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# Review of Optimization Techniques for Integrated Hybrid Distribution Generation

**Srikanth Goud.B, B. Loveswara Rao**

***Abstract*: Non-Conventional energy sources are predominantly used in generation of power as there is no fuel cost, pollution free and low maintenance. Among various resources available PV and wind are most important sources due to its availability and easy to convert into electrical energy. A rapid increase of photovoltaic power generators and wind turbines are designed and many installations took place in recent years. Developments of countries are depended on electricity and it is becoming harder to generate from conventional sources and they become extinct in recent years. This can be resolved by substantial increase of generation of power from renewable energy sources. Sources are intermittent in nature due to which there are some problems like Maximum Power Extraction during Generation, mitigation of undesirable constraints in Distribution (Demand Side)and protection of multiple DG systems connected grid, with the use of latest passive techniques to work at balanced islanding. To resolve these problems one has to use intelligent algorithms for better accuracy and efficiency. We mainly focused in literature about various MPPT techniques and problems raised during Integration under various conditions.***

***Index Terms*: Grid Integration, MPPT techniques, Optimization Techniques, Power Quality-UPQC**

## I. INTRODUCTION

In contrast to fulfill the huge requirement of electrical energy usage of fossils fuels is becoming more and they become extinct in next coming years as they are conventional in nature and also keeping in view of pollution and global warming Non-Conventional energy sources are used. These sources are intermittent in nature and once installed and maintained properly then life span can be increased. [1-4]

Generation of power from Photovoltaic and Wind has been significantly raised due its availability in nature. Inputs to PV system are solar irradiance and temperature whereas in Wind it depends on speed and air condition [5].Non-conventional energy sources are intermittent in nature which produce uncertainties in voltages in order to overcome from these uncertainties we adopt various converters from power electronics devices and control techniques which are discussed[6-7]forms a system and which are operated by generating duty pulses by various MPPT methods to extract maximum power from these energy sources[8].In literature many number of MPPT techniques like Incremental conductance, Perturb and Observe[9-13] were implemented to derive maximum power. Now we would like to implement Particle swarm optimization, Cuckoo Search were used to derive Maximum power from these sources have their own advantages and limitations. Apart from this we have many other constraints like power quality issues like sag ,swell, reactive power, total harmonics distortions harmonics etc., at distribution side can be by proposed distributed generator connected three phase multilevel for photovoltaic which reduces filtering requirements and enables to use transformer less interface with the grid.BBO technique is used to evaluate switching angles for the inverter at each modulation to reduce to total harmonic distortions in output voltage. In literature survey many methods have been adopted to improve power quality such as Z source inverter, DVR, STATCOM modes [14].

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## II. MODELING CIRCUIT OF PV SYSTEM

### A. Standalone Photovoltaic System:

Standalone PV systems are mainly used to operate independently so they are called direct coupled systems. During Sunlight only the energy absorbed by the PV panels are directly converted in electrical energy and can be directly fed to DC fans , solar heaters, Solar pumps etc. This system does not contain any storage unit like battery [13].

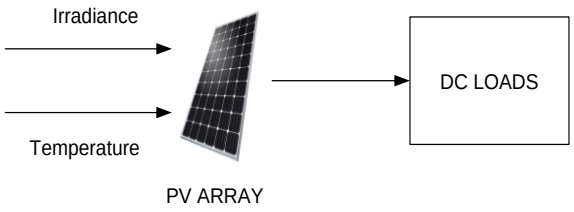


Fig. 1 Standalone PV system

### B. Modeling of Grid Connected PV with MPPT controller

Solar energy plays a vital role in conversion of energy coming in form of solar radiations into Electrical energy. This conversion is possible by using Special Devices called Photovoltaic panels. The inputs are irradiance and temperature in such a way that if irradiance gradually increased then the current also increased but voltage variation is very low. If temperature gradually increased open circuit voltage decreased while if the intensity of solar radiation increased, short circuit current increased.

The generated power depends on the nature of load connected because they are intermittent in nature. The output of PV panel cannot be directly connected to load as they continuously fluctuate. In order to track voltages and currents continuously we adopt MPPT Techniques to derive maximum power and thus generate duty pulses to the power electronics Converters and higher efficiency can be obtained [22-23].

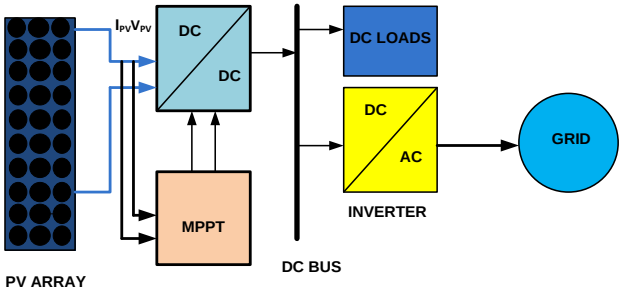


Fig. 2 Grid Connected Photovoltaic

In this system a group of cells are connected in series together in such a way that whenever the inputs solar irradiance and Temperature falls on PV panel some current is generated and it can be taken as light generated current $I_{gc.}$ Generally the equivalent circuit consists of current source in shunt with Diode, as solar cell is not ideal so we connect a parallel resistor and series resistor as shown in figure. Applying Kirchhoff's law $I_{PV}$ is obtained as follows [13-15].

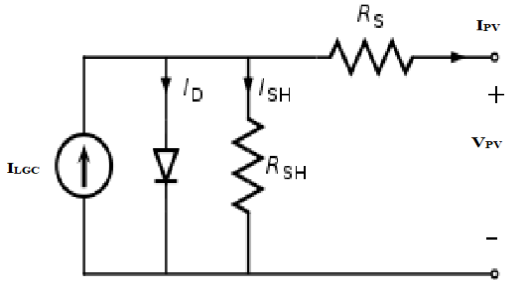


Fig. 3 Solar Cell Circuit

$$I_{PV} = I_{LGC} - I_D - I_{SH} \quad (1)$$

Where

$I_{LGC} = light\ generated\ current$

$I_D = diode\ current$

$I_{PV} = photo\ voltaic\ curret$

$I_{SH} = shunt\ current$

$V_j = V + I_{PV}R_S$

$V_{PV} = voltage\ across\ output\ terminals$

$V_J = voltage\ acrossboth\ diose\ and\ resistor\ Rsh\ (V)$

$I_{PH} = output\ current(A)$

$R_S = seires\ resistance$

$$I_D = I_O\{\exp\left[\frac{V_J}{nV_T}\right] - 1\}$$

$I_O = reverse\ saturation\ current$

$n = diode\ density\ factor$

$K = Boltzman's\ constant$

$T = absolute\ temperature$

$V_T = KT/q$

By Ohm's Law

$$I_{SH} = \frac{V_J}{R_{SH}}$$

$$I_{PV} = I_L - I_O\left\{\exp\left[\frac{V + I_{RS}}{nV_T}\right] - 1\right\} - \frac{V_J}{R_{SH}}$$

$$I_{PV} = I_L - I_O\left\{\exp\left[\frac{V + I_{RS}}{nV_T}\right] - 1\right\} - \frac{V + I_{RS}}{R_{SH}}$$

### C. Grid Connected Wind with MPPT

Wind is also an important type of renewable energy source which is a form of solar energy produced due to heavy blown of hot airs. Generally Wind energy is in form of kinetic energy which converts into mechanical energy using turbines and then into electrical energy using generators. The inputs to the Wind Turbine are wind speed and air condition. Commonly used Wind generators are DFIG and SCIG.

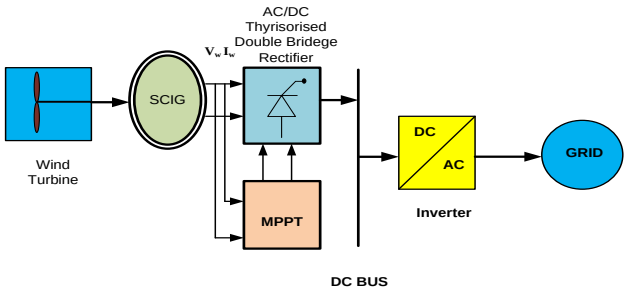


Fig. 4 Block Daigram of Wind Energy

Generally the output power from the wind turbine system is given by:

$$P_m = \rho A\frac{1}{2}V_{wind}{}^3C_P(\lambda,\beta)$$

Where, $C_p$ is cofficient of Power , $\lambda$ tip speed ratio

## III. WIND TURBINE GENERATOR

### A. DFIG

DFIG i.e., doubly fed induction generator, the rotor winding is connected to converter with slip ring and stator winding to the grid line respectively. The used system here is well known as the generator utilization for the wind turbine type, of variable speed. It is so due to the handling work of power electronic converter of about a fraction (20%-30%) of power total. This is far better when compared to the total power handling, as the losses in power electronic converter is reduced, additionally the converter cost can be reduced. We also see a variant method of the generator which uses controllable rotor's external other resistances.

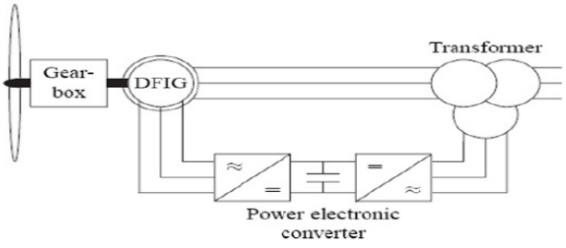


Fig. 5Turbine with variable-speed using double feed Induction Generator.


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There's a disadvantage with the kind of method used, that the energy often dissipates at the rotor resistances external. And also it is difficult in controlling the reactive power. In cell the so mentioned types; we use the type-1 due to the simplicity in it that is fixed-speed.

### B. SCIG System

First of all abbreviation of SCIG is squirrel cage induction generator. SCIG grid connected system as shown in figure 8. Basically, SCIG is used for a constant speed generator, in this mainly consists of various stages. Beginning stage is wind form stage that is (less voltage stage), second stage is distribution stage that is (intermediate voltage stage) and last stage is transmission stage that is (more voltage stage).In this designing rotor conductor bars or windings are short circuited and also the windings of stator are directly connected to the grid so this called as straight forward conversion technique method. This also called as an open loop control system. In this wind power increases and also correspondingly output power fixed. Some cases wind turbine rotates highly but output power not changed because our SCIG generator rotates fixed speed that's why output power not varied. In this mainly employed thing is pitch angle. Controlling speed of the turbine blades pitch angle is required. Speed of induction generator slip changes only few percent w.r.t changes in wind speed.in this main disadvantage of SCIG is reactive power compensation that is connected by externally, it is required to keep the line of distribution voltage and to stop total system from overloaded. In SCIG system voltage drop is more in distribution line, which is effect an over load problem. And another problem in SCIG is speed cannot be controlled because generator rotates constant speed. But there is no speed control mechanism for the generator. SCIG based wind turbines [12] are typically equipped with a soft-starter mechanism and an installation for reactive power compensation, as SCIGs consume reactive power. It is simple operation of construction and more reliable and cheaper.

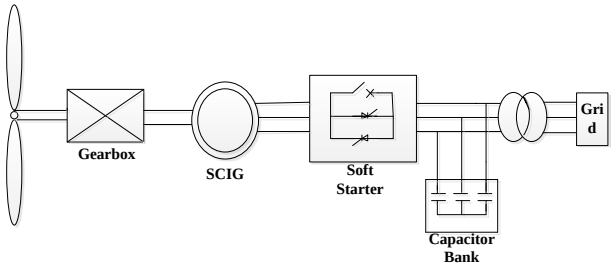


**Fig. 6** Structure of SCIG System

### C. Pitch Angle Control

It is nothing but an angle between a blades and height of the tower. It is denoted by the letter $\beta$ (Beta). In this paper pitch angle is prefer to only SCIG wind turbine system. Because in SCIG system a generator is fixed speed of operation and also output power will be fixed. That output value is called as nominal power. In some cases blades rotates highly also output power varies in slightly, in this situation pitch angle control is achieved. It is to be known that when the wind speed changes this means the rotational speed of the turbine is fixed .this is required to keep the rpm of the generator fixed. This reason for control pitch angle. Whenever, output power will be exceeding the nominal value then the pitch angle can be controlled. Rotation of the blades is called Pitch angle control it works only nominal speed is below the wind speed. Pitch angle varies only some degrees maximum cases zero to thirty degrees. The output power varies only within the limits. Diagram of the pitch angle control is as follows.

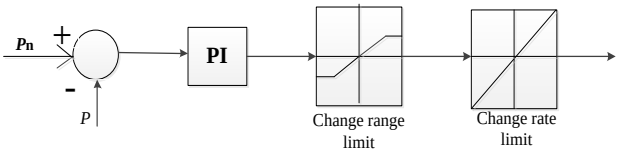


**Fig. 7**Schematic diagram of Pitch Angle control

Types of Optimization Problems in Non-Conventional Energy Sources based Integrated Grid

1. Maximum Power Point tracking using advanced Algorithms
2. Harmonic Reductions and Power quality improvement using various optimization techniques.

## IV. PEER REVIEW ON MPPT ALGORITHMS

### A. Incremental conductance MPPT Technique

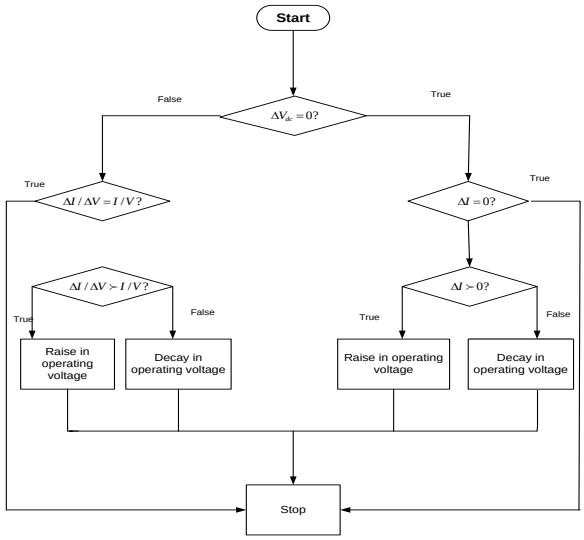


Fig 8.Incremental Conductance algorithm

It is most commonly used MPPT in PV system to drag maximum power. It computes MPP by comparing incremental conductance to the instantaneous conductance i.e., I/V and dI/dV to the solar PV array. It compares $I_{pv}$ and $V_{pv}$ such that there is no change in voltage and current i.e., zero which indicates MPP then there is no need to change Pulse width modulation [24-25] .The algorithm is as shown in Figure 8.

### B. Perturb and Observe MPPT Technique

P&O based MPPT technique is commonly used method to track maximum power from the Non-conventional energy sources. Here the reference voltage is given as a variable which periodically computes with the previous cycle when the maximum power is obtained then it generates the duty pulses to operate the converters otherwise it repeats its cycle until the best possible module voltage is reached under maximum power point is obtained. At some point MPP is obtained the Voltage oscillates around the ideal operating conditions.


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Perturbation size is set very small in order to maintain power loss very less. P&O technique is very advanced in maintaining the reference voltage with respect to Peak voltage for this we use PI controller to generate the operating point to the required voltage level. This technique fails to track maximum power under fast change in atmospheric conditions. But this is very simple and popular technique [9-15].

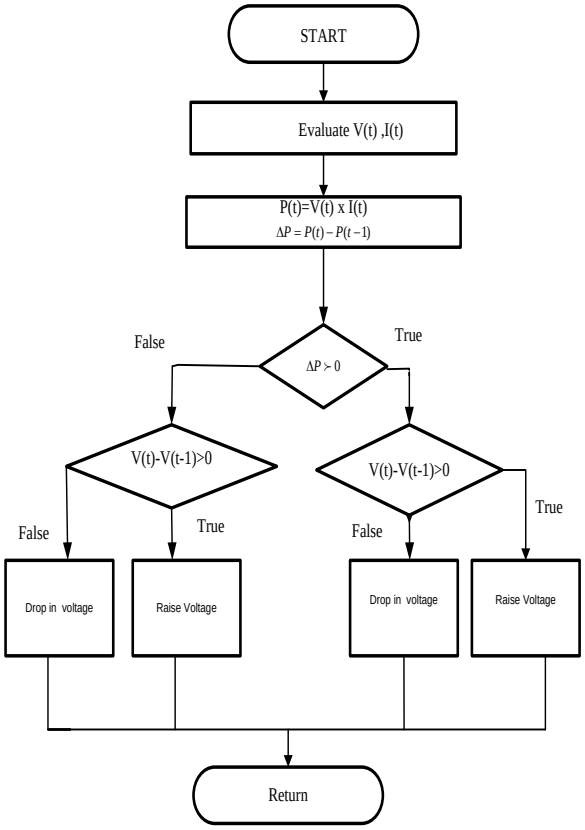


Fig. 9 Perturb and Observe algorithm

## C. PSO MPPT Technique

PSO techniques are widely used computing optimization basically works on the intelligent movement of swarms. Social communication for problem solving is applied with PSO. In a given specified search space it uses number of particles that constitute swarms moving around to track the best solution.

Every particle looks to track of its neighboring particle in the search space which are associated with the best solution that has achieved so far by the particles called the $P_{best}$. Another best value is tracked by PSO among the best value obtained by the particles in the coordinates of search space is called Global best ($G_{best}$). During the optimization process the particles take up the objective function values with the $G_{best}$ and $P_{best}$ are saved and determined by the following velocity function [9-15].

Velocity function:

$$V_{i(k+1)} = V_{i(k)} + t_{1i}(P_i - X_i(k)) + t_{2i}(G - X_i(k))$$

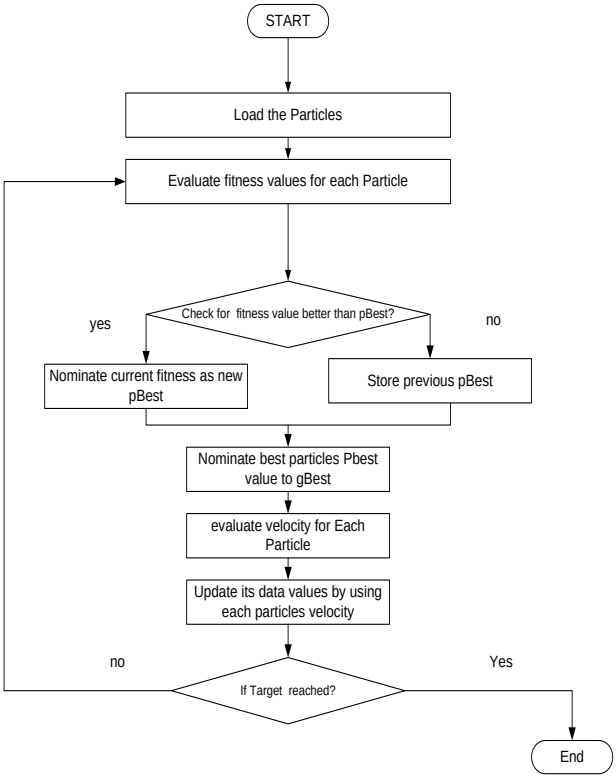


**Fig.** 10 Algoritham for PSO MPPT

## D. Cuckoo search algorithm

Many natures' inspired evolutionary methods have been developed for optimization in the past few years. These usually work based on a random search in some acceptable search region depending on the problem to be optimized. But the search is not truly random because there will be some mechanism in the algorithm which guides the search so that the solution vector gets improved with iterations [17]. Two crucial basic characteristics of these modern met heuristic algorithms are intensification (Exploitation) and diversification (exploration).

At the beginning initial conditions such as constants, variables like voltage, current, power and number of variables are set to the value. Power is measured using present values of voltage and current and these values of voltage and power are stored in some voltage and fitness arrays. Iterations are performed before every start by checking if samples achieved convergence. If convergence is not achieved then all the power evaluated are measures and stored in the fitness array. By calculating continuously the samples with highest power are chosen as best solutions [17].


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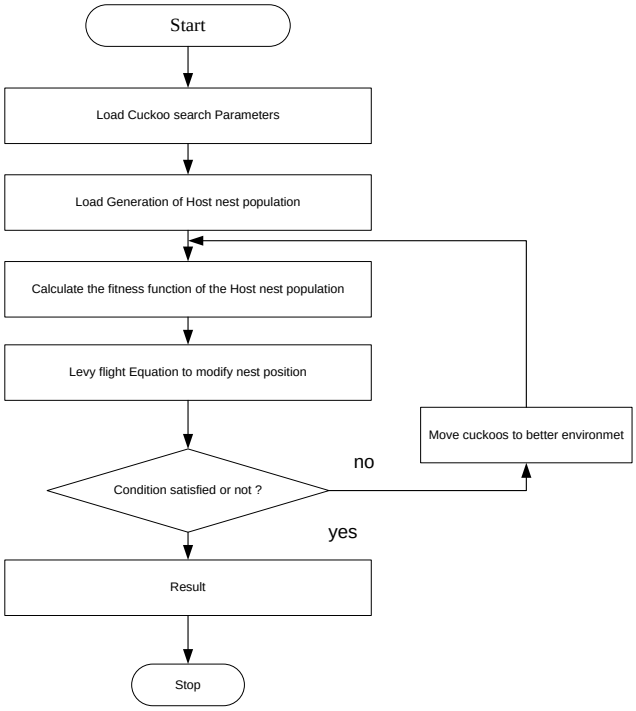


**Fig.11**Flowchart for Cuckoo MPPT

If the samples do not converge, all the power values of the corresponding samples are measured and are stored in the fitness array [27]. By evaluating the array, the sample with highest power is chosen as the best sample. Thereafter all other samples are forced to go towards this best value. The step sizes are calculated by performing the Levy flight as described by equations.[26]

$$V_i^{t+1} = V_i^t + \alpha \oplus levy(\lambda)$$

$$S = \alpha_o (V_{best} - V_i) \oplus levy(\lambda)$$

## E. Genetic Algorithm

GA is a heuristic search algorithm which is a natural evolution process adopted to solve optimization problems. It is a population based stochastic algorithm in which optimization starts with an initialized population from 'N' size where each individual represents a point in search space and thus a candidate solution to the problem and is called chromosome which includes a list of genes. In order to evaluate the genetic composition of population it uses three operators like selection, crossover and mutation. New generation with the highest fitness function is produced during each successive generation of the existing population is done during selection process where each solution is rated with the fitness and probably selects the best solution. Two offspring's are produced by using crossover operator by rejoining the information from two parents. Mutation is a random process of changing some gene values in individuals. The allele of each gene is a candidate for mutation, and the mutation probability determines its function [18-19].Competitively in new generation the population is highly suitable to the environment than previous generation. And the process repeats until meeting optimization criteria. Optimal solution is gained after decoding the last individual Gravitational Search Algorithm.

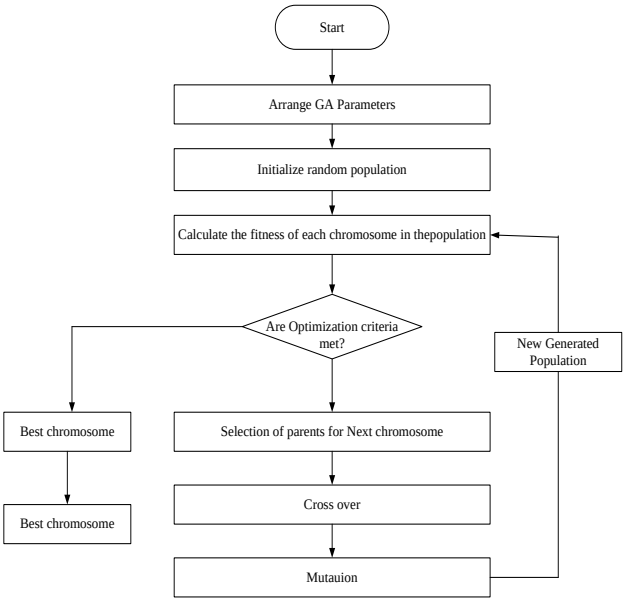


Fig. 12 Genetic Algorithm

## F. Gravitational Search algorithm

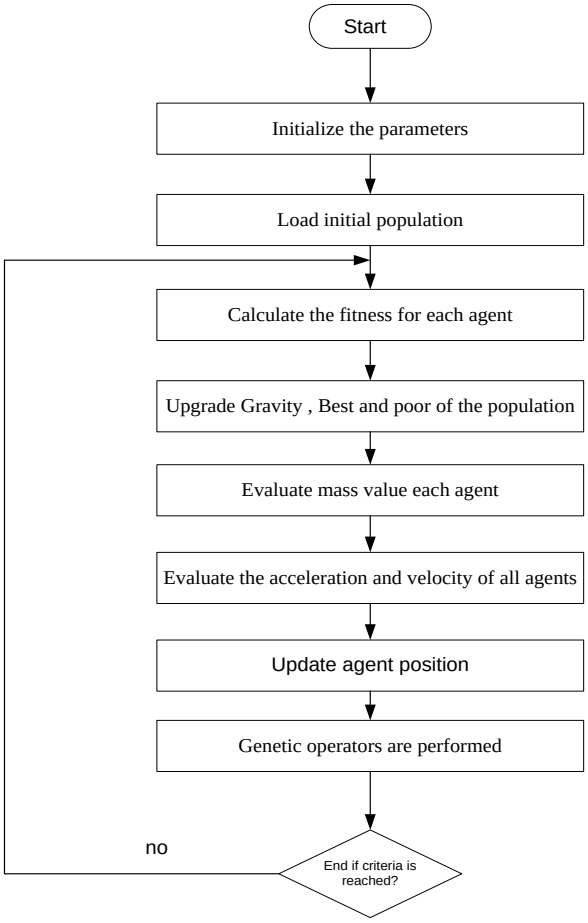


Fig. 13 Gravitational Search Algorithm

GSA is a heuristic algorithm which is also population based. Based on law of gravity and mass interaction GSA will work.


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Agents are called the solutions in GSA which generally interact with the other agents through gravitation force of attraction and their performance is measured by their masses. Finally the agent which is having higher mass is the best solution. Due to gravity force there is a global movement where each agent is considered as object and all the objects movement towards other objects which has higher mass. Generally the agent or object with heavier mass move slowly which represents exploitation step of the algorithm and leads to best solutions. [18-19].

### G. Bio-Geography Based optimization

BBO is a heuristic optimization which is again inspired from Swarm behavior in the nature. It is Observation of the distribution of biological species and their activities. Characteristics of any algorithm are immigration and emigration. Generally the geographical area where Habitat Suitability Index is high indicates that the area has good vegetation, rainfall land, temperature etc. so the biological species migrates from one island to the other in such cases. The variables that specify the habitability of habitat are called as Suitability Index Variables (SIV). Therefore Habitats with high HSI indicates species large in count and with less number of species indicates low HIS as species goes out from a habitat, then this process is known as emigration and the reverse process is called as immigration. High HIS solution resists change when compared with low HSI. So habitats with low HIS accept lot of new features from good solutions and results in praise of the quality of those solutions. Therefore this is called as a new approach to problem solving as BBO optimization [20-21]

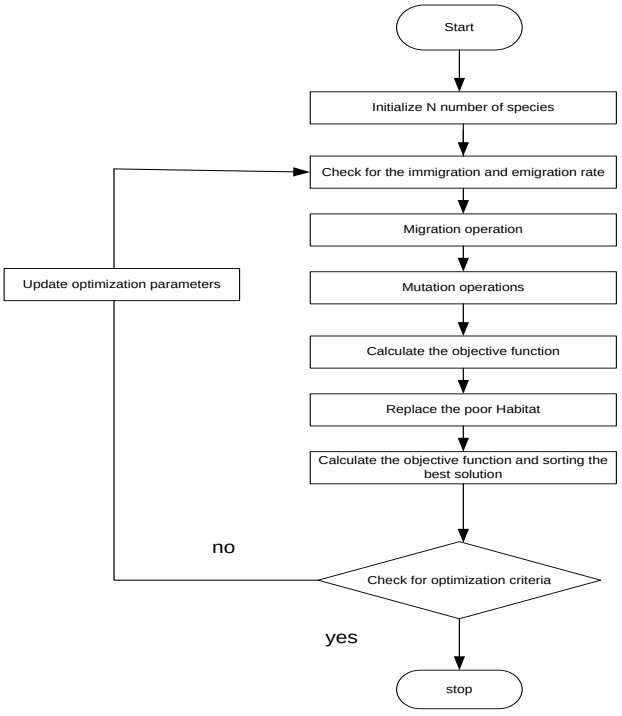


Fig. 14 BBO base optimization

## V. CONVERTERS WITH MPPT

### A. DC –DC Converters employed in PV System

The output of Photovoltaic system is nonlinear due to the energy which is available for is intermittent in nature. The inputs to the PV are solar irradiance and temperature which are unpredictable as they continuously changes. Tracking of solar Power using PV is somewhat complicated and the obtained I-V curves are distinct at different points of operation. Maximum power can be extracted by developing various optimization based MPPT techniques to optimize the generated power. In order to achieve this we commonly use DC-DC converter along with MPPT such as IC, P&O, PSO, Cuckoo etc. which are implemented to operate the PV. Generally two inputs to any proposed MPPT would be $I_{pv}$ and $V_{pv}$ by calculating the power obtained with previous value and generates a input current control ($I_{ref}$) which is built to lower the switching harmonics and fed to the MOSFET based DC-DC boost converter thus duty pulses are generated and steps-up the PV voltage to higher dc voltage [22].

### B. Double Bridge rectifier in Wind Turbine System

Generated power from wind experiences some changes in frequency and amplitude since wind energy is also intermittent in nature and produces variation in wind speed. In order to overcome such constraints we use controllable ac/dc converter to smoothen wind turbine output before fed to other electronic devices. To achieve this we generally use double-bridge rectifier as it has advantage is that variable dc output voltage can be obtained by controlling the firing angle pulse width modulation generator which reduces the harmonics towards source side [22].

### C. Battery and Inverters

Generally we use a battery source near the grid interfaced between PV-Wind systems in order to store the energy and can be used under off grid conditions. Inverter is ac/dc converters which are connected to the rotors of DFIG to withstand high current. Reduction of harmonics is possible by controlling the switching angles of the inverter due to which high stress is caused; to overcome this we used BBO techniques to reduce THD with less number of switching to improve efficiency of the inverter [22].

## VI. PV-WIND GRID CONNECTED DISTRIBUTION GENERATION SYSTEM TO REDUCE HARMONICS AND POWER QUALITY IMPROVEMENT USING BBO OPTIMIZATION TECHNIQUES

The main objective is to minimize various constraints like power loses ,improve power quality and effective reliable operation of the network by maximizing the voltage stability and load sustainability by reducing total harmonic distortions and also to minimize the generation and purchase of power from Conventional energy sources.

### A. Reduction of harmonics and power quality improvement in Distribution Generation systems

Grid integration by DG is widely used from past few years. DFIG in wind systems and PV sources are commonly used DGs. Performance and operation of DFIG are studied in literature which is suitable for Dynamic voltage restorer, static compensator and unified power quality conditioner methods of operation used to mitigate various constraints like faults, induced harmonics, harmonics in load and VAR in DS. There are some limitations for Dynamic voltage restorer which can only induce less active power.


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Harmonics in the output voltage can be reduced by implementing Multi-level selected harmonic elimination pulse width modulation on/off techniques to obtain low total harmonic distortion. This is achieved by implementing BBO with less number of switching which increases in inverter efficiency [14].

## VII. CONCLUSION

Generating electrical energy from PV-Wind sources is rapidly increasing to protect environment from various dangerous hazards. In order to meet huge demand by the utilities we are adopting alternative sources which are available for us in form of solar and wind which are eco-friendly. There is one main draw back with these sources as they are intermittent in nature maximum power tacking becomes a problem. In order to overcome this vast development of MPPT algorithms has come in existing which is encouraging for the domestic generation of power. It is observed that Incremental conductance and Perturb and observe optimization techniques used my many researches had experienced slow tracking, oscillations and efficiency are less. To overcome this we used PSO and Cuckoo Search algorithm are used for better performance. In order to boost up the voltage we are using power electronic converters. Filters designed to reduce the harmonics of DC-DC converter output in such a way that power quality is improved. This DC again fed to the inverter by BBO ML–SHEPWM techniques to lower the switching losses, frequency and harmonics in load voltage. In hybrid systems inverters with battery back are preferred under off grid conditions [22-27].

## FUTURE SCOPE

Researchers has carried out their work on designing wide range of MPPT controllers and this can be extended by implementing with new optimization techniques to obtain accurate MPPT by new algorithms. The Power quality and total harmonics distortions produced in output voltage can be improved by DG-UPQC with Gray Wolf techniques.

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