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Dynamic Optimal Power Flow for Active Distribution Networks

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ABSTRACT: Active Distribution Networks proposes the operation of distribution networks with high penetrations of renewable distributed generation. Technologies such as energy storage and flexible demand are now beginning to be included in Active Network Management(ANM) schemes. The Optimal Power Flow(OPF) is needed in Active Network Management(ANM) to maintain the power in grid system but this only optimizes for a single point in time. Dynamic Optimal Power Flow(DOPF) is an extension of OPF to cover multiple time periods. The optimization is done using PSO(Particle Swarm Optimization) that helps to schedule the ANM to maintain the power balance and also to improve the quality of output in DOPF. The simulation is done by MATLAB environment with standard IEEE bus system to measure the power flower and find the number of generators that maintain the power in the ANM system. Results obtained from the simulation gives the information about the demand level in the distribution network by optimizing the power flow which in turn gives the information about placing of generator to maintain the power quality and minimize the power loss.

KEYWORDS: Energy storage, Flexible demand, Active Network Management, Optimal Power Flow, Dynamic Optimal Power Flow, PSO, MATLAB

I.INTRODUCTION

The primary objective of Dynamic Optimal Power Flow(DOPF) is to solve the problem of how to optimally dispatch generation across a network and across a time-horizon to meet demand within that time-horizon. It allows the modelling of inter-temporal technologies and effects including energy storage, flexible demand and generator ramp rates. An area where inter-temporal technologies are being deployed is the management of Distribution Networks(DNs). Active Network Management(ANM) is the philosophy of planned and real-time management of a DN and connected devices. It is being driven by the pressure to increase the penetration of renewable generation connected to the power system as distributed generation(DG). Traditional operation of DNs assumes a “fit and forget” strategy which significantly limits DG penetration. ANM allows additional DG to connect under non-firm connection agreements and applies curtailment to these generators to maintain network constraints.

There are so many methods used to maintain the power flow in the distribution network side. The basic method is the manual calculation. The manual calculation based system helps to identify low voltage bus are demand bus and manually add the generator or all other parameters to maintain the bus voltage. Another method is linear based optimization which aims to find the place of DG in bus system network. The linear based method makes use of the linear equation which is solved to find out the bus place in overall bus system. The linear based optimization is one of the basic low complexity methods for flow analysis. The placing of DG is computationally reduced compared to the manual calculation.

The existing method got several drawbacks like accuracy, computational time power flow calculation etc. Manual method has better accuracy when compared to other methods though its computational time is high and it is not applicable to large system. The result is improved in linear based analysis and large scale of the bus system is verified by the accuracy which is very low to calculate the power flow and to place the DG in the distribution network. To overcome the above drawbacks, we use the optimization algorithm which is nothing but the heuristic optimization to find the DG places in IEEE standard bus system. The Power flow is calculated and then using the value from power flow we optimize the demand and choose the suitable place for injecting the power to reduce the power loss and to meet the demand in the overall system. It maintains the power efficiently and accurately to the maximum level. Since

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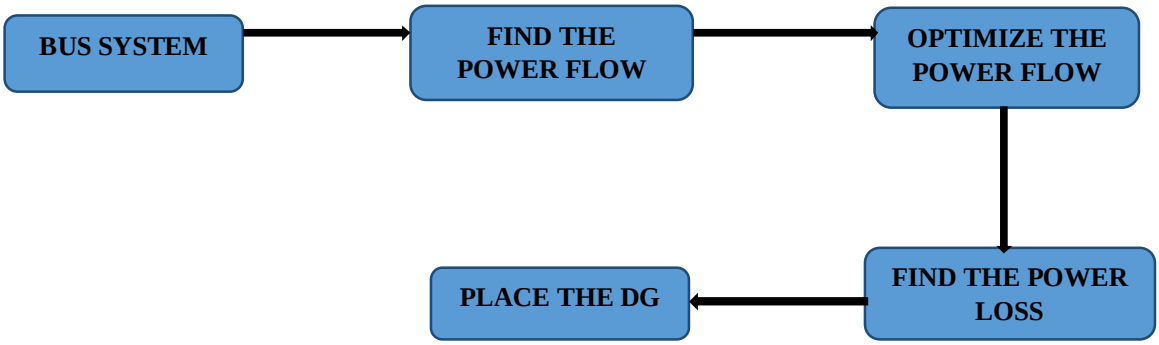
Heuristic Optimization methods may differ substantially in their underlying concepts, a general classification scheme is difficult to find.
This paper proposes the PSO algorithm to overcome the drawbacks of Heuristic Optimization which gives the accurate output in a computational time comparatively less than the previous methods. The main advantage is that the power losses to maintain the demand response and to place the DG has reduced drastically.

II.BLOCK DIAGRAM AND ASSUMPTIONS



IEEE bus system gives the standard data of network to solve and study the basic powersystem problem. Some of the IEEE bus systems are IEEE 14 bus system, IEEE 30 bus system, IEEE 57 bus system, IEEE 157 bus system etc. We choose medium size IEEE 30 bus system to solve the basic power system problem. We assume the base voltages are 11 kV and 1.0 kV. The model actually has these buses either at 132 kV or 33 kV. The 30 bus test case does not have line limits.

III.HEURISTIC OPTIMIZATION (HO)

The central common feature of Heuristic Optimization(HO) method is that they start off with a more or less arbitrary initial solution, iteratively produce new solutions by some generation rule and evaluate these new solutions, and eventually report the best solution found during the search process. The execution of the iterated search procedure is usually halted when there has been no further improvement over a given number of iterations i.e. when the obtained solution is good enough or when the allowed CPU time(or other external limit has been reached or when some internal parameter terminates the algorithm's execution. Another obvious halting condition would be exhaustion of valid candidate solutions as a case hardly ever realized in practice.

IV.PARTICLE SWARM OPTIMIZATION(PSO)

Particle swarm optimization(PSO) is a population based stochastic optimization technique developed by Dr.Eberhart and Dr.Kennedy in 1995, inspired by social behaviour of bird flocking or fish schooling. The system is initialized with a population of random solutions and search for optima by updating generations. PSO has been used because it is easy to implement and adjust few parameters. Once the parameters have been initialized, it looks for optimum solution by comparing new load with demand response value. The process continues until the best solution is obtained.
The output of PSO depends on the fitness function. The fitness function mainly depends on two parameters- Minimize Distribution Network Imports/Maximize Exports and Minimize Cost of Import/Maximize Revenue from Export. Thus by using PSO algorithm, optimization of power flow is done efficiently with minimum power loss in less computational time.

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V.POWER SYSTEM CHARACTERISTICS

Power systems are large and complex electrical networks. In any power system, generations are located at few selected points and loads are distributed throughout the network. In between generations and loads, there exist transmission and distribution systems. The system load keeps changing from time to time in the power system. Power flow analysis is concerned with describing the operating state of an entire power system which means a network of generators, transmission lines and loads that could represent an area as small as a municipality or as large as several states. Given certain known quantities – typically the amount of power generated and consumed at different locations and power flow analysis helps to determine other quantities.

VI.SIMULATION RESULTS AND DISCUSSION

The simulation is done using MATLAB for Heuristic optimization and PSO optimization. From the simulation, the total loss before optimization and after optimization can be found in both the methods and their results arecompared to find the best method.

Bus data and line data are the known quantities and from the known quantities current flowing through the transmission line can be calculated and thus the power flow data can be obtained.In the fig 1, it shows the Power Vs Time Characteristics of Heuristic Optimization. It represents the actual demand and demand response obtained using Heuristic Optimization which is slightly higher than the actual demand.

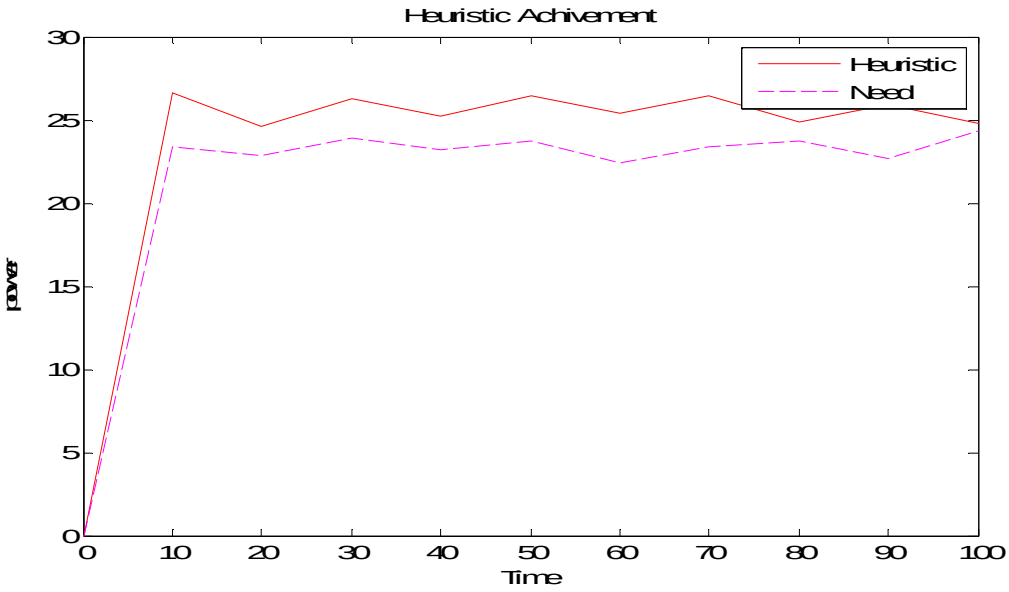

Fig 1 – Power Vs Time Characteristics of HO

In the fig 2, it shows the Power Vs Time characteristics of PSO. It represents the actual demand and demand response obtained using PSO which is more or less same as actual demand.

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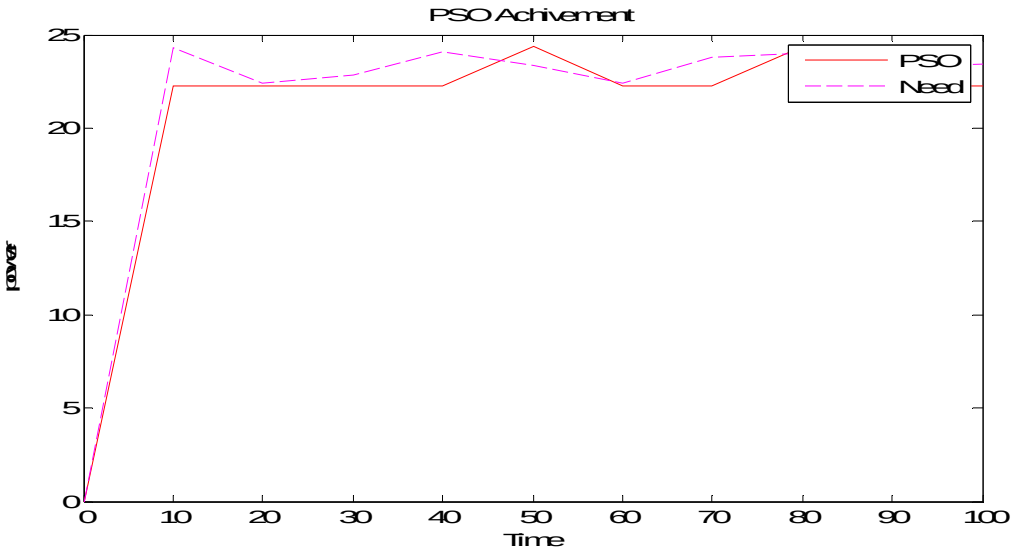

Fig 2 – Power Vs Time Characteristics of PSO

In the fig 3, it shows the overall Power Vs Time Characteristics. It represents the actual demand, demand response before optimization and demand response of HO and PSO.

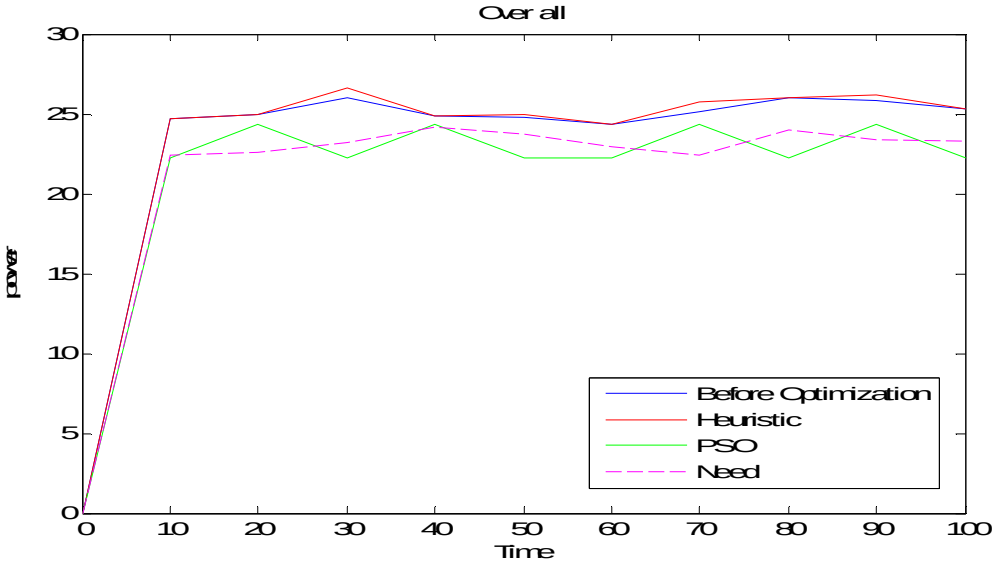

Fig 3 – Overall Power Vs Time Characteristics

From the above results, it can be seen that PSO gives the best solution and it meets the power demand efficiently with minimum power loss.

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VII.CONCLUSION

Thus the demand response for IEEE 30 bus system has been calculated using Heuristic Optimization and PSO Algorithm in the MATLAB environment. From the simulation results, it is evident that PSO Method optimize the power flow with minimum power loss in a computational time comparatively less than the heuristic optimization and other manual methods. It also gives quality output and maintains the power accurately and efficiently.

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