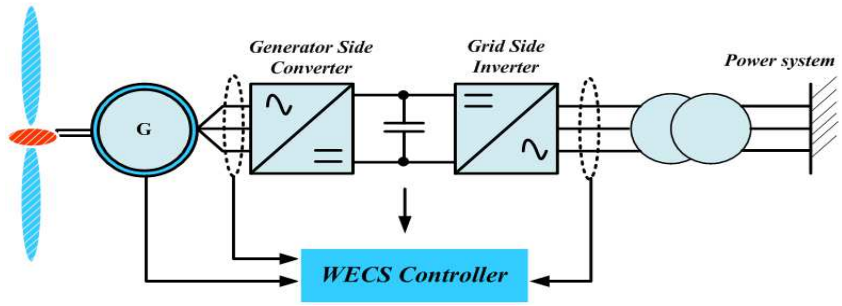

Fig 2: Wind Energy Conversion System

From the above equation, the pitch angle of turbine blade is expressed as β. The recognized fixed value is wind speed, the thickness of the air and the distance of the blade. Fig 2 shows the wind energy conversion system. The system is expressed as c_P. Based on TSP, the WT, power coefficient is expressed as λ. For the power production the productivity of WT was suggested by the power gradient of turbine and it associate the mechanical output of turbine with overall wind power (Barros et al. 2017).

Based on the features of turbine the common equation for the coefficient of wind turbine is expressed as

$$c_p = 0.5176 \left[\frac{116}{\lambda_1} - 0.4\beta - 5 \right] E^{\frac{-21}{\lambda_1}} + 0.00685\,\lambda \tag{4}$$

$$\lambda = \frac{\omega_T r}{v_W} \tag{5}$$

From the above equation, the rotational speed is expressed as ω_T, based on the turbine blades the radius of swept area is expressed as r. Based on the equation (2) and (3), r, v_W and β are regarded as constant. For optimum c_p there must be a particular value of λ in a specified wind speed. The wind system retrieves high potential wind speed and the optimum power output is accessed from the rotational speed (Chen et al. 2020).

3.3. Modelling of Switched Reluctance Generator (SRG)

Attaining specific control system is the one of the challenging task with the development of SRG in WECS. The SRG is described as the salient double pole machine and consists of highest magnetic saturation. According to this phase current and rotor position the parameters of inductance, flux and torque of SRC are considered (Wang et al. 2020). Fig 3 shows the Switched Reluctance Generator. By ignoring the mutual inductance, the required voltage generator is expressed as follows,

$$V = Ri + \frac{D\lambda(i,\theta)}{dt} \tag{6}$$

$$V = Ri + l(i,\theta)\frac{D\lambda}{dt} + E \tag{7}$$

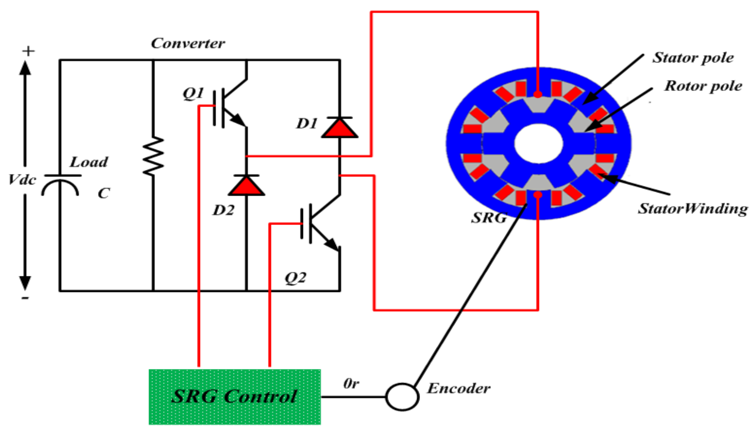

Fig 3: Switched Reluctance Generator

From the above equation, the back EMF of system is expressed as $E = iW\frac{Dl(i,\theta)}{d\theta}$, the winding resistance per phase is expressed as *R*, the rotor speed is denoted as ω and the voltage excitation is expressed as V. Based on the equation (4) there are three categories are presented they are, 1. Voltage drops of phase winding resistance, 2. Phase inductance volatge of reliant angle, 3. Back EMF of SRG. The SRG consists of 8 stator fundamental poles and 6 rotor fundamental poles.

For rising speed and the conditions of rising operating temperature will make the inability of permanent magnet and rotor winding as adaptable (Wang et al. 2020; Kumar et al. 2019; Vijay et al. 2019) The electric power produced is transferred to the system of utility grid (Chen et al. 2019). For particular position of rotor by each phase coil the torque was generated by

$$t = \left| \frac{\delta w_C(i,\theta)}{\delta \theta} \right|_{i=Constant} \tag{8}$$

If magnetic saturation is excluded, the SRG torque may be decreased which is expressed as follows,

$$t = \frac{1}{2} i^2 \frac{Dl(\theta)}{D\theta} \tag{9}$$

For monitoring mode $\frac{Dl(\theta)}{D\theta}$ is positive value and to generate mode it's negative. The unsaturated inductance phase is expressed as l, the summation phases of all torque in the overall torque of the SRG is expressed as follows,

$$t_E = \sum_{i=1}^{n} t_n(\theta, i) \tag{10}$$

From the above equation, the electrical torque of SRG and phase number is expressed as t_E *and n* is positive [38].

4. Proposed Approach of Mayfly Algorithm (MA) and Transient Search Optimization (TSO)

In this section, fast and efficient MPPT in WECS based on optimal hybrid method is presented. An MPPT-based control of switched reluctance generator (SRG) comprising a hybrid metaheuristic algorithm was provided on system. The proposed hybrid method is joint implementation of Mayfly algorithm (MA) and Transient Search Optimization (TSO) named as

Enhanced MATSO Technique (EMATSO). Mayfly Algorithm (MA) is adapted from the flight behavior and the mating process of mayflies, the proposed method integrates huge benefits of swarm intelligence and evolutionary algorithms (Zervoudakis and Tsafarakis 2020). The Transient Search Optimization (TSO) algorithm is adapted using transient behavior of switched electric circuits, which comprise storage components like inductance and capacitance (Qais et al. 2020). The objective aim of proposed method is the reduction of speed error. Here, the search behavior of the MA is adapted by applying the effective TSO algorithm. By applying the MPPT method, the direct axis set point and the current parameters of WECS quadrature axis are observed and depending on generator speed variation, the loss reduction method was observed. The proposed EMATSO method has enhanced the productivity of the WECS with this appropriate control. Figure 4 portrays that flow chart of proposed EMATSO system.

The step by step process of EMATSO is expressed as below,

Step 1: Initialization

In this step, the population of male mayfly $x_i(i = 1,2,...N)$ and *velocities* v_{mi} then initialize the population of female mayfly $y_i(i = 1,2,..M)$ *velocities* v_{fi}

Step 2: Random Generation

After the process of initialization, randomly produce both the male and female may fly

$$rand = \begin{bmatrix} x_1 & x_2 & x_3 & x_n \\ y_1 & y_2 & y_3 & y_4 \end{bmatrix} \tag{11}$$

Step 3: Fitness Function

Based on their velocities of male and female mayfly obtain the best may fly

$$fitness = gBest\ (or)\ PBest \tag{12}$$

Step 4: Crossover and Mutation

The update function was modifying by the Mayfly method for the consequent of the solution can be optimized based on the crossover and mutation operator. A novel solution set, crossover rate is established to create between two individuals.

According to the fitness value the process is accomplished and the individual and new solution is produced. Individuals are mutated randomly at mutation process in light of particular mutation rate. To measure crossover and the mutation rate of mayfly are calculated interns of equations as follows: (13) & (14):

$$X = \frac{N_{gX}}{l_c} \tag{13}$$

$$M = \frac{M_p}{l_c} \tag{14}$$

where, the individual number of crossover is expressed as n_{gX} , mutation point is denoted as m_p and prey length is expressed as l_c

Step 4: New Position Updation using TSA

Based on updating the flight behavior and the mating process of mayflies the new solution was developed. Analyze the optimum and lowest initial population of fitness function. The optimal value is choosen as the best solution. As it is determined from the process,

Step 5: Evaluation

Evaluate the objective functions of particle voltages then find the voltage for lowest objective functions.

Step 7: Termination

Repeat until the lowest error value is achieved or the optimal number of iterations is achieved.

Depending on fitness function the best solution is choosen on termination stage.

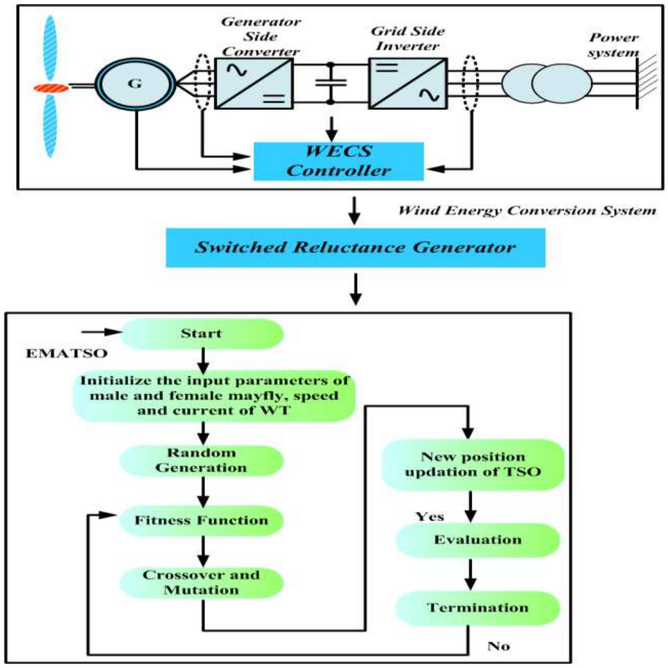

Fig 4: Flowchart of proposed EMATSO method

5. Result and Discussion

This section describes the hybrid strategy to fast and efficient MPPT on WECS with the proposed EMATSO method that has been executed on MATLAB / Simulink working platform. In this operation, the optimum control signal is created using EMATSO controller that has been transformed with MPPT controller of wind generation system as well as for the proposed converter. The efficiency of the proposed system is evaluated depending on PV output, wind energy converter and several control modes and events the system is experimented for verifying their performance. In this section, several case studies are discussed for the proposed system for verifying the simulation outcomes that has been obviously described on next section. Fig 5 shows the proposed analysis of current. In subplot 5 (a) shows the proposed current. Here the current of proposed EMATSO method flows from 0 to 20A at the time period of 0.17sec and at the time period of 0.4 to 0.5sec the flow of current is decreased. In subplot 5 (b) shows the Zoom graph of proposed current. Here the current of proposed EMATSO method flows from 0 to 20A at the time period of 0.17sec and at the time period of 0.4 to 0.5sec the flow of current is decreased. Fig 6 shows the proposed analysis of power. Here the proposed method flows from 0 to 5W at the time period of 0sec then it flow constant at 5W at the time period of 0.02 to 0.2sec. Then the power slightly reduced to 4.5W at the time period of 0.022 to 0.5sec then at the time period of 0.4 to 0.5sec the flow of power is increased. Fig 7 shows the proposed analysis of voltage. In subplot 7 (a) shows the proposed volatge. Here the voltage of proposed EMATSO method flows from 0 to -4000V at 0 sec time interval and at 0.4 to 0.5sec time interval the flow of voltage is increased up to 4000V. In subplot 7 (b) shows the Zoom graph of proposed volatge. Here the voltage of proposed EMATSO method flows from 0.4 to -4000V at the time period of 0.17sec and at the time period of 0.4 to 0.5sec the flow of voltage is increased. Fig 8 shows the proposed analysis of grid current. In subplot 8 (a) shows the proposed grid current. Here the grid current of proposed EMATSO method flows from 0 to -4000V at 0 sec and 0.4 to 0.5sec time interval the flow of grid current is increased up to 4000V. In subplot 8 (b) shows the Zoom graph of proposed grid current. Here the grid current of proposed EMATSO method flows from 0.4 to -4000V at the time period of 0.17sec and at the time period of 0.4 to 0.5sec the flow of grid current is increased.

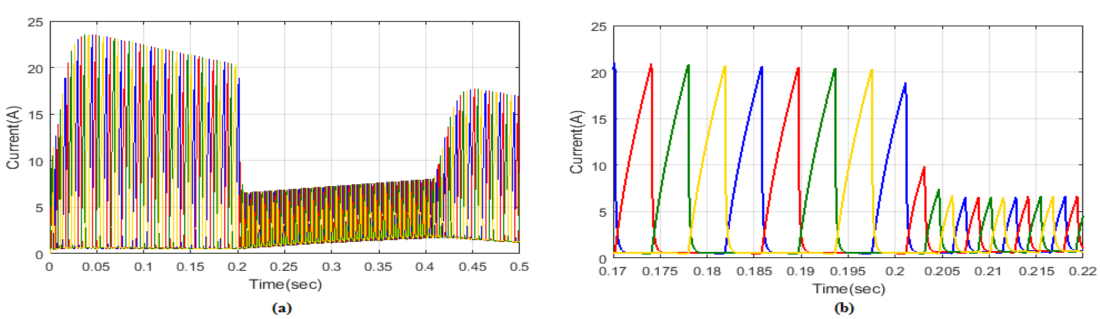

Fig 5: Proposed analysis of (a) Current (b) Current Zoom

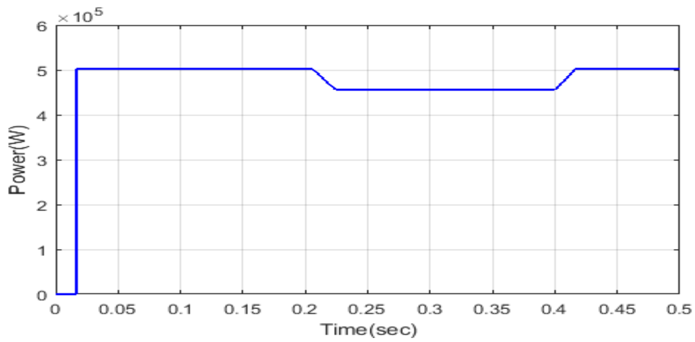

Fig 6: Proposed analysis of power

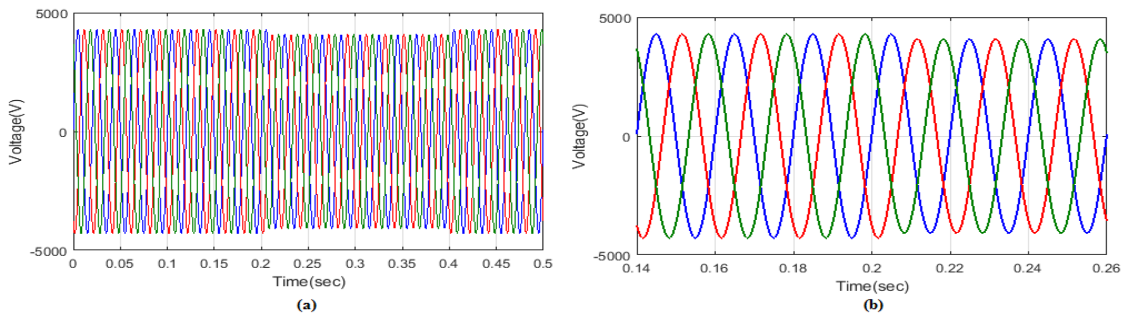

Fig 7: Proposed analysis of (a) Volatge (b) Voltage Zoom

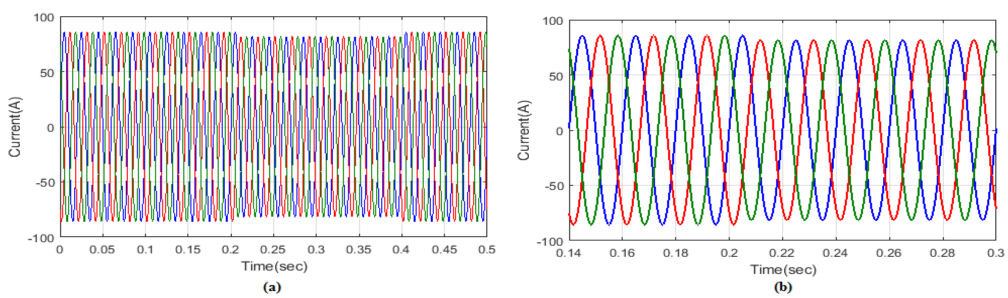

Fig 8: Proposed analysis of (a) Grid current (b) Grid current Zoom

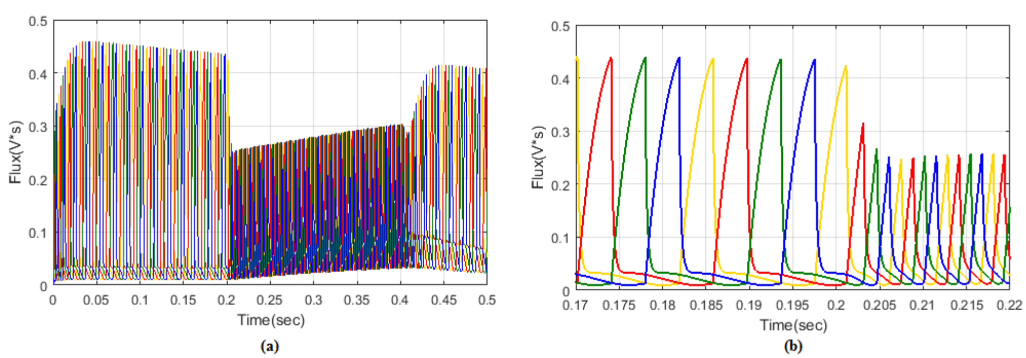

Fig 9: Proposed analysis of (a) Flux (b) Flux Zoom

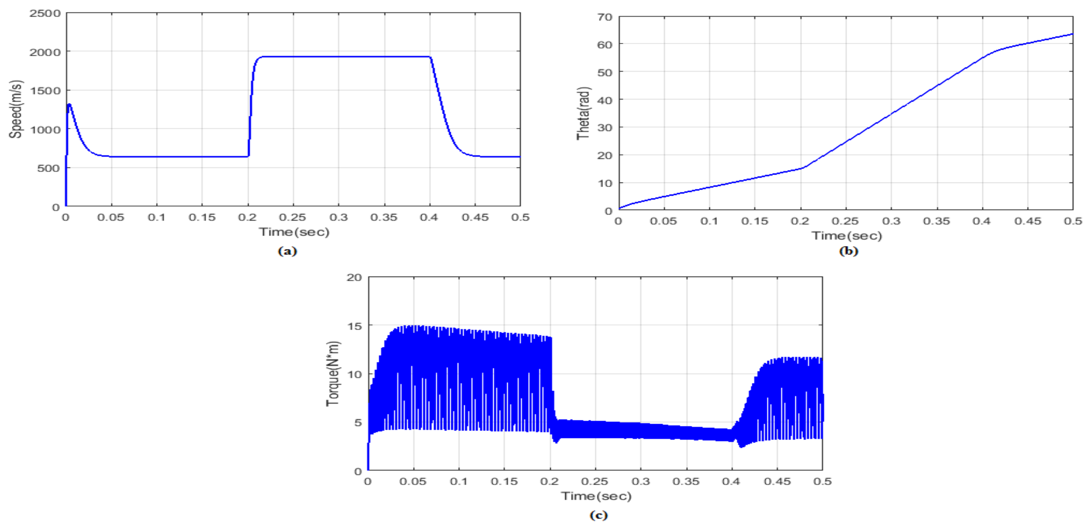

Fig 10: Proposed analysis of (a) Speed (b) Theta (c) Torque

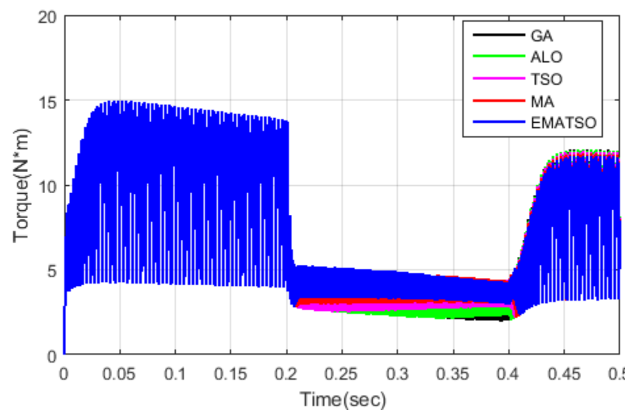

Fig 11: Torque comparison of proposed and existing technique

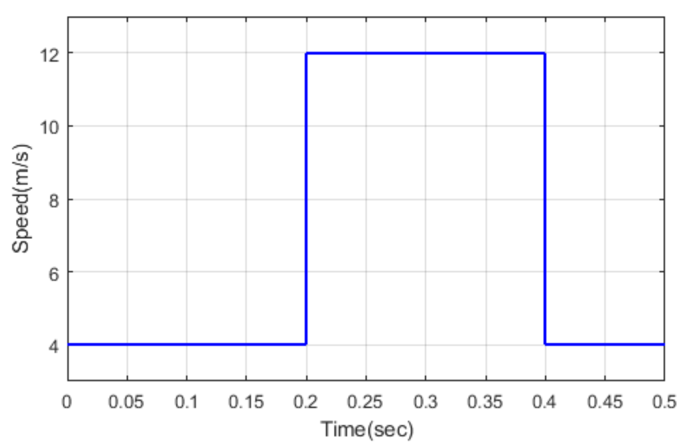

Fig 12: Proposed analysis of reference speed

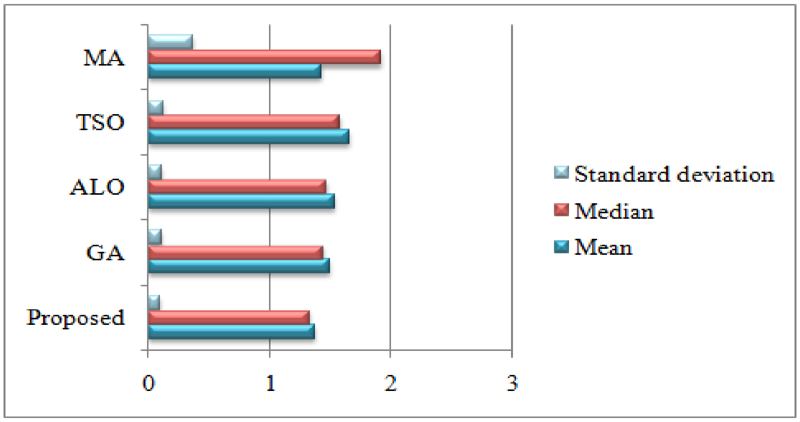

Fig 13: Statistic analysis of proposed and existing system

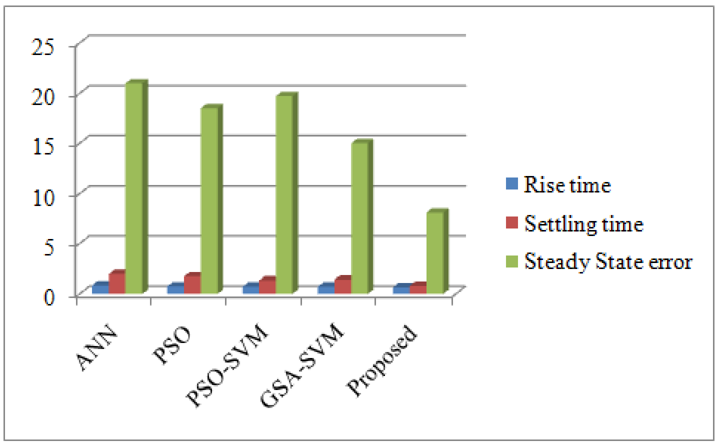

Fig 14: Comparison of time domain parameters of proposed and existing system

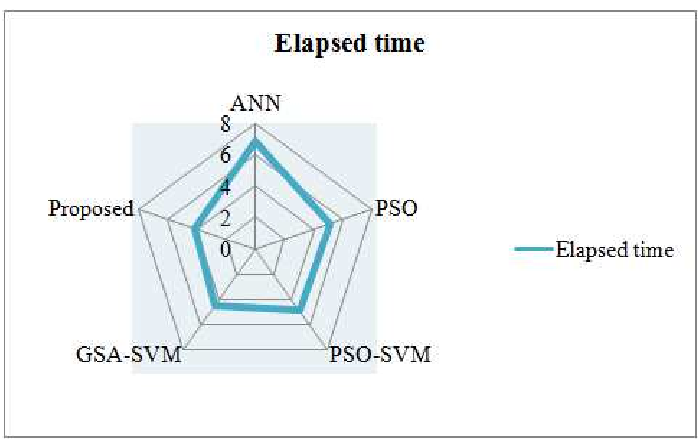

Fig 15: Elapsed time of proposed and existing technique

Fig 9 shows the proposed performance of flux. In subplot 9 (a) shows the proposed flux. Here the flux of proposed EMATSO method flows from 0 to 20A at the time period of 0.17sec and at the time period of 0.4 to 0.5sec the flow of flux is decreased. In subplot 9 (b) shows the Zoom graph of proposed flux. Here the flux of proposed EMATSO method flows from 0 to 20A at the time period of 0.17sec and at the time period of 0.4 to 0.5sec the flow of flux is decreased. Fig 10 shows the proposed analysis of speed, theta and torque. In subplot 10(a) shows the proposed analysis of speed. Here the speed flows from 0 to 1300m/s at the time period of 0sec and then it reduced up to 550m/s at the time period of 0.01sec. At the time period of 0.2 the speed of the proposed method increased up to 2000m/s and it remains constant at the time period of 0.2 to 0.4sec. Subplot 10(b) shows the proposed analysis of theta. Here the theta flows from 0 to 65rad at the time period of 0 to 0.5sec. Subplot 10(c) shows the proposed analysis of torque. Here the proposed analysis of torque flows from 0 to 15 N*m at the time period of 0sec then the torque slightly reduced up to 14N*m at the time period of 0.2sec. Then the torque reduced up to 5N*m and remains constant at the time period of 0.2 to 0.4sec then it increased up to 12N*m. Fig 11 illustrates that torque comparison of proposed and existing system. The proposed EMATSO method flows from 0 to 15N*m at the time period of 0sec. The existing method of GA flows from 3 to 7N*m and it increased up to 13N*m. The existing method of ALO flows from 3 to 7N*m and it increased up to 13N*m. The existing method of TSO flows from 3 to 7N*m and it increased up to 13N*m. The existing method of MA flows from 3 to 7N*m and it increased up to 13N*m. Compared with existing method the torque of proposed method is low. Fig 12 portrays that proposed performance of reference speed. Here the speed of proposed method flows from 4m/s and it remains constant at the time period of 0 to 0.2sec then the speed of proposed method increased up to 12m/s and it remains constant at the time period of 0.2 to 0.4sec and then the speed of proposed method decreased up to 4 at 0.4sec time interval and then it leftovers stable until the end. Fig 13 shows the Statistic analysis of proposed and existing system**.** Fig 14 shows the Comparison of time domain parameters of proposed and existing system and Fig 15 shows the Elapsed time of proposed and existing technique.

Table 1: Statistic measures of proposed and existing systems

Solutions	Mean	Median	Standard deviation
Proposed	1.3789	1.3269	0.1004
GA	1.4930	1.4410	0.1132
ALO	1.5334	1.4704	0.1154
TSO	1.6527	1.5802	0.1256
MA	1.4261	1.9161	0.3621

Table 2: Comparison of proposed technique with existing techniques in terms of time domain parameters

Solution Techniques	Time domain parameters		
	Rise time (sec)	Settling time (sec)	Steady state error (volts)
ANN	0.837	1.96	21
PSO	0.751	1.73	18.5
PSO-SVM	0.727	1.33	19.73
GSA-SVM	0.73	1.4	15
Proposed	0.65	0.81	8.1

Table 3: Elapsed time comparison

Solution Techniques	Elapsed time
GA	6.875
ALO	5.112
TSO	4.867
MA	4.5
Proposed	4.12

Table 4: Performance comparison of proposed with existing method for 50 number of trials

Method	Accuracy (%)	Precision (%)	Recall (%)	Specificity (%)
GA	55	52	60	50
ALO	75	72	80	70
TSO	85	82	90	80
MA	90	90	92	90
Proposed	99.76	99.13	98.97	99.06

Table 1 explain the Statistic measures of proposed and existing systems Comparison of proposed technique with existing systems in terms of time domain parameters is shown in Table 2. Comparison of time elapsed is shown in Table 3. Based on the above considerations, the efficiency of the proposed and existing techniques is analyzed by torque and stator flow waves, the time domain parameters and elapsed time obtained by the system drive.

Table 5: Performance comparison of proposed with existing system for 100 trials

Method	**Accuracy (%)**	**Precision (%)**	**Recall (%)**	**Specificity (%)**
GA	60	55	57	53
ALO	70	65	60	63
TSO	80	72	85	75
MA	90	95	80	85
Proposed	99.81	99.25	99.91	99.543

Table 6: Performance comparison of proposed with existing system for 150 trials

Method	**Accuracy (%)**	**Precision (%)**	**Recall (%)**	**Specificity (%)**
GA	78	58	65	56
ALO	78	71	87	71
TSO	78	72	74	87
MA	99	84	86	87
Proposed	99.89	99.82	99.45	99.476

From the evaluations, the effectiveness of proposed system is determined. Efficiency is assessed based on overall performance of the IM drive system powered by QZSI. By using the proposed strategy, the IM drive system powered by QZSI achieves a better speed response with a lower error compared to that of other controllers. From the previous analysis, the performance of the proposed strategy is much higher in all cases by reducing ripples, efficiency and statistical measures

The accuracy, precision, recall and specificity of the proposed method is calibrated via the eqn. (15), (16), (17) and (18)

$$A = \frac{TP^* + TN^*}{TP^* + TN^* + FP^* + FN^*} \tag{15}$$

$$P_{rec}^* = \frac{TP^*}{TP^* + FP^*} \tag{16}$$

$$R_{ca}^* = \frac{TP^*}{TP^* + FN^*} \tag{17}$$

$$S_{pe}^* = \frac{TN^*}{TN^* + FP^*} \tag{18}$$

Furthermore, the performance comparison of the proposed method with the conventional approaches for 50, 100 and 150 numbers of trials table 4,5, 6 The proposed method EMATSO attains the better outcome when compared to existing approaches like GA, ALO, TSO, and MA. So resolve that proposed system provide best result to existing method.

6. Conclusion

In this manuscript presents an efficient hybrid strategy for fast and efficient MPPT on WECS. Here, wind energy is transformed into electric energy through the use of SRG. Based on three-phase inverter and step-up transformer, the electricity generated to the grid is supplied by the SRG. Based on the discrete PWM generator and voltage regulator, the inverter is dominated. Based on the application of proposed methods to gain MPPT, the WT rotational speed is restricted. The proposed systems are replicated on MATLAB environment. The output of the controllers is contrasted and the outcomes establish that EMATSO method may achieve MPPT more efficiently compared to other methods and furthermore, the performance of the proposed method is better to existing methods. The outcomes demonstrate that the dissimilarity among turbine and optimal rotation speed have a direct consequence on absorbed power of the wind turbine and in comparison with several existing systems. By using the proposed hybrid method, the productivity of the WECS is accessed with efficient results. Also, the proposed method is efficient for obtaining optimal solution with less computation and minimizes the complexity of the required algorithm.

Data availability statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Compliance with Ethical Standards

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Author Contribution

Mr. S. Sridharan: Conceptualization, Methodology, Writing- Original draft preparation.
Dr. Vasan Prabhu V: Supervision.

Dr. P. Velmurugan : Supervision.

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