



# Performance Enhancement in Transmission Lines by Locating the Distributed Generators using Improved Particle Swarm Optimization Algorithm

S. Syed Musthafa Gani, S. Boobalan, S. Arun Prakash, S. Faizal Mukthar Hussain, A. Mohamed Ifthikar Ali

**Abstract:** This paper indicates the nonlinear congestion mitigation in the transmission lines. The generator active power is rescheduled to achieve the congestion- transmission line network in electrical power system. The transmission congestion in the buses can be reconfigured by using the Improved Particle Swarm Optimization Algorithm. By locating the Distributed Generators in the identified weak buses the voltage profile and the power loss in the transmission system can be improved. The proposed solution's achievability is tested by estimating the cost of congestion on different standard IEEE transmission line networks. The algorithm have the recompense such as the capability of local search and the capability of global search in the algorithms Gravitational Search Algorithm (GSA) and Particle Swarm Optimization (PSO) algorithm respectively. Consistence with the calculation is tried by considering different contextual investigations including clog on the separate test transport arrange because of two-sided, polygonal exchanges and line blackouts.

**Keywords:** Artificial intelligence, Improved particle swarm optimization (IPSO), Available Transfer Capability (ATC), power system planning, Open Access Same-Time Information System (OASTIS), Economic Dispatch (ED), Distributed Generators (DG).

## I. INTRODUCTION

The world's power market is undergoing a dramatic shift in its industry. The power utilities are being unbundled and opened up to competition with private companies in a vertically integrated process. It allows for the end of the monopoly period. By implementing government policies, guidelines, and regulations, the monopoly electricity market produces, transmits, distributes, and supplies electricity in a region, state, or nation. This causes incompetence and tired attitude in the industry as they lack managerial productivity, enthusiasm for technological advancement and emphasis on the customers. Most of the utilities are undergoing restructuring to dispense with these adversities of the electricity markets.

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\* Correspondence Author

S. Syed Musthafa Gani\*, Assistant Professor, Department of EEE, Mohamed Sathak Engineering College, Kilakarai

S. Boobalan, Professor and Head, Department of EEE, Mohamed Sathak Engineering College, Kilakarai.

S. Arun Prakash, Assistant Professor, Department of EEE, University College of Engineering, Ramanathapuram.

S. Faizal Mukthar Hussain, Assistant Professor, Department of CSE, Mohamed Sathak Engineering College, Kilakarai

A. Mohamed Ifthikar Ali, Associate Professor, Department of ECE, Mohamed Sathak Engineering College, Kilakarai.

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The main aim of reforming the power system is to promote competition wherever possible at different levels and to establish market conditions in the industry that are seen as necessary to reduce energy production and distribution costs, remove some inefficiencies and increase Consumer choice. The first step in the energy industry's reform process would be to isolate the transmission actions from the electricity production activities. The required measures taken to generate activities such as creating Power networks, allowing for direct mutual negotiation or request on the power markets.

The generating firms have signed contracts to supply electricity to power producers or distributors or bulk consumers in a pool in which power traders and customers are also involved. Buyers can bid on a power exchange market for their demands along with their willingness to pay on. Power trading is free from and competitive with traditional regulations. Also popularly known as the restructured power market is open power market, re-regulated market, competitive power market, a vertically unbundled power system, open access etc. In the deregulated market, private investment, increased productivity, fulfillment of social responsibilities, easy buying process, promotion of technological growth and enhancement of customer satisfaction are expected.

## II. STRAGIES FOR CONGESTION MANAGEMENT

The congestion reduction approaches are variable with customer forms. The following three strategies are implemented specifically to alleviate the congestion in transmission.

Market participants bid for each and every price area in which they have generation or load in the Congestion Management Price Area. When there is no competition, the market should settle at a single level, which would be the same as if there is no current demand field. Once congestion occurs, price rates are negotiated individually at levels that satisfy the constraints of transmission lines. Areas of over generation have lower prices; areas with excess loads have higher prices.

ISO will be conscientious for managing its personal national transmission networks in electrical power system in Available Transfer Capability (ATC) based congestion management system by measuring the ATC for potentially overcrowded paths entering, leaving and beyond its network. The ATC is a calculation of how much extra electrical power a route will transmit from start to finish.



Next hour ATC values for any hour in the future will be put on Open Access Same-Time Information System (OASTIS). Any buyer or seller can access the OASTIS for the ATC details to determine if the system can accommodate the transaction.

OPF has been used for the last 50 years in the electric power industry, and is usually conducted to reduce the running costs of the generator. While it is similar to the Economic Dispatch (ED) feature, it differs by adding constraints that define the transmission system model the generators work within. If there is no obstruction of the transmission grid, then the optimal power flow (OPF) elucidation is the same as an ED solution. OPF utilizes an entire arrangement of intensity stream conditions applied to the financial dispatch as fairness limitations and stream and voltage requirements as imbalance imperatives, so the expense of producing vitality is run as the figuring.

### III. TRANSMISSION LINE CONGESTION

Transmission line clog is where more force is modified or courses through transmission lines and transformers than as far as possible set up in the deregulated condition. It might occur because of inadequate coordination among age and transmission utilities, or because of surprising possibilities, for example, power blackouts, unexpected increment popular for burdens or disappointment of gear Congestion. During clog the entirety of the arranged exchanges in real help are hard to oversee. The blockage can be overseen by coordinating line limit requirements into the force booking forms.

The executives of blockage are viewed as an OPF issue and legitimate displaying of the transmission lines is required for investigation. The transmission line is seen as a straightforward model with end transport i and end transport j accepting complex transport voltages at transport i and transport j as  $V_{ii}$  and  $V_{jj}$ , as appeared in Figure 1. Let  $P_{ij}$  and  $Q_{ij}$  represent the dynamic and receptive force stream from the i transport. Moreover,  $P_{ji}$  and  $Q_{ji}$  mirrors the development of dynamic and responsive force from the transport j-i.  $R_{ij}$  and  $x_{ij}$  speak to the obstruction arrangement and the transmission line response grouping, respectively. The arrangement impedance,  $Z_{ij}$  of the line is communicated as  $Z_{ij}=r_{ij}+jx_{ij}$ . The conditions for power calculation can be inferred as follows

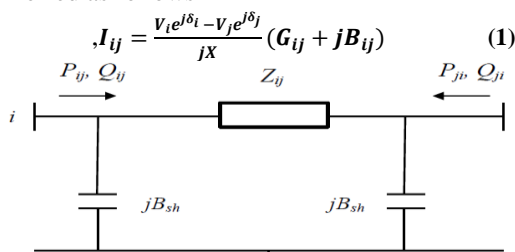


Fig 1 : Transmission line Model

### IV. MATHEMATICAL MODELLING

The active and reactive power flow  $P_{ij}$  and  $Q_{ij}$  can be expressed as,

$$P_{ij} = V_i^2 G_{ij} - V_i V_j (G_{ij} \cos(\delta_i - \delta_j) + B_{ij} \sin((\delta_i - \delta_j))) \quad (2)$$

$$Q_{ij} = -V_i^2 (B_{ij} + B_{sh}) + V_i V_j ((B_{ij} \cos \delta_i - \delta_j) - G_{ij} \sin(\delta_i - \delta_j)) \quad (3)$$

To ensure proper operation, the OPF should be subjected to the subsequent equality and inequality constraint as,

$$P_{Gi} - P_{Di} = \sum_j P_{ij} \quad (4)$$

$$Q_{Gi} - Q_{Di} + V_i^2 B_{shi} = \sum_j Q_{ij} \quad (5)$$

where,  $P_{Gi}$  is active power and  $Q_{Gi}$  is the reactive power of generators while  $P_{Di}$  is active power demand and  $Q_{Di}$  is the reactive power demand at the each bus (i) in the power system.  $B_{shi}$  is the representation of the susceptance of any shunt device connected at bus i.

Inequality constraints as,

$$V_i^{min} \leq |V_i| \leq V_i^{max}, \forall i \in NB \quad (6)$$

NB is the set of all generation and load buses.

$$P_i^{min} \leq |P_i| \leq P_i^{max}, \forall i \in NG \quad (7)$$

$$Q_i^{min} \leq |Q_i| \leq Q_i^{max}, \forall i \in NG \quad (8)$$

In a deregulated setting, the degree of transmission congestion is more pronounced as a result of multilateral transactions that result in violation of the line's physical limits and can even cause line outages. In the event of contingencies, subsequent voltages and power flows shall be within limits by using the contingency constraints in the OPF model.

### V. IMPROVED PSO ALGORITHM (IPSO)

Populace of focuses arbitrarily inspected in conceivable space. The populace is then subdivided into many sub-swarms. Every intricate performs PSO or its variations autonomously including refreshing the position and speed of the particles. The sub-swarms are compelled to blend and focuses are reassigning after a specific number of ages to guarantee information sharing;

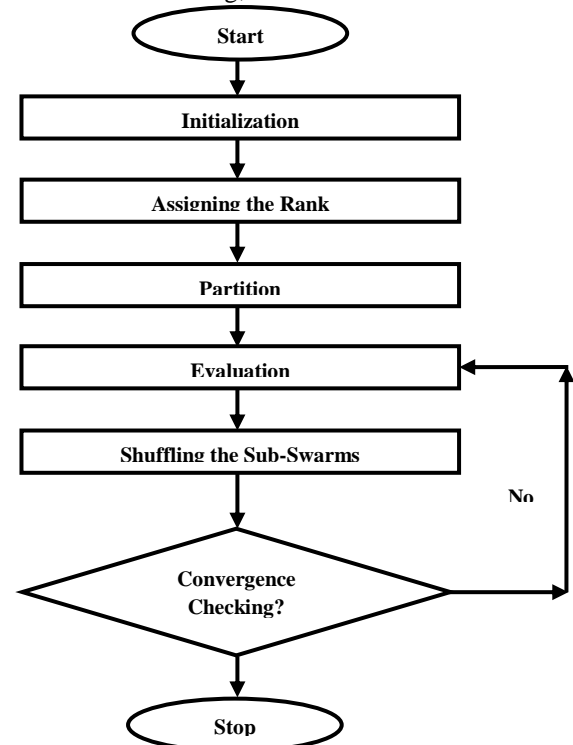


Fig:2 Steps in the IPSO Algorithm

**Step 1:** Assume the number of sub-swarms ( $p$ ) and the number of points ( $m$ ) in each complex search space and to compute the sample size as  $s = pm$ . Sample  $s$  points  $X_1: X_s$  in the feasible space. Compute the value  $f_i$  at each point  $X_i$ .

**Step 2:** To categorize the given points in the increasing order of the given function value. This value may be stored in an array  $E = [X_i: f_i]$  where  $i = 1 \dots s$ .

**Step 3:** The array values will be spitted into each of  $p$  sub swarms as  $A = (A_1: A_p)$  each containing points  $m$ .

**Step 4:** Particle swarm optimization (PSO) technique is used to evaluate each complex point separately.

**Step 5:** The partitioned swarms  $A_1: A_p$  can be replaced into  $E$ . The value of  $E$  can be arranged in ascending order of the function value.

**Step 6:** Stop if the conditions of convergence are achieved. If not, go back to Step 4.

The IPSO method incorporates the capabilities of maximizing the particle swarming, dynamic development and specific mixing principle. The sharing of the data obtained separately from each complex significantly enhances survival. Each member of a complex has the capacity to participate in an evolutionary process. A couple of parents from sub-swarms were picked. To make the production cycle successful, we need a higher chance of better parents than bad parents contributing.

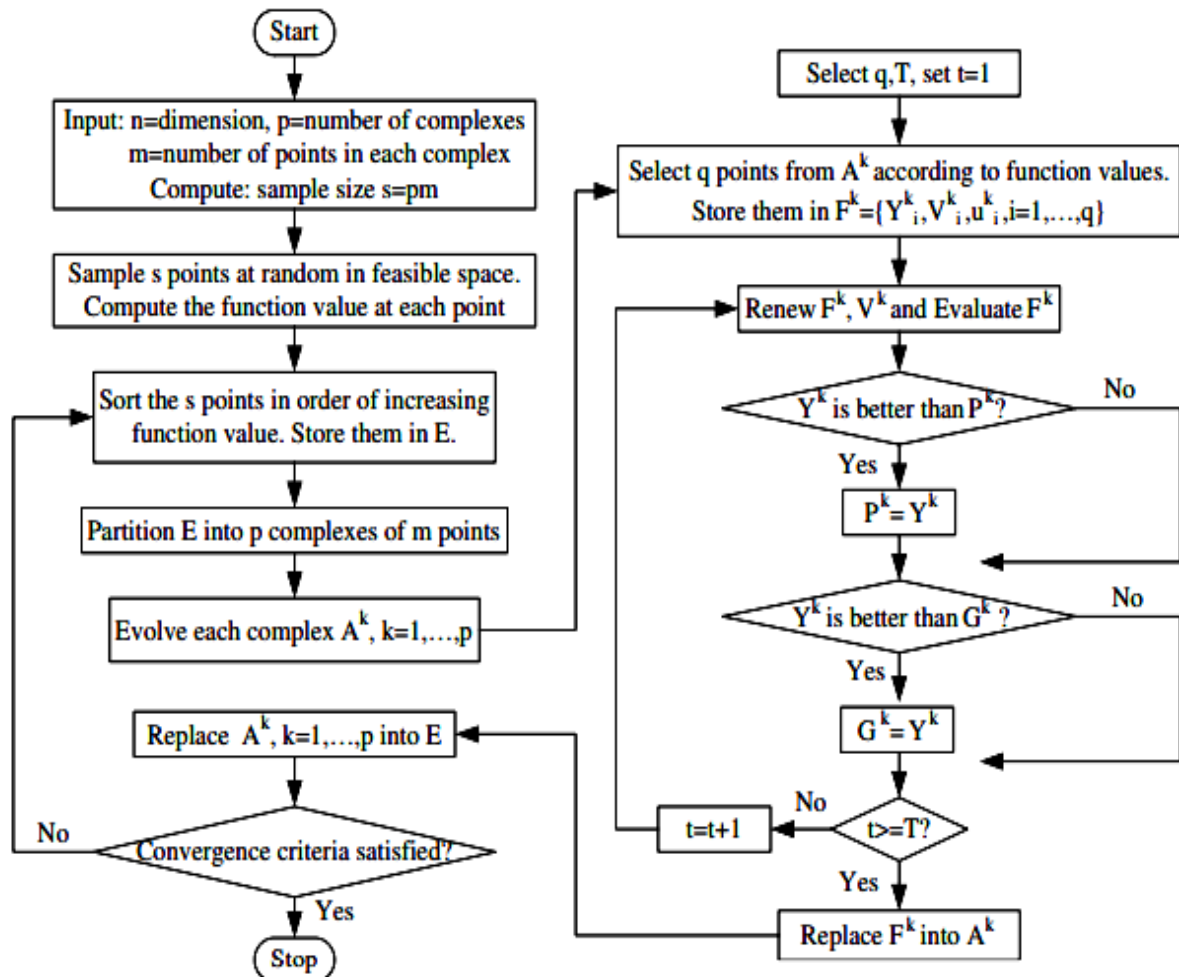


Fig 3: Flow chart –IPSO Algorithm

## VI. RESULTS AND DISCUSSION

### A .Load Flow Analysis Using IPSO Algorithm

This test system is a radial IEEE 33-bus distribution system having Synchronous generators, Transmission lines with tie-switches and sectionalizing switches of 5, 33 respectively. The sectionalize switches (normally closed) are numbered from 1 to 32, and tie switches (normally open) are numbered from 33 to 37 are available in the transmission network. The problem of congestion of the transmission network is resolved in the presence of Distribution Generator (DG) in the distribution system.

There are other methods that can be used for the reconfiguration such as Harmony Search Algorithm (HSA),

Bacterial forging algorithm (BFA), Refined Genetic Algorithm (RGA) and Genetic Algorithm (GA) .

The new heuristic algorithm called Improved Particle Swarm Optimization (IPSO) is employed to reconfigure and define the best positions to install the distributed Generator units in a distribution network simultaneously.

Results obtained through IPSO algorithm are compared with the reconfiguration with the PSO Algorithm results. The numerical results suggested that IPSO performance is higher than GA and PSO efficiency.



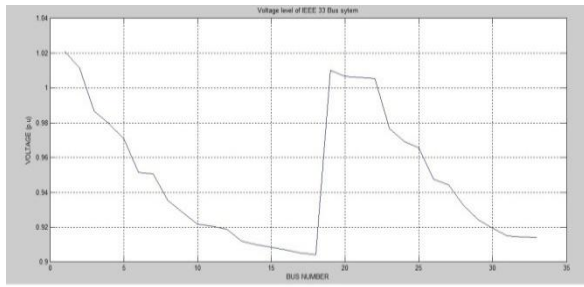


Fig.4: Voltage profile variation in Test System- (IEEE 33 bus system)

Table I- Load flow results in base case

Case		Load stage		
		Light (0.5)	Nominal (1.0)	Heavy (1.6)
Base	Power Loss (kw)	178.3	353.366	752.9
	V <sub>min</sub> (p.u.)	0.9085	0.90444	0.8879

It is noticeable from the result that the weak buses are between Bus 8 and Bus 18. The estimated minimum voltage is 0.90443 per unit. And the loss of power is 353.366 KW. So DG has to be positioned at these positions in the loss reduction and enhance the voltage magnitude in the bus..

### B. Optimal Location of DG Using IPSO Algorithm

In this case IEEE was tested for 33- bus network. When reconfiguration is performed in the Transmission network, a significant decrease in the power loss values is observed. The switches obtained via the Algorithm of Improved Particle Swarm Optimization give the minimum loss.

Table II- Load flow results with Reconfiguration using IPSO

Case		Load Stage		
		Light (0.5)	Nominal (1.0)	Heavy (1.6)
With reconfiguration	Power Loss (kw)	43.3	113.02	371.9
	V <sub>min</sub> (p.u.)	0.972	0.9334	0.904

The above table demonstrates voltage profiles for different cases and the results suggest a boost in voltage profile for reconfiguration using PSO algorithm and reconfiguration using IPSO is compared with the base case.

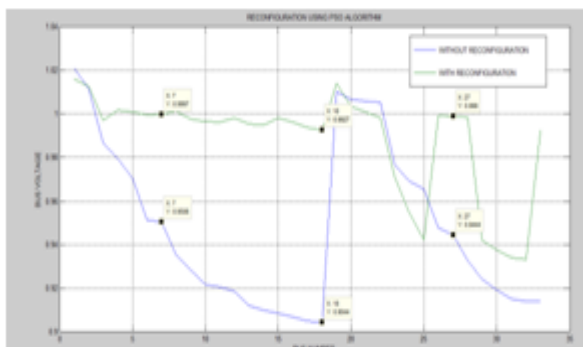


Fig.5: Voltage profile variation with Reconfiguration using IPSO

Table III- Load flow Reconfiguration results with PSO and IPSO Algorithm-Comparison

Case		Load Level		
		Light(0.5)	Nominal (1)	Heavy (1.6)
Base	Power Loss (Kw)	178.3	353.366	752.9
	V <sub>min</sub> (p.u.)	0.90850	0.90444	0.8879
Reconfiguration using PSO	Power Loss (Kw)	98.5	251.266	513.2
	V <sub>min</sub> (p.u.)	0.94326	0.92808	0.8963
Reconfiguration using IPSO	Power Loss (Kw)	43.3	113.024	371.9
	V <sub>min</sub> (p.u.)	0.972	0.93340	0.9048

From the above results, it is evident that the voltage profile in the PSO based reconfiguration is 0.94326 p.u and it is improved as 0.9722 p.u by IPSO based reconfiguration in the transmission lines. The power loss is reduced in the transmission lines by installing the Distributed generators in the low voltage profile buses.

## VII. CONCLUSION

Improved Particle Swarm Optimization (IPSO) technique has been used to find the most appropriate topology of the distribution system in the presence of distributed generation. The IEEE 33 bus systems with the distributed generation are used for the test system of above investigation. By adding the distributed generation in the transmission networks and the power losses were analyzed in the distribution networks. The results show that the optimal switching strategies, in general on/off pattern of the switches can be identified which give the minimum power loss and improve the voltage profiles. The obtained results confirmed the effectiveness of the Improved Particle Swarm Optimization Algorithm.

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## AUTHORS PROFILE



**Mr. S. Syed Musthafa Gani** is currently working as Assistant Professor in the department of EEE at Mohamed Sathak Engineering college, Kilakarai. He Completed M.E in Power systems Engineering in 2011. He is a member of IEE, ISTE. He is pursuing his Ph.D in Anna University, Chennai from 2018. His area of interest includes Power Systems Restructuring, Optimization Techniques, and Optical fiber applications in Power Systems.



**Dr. S. Boobalan** is working as Professor and Head, Department of EEE, Mohamed Sathak Engineering College, Kilakarai. He completed his post graduate degree in 2010. He completed his PhD in the field of Analysis and design of FACTS controllers in the year 2017. His research areas are Nonlinear Control Systems, Power Electronics and drives, Soft computing techniques.



**Dr. S. Arun Prakash** is working as Assistant Professor and Head, Department of EEE in University College of Engineering, Ramanathapuram. He completed his PhD in the year 2016. His research areas are Power System Optimization, Optical Engineering, and Renewable Energy Systems.



**Mr. S. Faizal Mukthar Hussain** is working as Assistant Professor, Department of CSE Mohamed Sathak Engineering College, Kilakarai. He completed his post graduate degree in 2009. His research areas are Machine learning, Internet of Things and Soft Computing.



**Mr. A. Mohamed Ifthikar Ali** is working as Associate Professor, Department of ECE Mohamed Sathak Engineering College, Kilakarai. He completed his post graduate degree in 2008. His research areas are VLSI Design, Computer Networks, Embedded Systems, Internet of Things and Soft Computing.