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AN OPTIMIZED DESIGN PARAMETERS FOR PI CONTROLLERS UTILIZED FOR FREQUENCY CONVERSION USING GENETIC ALGORITHM

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ABSTRACT
In order to maximize profits while minimizing negative effects on the environment, the construction of new wind energy projects necessitates the analysis of several aspects. In order to determine the best location for turbines to produce the most energy, an analytical framework using fuzzy logic has been created in this research using Geospatial Information System (GIS). Environmental, physical, and human considerations are the requirements for a good location for energy optimization. The current analysis aids in determining the best locations for Gujarat's wind farms. The study's findings demonstrate the potential of wind turbine development in Gujarat's western regions. The proposed model might be used to choose the location of the wind turbine in the future, which could then be of energy planners and decision makers. This paper attempts to optimally design the parameters of the PI controllers used in the frequency converter of a variable speed wind energy conversion system (WECS). The optimization of the controller parameters can be obtained by using GAs.
Keywords: genetic algorithms (GAs), permanent magnet synchronous generator (PMSG), wind energy conversion system (WECS).

INTRODUCTION
Now Because of the world's uneven distribution of temperature and pressure, wind is a natural occurrence. Based on the topographical features, the wind can have a variety of speeds and directions. The fundamental worry for many nations is the dependence on fossil fuels, which is reduced by the implementation of new energy sources from renewable power. The enormous potential of renewable energy to lower CO2 emissions and so safeguard the environment is another significant contribution. Wind energy is one of the most well-known sources of energy among the different renewable ones.
India now has a total of 26.9 GW of grid-interactive or grid-tied renewable energy capacity (excluding large hydro), of which 68.9% originates from wind and about 4.59% of the Renewable Energy installed capacity in India.
Table 1 below shows the renewable energy technologies' in respect of capacity in India. Wind energy, like many other renewable energy resources, does not release any atmospheric emissions while generating power but at the same time there are some negative impacts to both the society and ecology. Many researchers have been working on various aspects of wind energy for more economic benefits, site selection procedures, environmental impacts, etc. Evaluation of wind energy systems

Table 1. Renewable energy technologies' respective capacity in India

Source	Total Installed Capacity (MW)
Wind Power	19779.15
Solar Power (SPV)	1968.84
Small Hydro Power	3711.75
Biomass Power	1264.80
Bagasse Cogeneration	2337.43
Waste to Power	99.08

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Total	29161.05

aspects of a particular area. The present study aimed to analyse all aspects related to wind energy system of Gujarat state, India. The State of Gujarat has the longest coast line in the country. Inland wind sites have an estimated potential of over 10,000 MW of Power. In India the wind generation capacity until April 2013 has reached about 3.11 GW [3]. 15 wind farm locations are shown in Table 2, most of which are located in western part of Gujarat. Over a period of 25 years, more than 65 sites have been monitored for wind speed and wind power density, out of which over 50 sites have been found feasible for harnessing the Wind Power by Gujarat Energy Development Agency (GEDA).
To evaluate the site suitability for wind turbines, the framework predictions are based on human, physical and environmental factors that influence the placement. For example, human factors are based on the proximity to development, public recreational area and agricultural land; physical factors are based on the wind resource and the proximity to sub-station and terrain, and the environmental factors depend on the land use, vegetation, wetlands, national parks etc.

Objective

Here we studied wind farm of Bhuj located at gujrat state where A 54-MW wind farm consisting 34 of 1.5 MW wind turbines connected to a 25-kV distribution system exports power to a grid through feeder. A load is connected on the same feeder at bus. Both the wind turbine and the load have a protection system monitoring voltage, current and machine speed. The DC link voltage of the PMSG is also monitored.
Wind turbines use a PMSG and an AC/DC/AC IGBT-based PWM converter control by genetic algorithm. The stator winding is connected directly to the 50 Hz grid while the rotor is fed at variable frequency through the AC/DC/AC converter. The PMSG technology allows extracting maximum energy from the wind for low wind speeds by optimizing the turbine speed, while minimizing mechanical stresses on the turbine during gusts of wind. Another advantage of the PMSG technology is the ability for power electronic converters to generate or absorb reactive power, thus eliminating the need for installing capacitor banks as in the case of squirrel-cage induction generators.

LITERATURE REVIEW

An Raimon Bawazir; Numan Çetin; Mustafa Mosbah; Karim Sebaa,‖ Genetic Algorithm for Improving Voltage Stability by Optimal Integration of Wind Source‖, :IEEE 2020 International Conference on Electrical Engineering (ICEE) To modernize the electrical network, it is important to integrate the Distributed-Generation (DG)-based on wind energy sources. Such a source has already become necessary due to the limited availability of fossil fuels and the tendency to use clean energy. This work is focused on the study of the optimal integration of Wind Turbines (WT-DG) which takes into account the system constraints. This is achieved by searching for the optimal sites and sizes of WT-DGs for maximize voltage stability using a Genetic Algorithm (GA). The study is performed on the standard 30-bus modified power network using MATLAB code. The simulated results prove the voltage stability improved and power loss reduced as long as the number of WT-DGs increased in the network.
Veeresh. S. Gonal; G. S. Sheshadri,‖ Modified Genetic Algorithm for Optimization of Wind Energy Based Grid Connected System‖.IEEE 2018 4th International Conference for Convergence in Technology (I2CT)
Energy is considered as a vital source for financial with social growth activities. It is one amongst fast utilization in commerce, cultivation of domestic activities effectively. This further increases the demand remarkably. It will increase the energy rate. These sources of energy are reliant on climatic circumstances gap that presents in output features like environmental parameters. This suggests improvement of power approaches and plans that are used in the energy system of wind. The wind-turbine process, stability, control techniques, Power Quality (PQ) difficulties are the main concerns for wind farms. Accordingly, previous research proposed optimization techniques and controller to enhance wind energy system by PSO, Genetic Algorithm (GA) etc. This category of GA has many problems like very low convergence and great

computational time. In this paper, the optimization is carried out by Modified Genetic Algorithm (MGA) for grid tied wind energy system. MGA delivers a better Total Harmonic Distortion (THD) and reduces the time of computation and the obtained results are compared with GA, fuzzy logic control using MATLAB Simulink Hessam Kazari; Hashem Oraee; Bikash C. Pal,‖ Assessing the Effect of Wind Farm Layout on Energy Storage Requirement for Power Fluctuation Mitigation‖, IEEE Transactions on Sustainable Energy (Volume: 10, Issue: 2, April 2019)Page(s): 558 – 568 Optimization of wind farm (WF) layout has been studied in the literature with the objective of maximizing the wind energy capture. Based on the power spectrum density theorem, this paper shows that the WF layout affects not only the total harvested energy but also the level of power fluctuation, which, in turn, influences required capacity of battery energy storage system (BESS) needed to mitigate the inherent power fluctuation of the WFs. Since, both harvested energy level and BESS capacity directly influence the profit of WF owner, the effect of WF layout on these quantities is taken into account simultaneously, and WF layout optimization problem is redefined. Genetic algorithm is then employed in order to optimize the resulting objective function. The proposed method and optimization process are performed on the layout of an actual offshore WF using real wind data. Anew index is introduced to quantify the power fluctuations, and energy curtailment is assessed. The comparative analysis between the actual layout performance and the optimal layout in different scenarios is conducted, showing the reduction of power fluctuations and improvement of energy curtailment. In addition, different BESS technologies have been analyzed to study the impact of their parameters on the optimization results.

Lei Liu; Tomonobu Senjyu; Takeyoshi Kato; Paras Manda,‖ Renewable Energy Power System Frequency Control by using PID controller and Genetic Algorithm‖, 2020 12th IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC)

This work proposed a frequency control approach in a hybrid power system, which include Wind Generation(WG), Photovoltaic Generation(PV), Diesel Generation and storage battery. Proportional Integral Derivative(PID) controller was designed for the blade pitch system of wind turbine to improve the system dynamic performance. In addition, to minimize the oscillation of system, (Super-conducting Magnetic Energy Storage(SMES) with first order lead-lag controller was implemented, it would supply and absorb active power quickly to reach power generation/demand balance and thereby control system frequency. Minimization issues of frequency and wind output power deviations are considered as two objective function of PID controller of wind turbine. Also, frequency and diesel output power deviations are present as two objective functions of lead-lag controller of SMES. modified version of Non-dominated Sorting Genetic Algorithm(NSGA-II), was used to tune the parameters of controller. The robustness and effectiveness of the proposed /Simulink ® method was verified by simulation using Matlab ® . From simulation results we examined the ability of the controllers to damp all frequency and output powers fluctuations and enhance the stability and reliability of system

Mei Hongkun; Fu Jun; Jia Chunjuan,‖ Optimization of Grid - Connected Wind - Storage Capacity Based on Adaptive Genetic Algorithm‖, IEEE,2018 China International Conference on Electricity Distribution (CICED) Grid-connected wind power will bring a series of interference to the power system. How to allocate the wind-storage capacity reasonably in the grid-connected wind-storage power generation system, so as to reduce the power fluctuation, is the key link in the design of wind -storage power generation system. The wind and storage power are modeled jointly. We adopt the adaptive genetic algorithm, and the improved charging and discharging strategy of energy storage device. Taking the number of fans and batteries as the decision variables, and the probability of fluctuation over limit as the objective function, considering of battery charge and discharge as constraint function, we can quickly get the capacity configuration, and a year of real-time wind power data shows that the program feasible

Meryeme Azaroual; Mohammed Ouassaid; Mohamed Maaroufi ,‖Optimal Control for Energy Dispatch of A Smart Grid Tied PV- Wind-Battery Hybrid Power System‖, IEEE, 2019 Third International Conference on Intelligent Computing in Data Sciences (ICDS) The aim of this paper is to develop an optimal control (OC) for energy scheduling of a grid-connected photovoltaic (PV)-wind turbine (WT)-battery storage system. The objective of the model is to reduce the electricity cost and maximizing the sale of electricity to the grid. The time-of-use (TOU) electricity tariff is evaluated in the optimal control computation. Two optimization methods involving `Linear Programming (LP)' and `Genetic algorithm (GA)' techniques are used to solve this problem. A case study is performed based on an industrial load and the simulation results demonstrate that the developed control reduces the operational cost of the studied system and the customers can receive an important income from the renewable energy sale. In addition, the simulation results demonstrate that using the LP based OC, a significant cost and energy savings can be attained when compared with using the GA.

Hazem Fathy Mohamed; Naggar Hassan Saad; Khaled Abdel Aty Salah Eldin ,‖Moderation of Voltage Sag and Swell in Grid Connected Wind Energy Based PMSG by DSTATCOM‖.IEEE, 2018 Twentieth International Middle East Power Systems Conference (MEPCON) Integrating wind power into existing power system presents technical challenges, which requires the consideration of voltage and frequency regulation and stability. In this paper, a control strategy for grid voltage control using distribution static compensator (DSTATCOM) with an advanced technique genetic algorithm for setting the best values of tuning gains PI controller has been proposed. The control of DSTATCOM is proposed for enhancing the voltage in the wind energy based on Permanent Magnet Synchronous Generator (PMSG) grid connected system. The power flow has also been regulated. The power quality of the grid connected wind energy system has been improved using DSTATCOM. The system is implemented in Matlab/Simulink and the results verify the excellent response of the different dynamic changed of the system and improve their dynamic response.

Alireza Askarzadeh,‖A Memory-Based Genetic Algorithm for Optimization of Power Generation in a Microgrid,‖, IEEE IEEE Transactions on Sustainable Energy (Volume: 9, Issue: 3, July 2018)

In smart grids, one of the most important objectives is the ability to improve the grid's situational awareness and allow for fast- acting changes in power generation. In such systems, an energy management system should gather all the needed information, solve an optimization problem, and communicate back to each distributed energy resource (DER) its correct allocation of energy. This paper proposes a memory-based genetic algorithm (MGA) that optimally shares the power generation task among a number of DERs. The MGA is utilized for minimization of the energy production cost in the smart grid framework. It shares optimally the power generation in a microgrid including wind plants, photovoltaic plants, and a combined heat and power system. In order to evaluate the performance of the proposed approach, the results obtained by the MGA are compared with the results found by a genetic algorithm and two variants of particle swarm optimization. Simulation results accentuate the superiority of the proposed MGA technique.

Bhavya Bhardwaj; J Jaiharie; R Sorabh Dadhich; Syed Ishtiyaq Ahmed; M Ganesan,‖ Windfarm optimization using Nelder-Mead and Particle Swarm optimization‖, IEEE, 2021 7th International Conference on Electrical Energy Systems (ICEES) Wind energy is a source of green and clean energy and has become the focus of environmentalists across the globe. As companies and governments invest and expand on wind farms it becomes crucial to implement ways to optimize its layout. Wind farms are generally plagued by the wake effect which causes reduced output and can affect the generation capacity and profits of a company. As wind farms can have up to hundreds of turbines, the problem of optimizing its performance to reap maximum energy with minimum area arises. With the goal of solving this problem, this paper suggests the combined use of genetic algorithm, Particle Swarm optimization (PSO) and Nelder-Mead Simplex Method for optimization. This approach uses genetic algorithm for greedy search, and PSO and NelderMead for local and fine search. The approach as will be seen in subsequent sections can help improve the annual production by 4-7%. The wake effect considered in the optimization problem is calculated using the Jensen's model. Final result obtained for a windfarm of dimension 4000x4000 m2 and 50 turbines to have an AEP of ry 526GWh improved from 505GWh. Isaac Kofi Otchere; Kwabena Amoako Kyeremeh; Emmanuel Asuming Frimpong,‖ Adaptive PI-GA Based Technique for Automatic Generation Control with Renewable Energy Integration‖, IEEE, 2020 IEEE PES/IAS Power Africa To enhance the reliability of the power system, conventional power grid requires a robust automatic generation control system to maintain the balance between generation and demand. However, high penetration of renewable energy such as photovoltaic and wind energy to the power grid requires a flexible control technique to maintain the stability of the power system. This paper presents an adaptive proportional-integral (PI) based genetic algorithm (GA) controller for a two-area non-reheat thermal plant coupled with renewable energy sources (RES). The test system is simulated in a MATLAB/Simulink environment. Test results of the proposed technique shows an improved performance with zero frequency deviation and less settling time after a load disturbance. PI based particle swarm optimization control is used as a benchmark.

R. Bakshl ,‖Wind energy-the Indian scenario‖, IEEE 2002 IEEE Power Engineering Society Winter Meeting. Conference Proceedings Summary form only given as follows. In India, grid connected wind power generation has now gained a high level of attention and acceptability as compared to other renewable technologies available in the country. Wind energy installation in the country is around 1340 MW as on March 31, 2001 and around 6.75 billion units of electricity have been fed to the state grids so far. India has undertaken one of the world's largest efforts for wind resource assessment, a programme that covers 25 states comprising about 900 stations. The study has indicated a gross wind potential of around 45000 MW and the technical potential is currently estimated at 13000 MW. A notable feature of the Indian wind energy programme has been the interest evinced by private investors/developers in setting up of commercial wind power Santanu Paul; Akshay K. Ahirwar; Zakir H. Rather,‖ Optimal and Economic Cable Connection for 1 GW Offshore Wind Farm Project Near the Gujarat Coast in India IEEE : 2020 IEEE International Conference on Power Electronics, Drives and Energy Systems (PEDES)

Wind generation in India is an up-rising power sector in recent times, which is nearly 10% of its total installed generation capacity. India is also exploring the potential of offshore wind energy near the coastal area of Gujarat. This paper presents an optimal and economic methodology to connect wind turbines (WTs) of 1 GW offshore wind farm (OWF) to be constructed near the Gujarat coast. The OWF consists of 500 WTs, with each having capacity of 2 MW. A segment of the proposed layout (about 25% of the total capacity) of the OWF has been identified for this study. Sweep algorithm is used to determine an appropriate number of WT clusters, followed by optimal cabling by minimizing the length of submarine cables of each WT cluster using Clarke and Wright saving algorithm. Each WT cluster is connected to an offshore substation (OS). The optimal placement of OS for the segment of OWF has been determined considering the lowest capital cost for the submarine cable in this study

METHODOLOGY

The study area is of Gujarat state located on the western Table 2. The table shows the wind generation capacity until 2011 and per annum capacity of single wind turbine part of India between 20˚N - 24˚N, to 68˚E - 74˚E in Figure 1 as obtained from GEDA. The area nearly covers 196024 sq. km with 26 districts . In this area, wetland covers 2113.86 sq. km, agriculture 93967.60 sq. km, urban land 1981.85 sq. km etc. The western part of Gujarat has 1915.29 km long coastline covering the Arabian Sea . The elevation is between 0 to 1050 m. The wind potential for Gujarat state is shown in Figure 2 as obtained from United Nation Development Program (UNDP) Wind Zone map as of 2006 As can be seen from Figure 2 the eastern part has less wind energy potential as compared to the western part

Table 2. Renewable energy technologies' wind farm capacity in Gujrat in respective areas .

Code no	Name of the wind farm location	No of Turbine	Installed Capacity	MW/ Turbine
1	Bhuj	34 turbines	51 MW	1.50
2	Badi	5 turbines	4 MW	0.80
3	Umrala	31 turbines	25 MW	0.80
4	Suthri	2 turbine	10 MW	5.00

5	Ratdi	1 turbine	1 MW	1.00
6	Rajkot	35 turbines	53 MW	1.51
7	Navagam	12 turbine	10 MW	0.83
8	Kutch	2 turbines	2 MW	1.00
9	Kandla	10 turbines	21 mW	2.10
10	Bhavnagar	4 turbines	5 MW	1.25
11	Visavadar	2 turbines	5 MW	1.00
12	Bhogat	7 turbines	9 MW	1.28
13	Shikarpur	1 turbine	2 MW	2.00
14	Jamnagar & Rajkot	12 turbines	10 MW	0.83
15	Lathedi	6 turbines	9 MW	1.50

GENETIC ALGORITHM

Genetic Algorithm (GA) is search and optimization method based on natural evolution. It consists on a population of bit strings transformed by three genetic operators: Selection, crossover and mutation. Each string (chromosome) represents a possible solution for the problem being optimized and each bit (or group of bits), represents a value for some variable of the problem (gene). These solutions are classified by a evaluation function, giving better values, or fittest, to better solutions The genetic algorithms start with randomly chosen parent chromosomes from the search space to create a population. They work with chromosome genotype. The population ―evolves‖ towards the better chromosomes by applying genetic operators modeling the genetic processes occurring in the nature—selection, recombination and mutation. Selection compares the chromosomes in the population aiming to choose these, which will take part in the reproduction process. The selection occurs with a given probability on the base of fitness functions. The fitness function plays a role of the environment to distinguish between good and bad solutions. The recombination is carried out after selection process is finished. It combines, with predefined probability, the features of two selected parent chromosomes forming similar children. After recombination offspring undergoes to mutation. Generally, the mutation refers to the creation of a new chromosome from one and only one individual with predefined probability. After three operators are carried the offspring is inserted into the population, replacing the parent chromosomes in which they were derived from, producing a new generation. This cycle is performed until the optimization criterion is met

Essential to the SGA’s working is a population of binary strings. Each string of Os and Is is the encoded version of a solution to the optimisation problem. Using genetic operators - crossover and mutation - the algorithm creates the subsequent generation fromthe strings of the current population. The generational cycle is repeated until a desired termination criterion is reached (for example, a predetermined number of generations are processed). summarises the working of the SGA, which has the following components:mA population of binary strings ii. Control parameters iii. A fitness function iv. Genetic operators (crossover and mutation) v. Aselection mechanism, and vi. A mechanism to encode the solutions as binary strings.

Flow Chart of SGA

```
Simple Genetic Algorithm ()
{
Initialise population;evaluate population;
{
select solutions for next population;perform crossover and mutation; evaluate population;
}
} while termination criterion not reached
```

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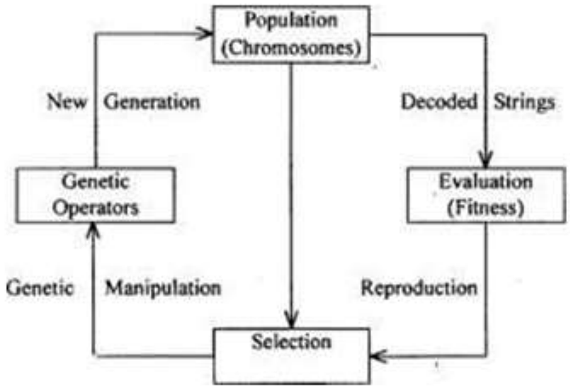

Fig. 2 GA Structure

MODELINGANDCONTROLOFFREQUENCY CONTROL

The schematic diagram of VSWT-PMSG topology used in this paper is shown in Fig. 4. The frequency converter consists of a generator-side ac/dc converter, a dc-link capacitor, and a grid-side dc/ac inverter. Three-level (3L) neutral-point clamped (NPC)topologyisused for boththe converter and inverter, as shown in Fig. 4.

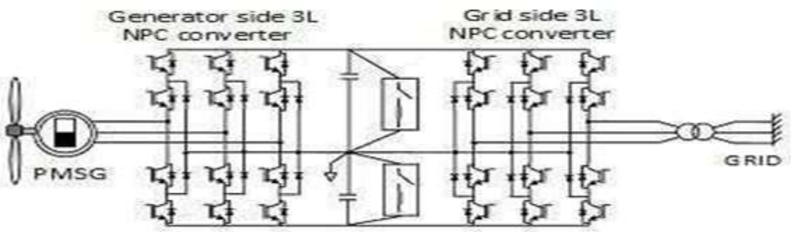

Fig. 3 Schematic diagram of VSWT-PMSG

For both generator-side ac/dc converter and grid-side dc/ac inverter the well-known cascaded control is used. The insulated gatebipolartransistor(IGBT) switchingtablefor 3L NPC-based voltage source converter/inverter is shown below in TableI.

Table I IGBT switching table

V_{out}	+Vdc	0	-Vdc
SW1	1	0	0
SW2	1	1	0
SW3	0	1	1
SW4	0	0	1

The gate signal generation scheme for the IGBT devices used in converter/inverter is shown in Fig. 5. The carrier frequency for an inverter is chosen 1050 Hz. The reference value of the controller shown in Fig. 5 is determined from the cascaded control.

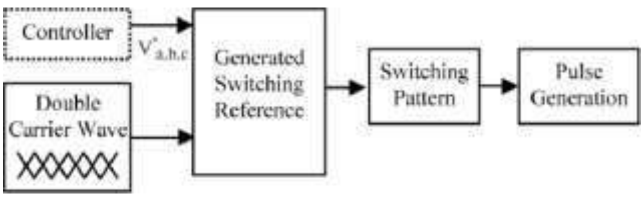

Fig. 4 Gate signal generation scheme

The generator-side converter ensures the maximum power point tracking control along with unity power factor operation at the generating side. The grid-side inverter controls the dc-link voltage and maintains the voltage of the grid side as well, at the desired level set by the network operator. In this study, as the fault-ride-through of VSWT-PMSG is emphasized, the control of the grid-side inverter

CONCLUSIONS

The In this, the wind energy system is modeled using MATLAB Simulink. to present an approach to optimally determine the controller parameters which control, in general, the switching of the frequency converter used in VSWT-driven PMSG to wind farm grid code. GA techniques are proposed to determine the controller parameters, in a precise way. The parameters even worked well for the unsymmetrical fault condition. It should be noted that, GAs- capability of the wind farm. The optimum design procedure can be applied to other inverter/converter topology used widely in variable speed wind energy conversion systems

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