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Optimal Path for Power Flow in Future Distribution System Planning With Uninterruptable Power Supply Using Graph Theory

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ABSTRACT

In the perspective of the emerging Smart grid concept, the future distribution network requires repeated and fast load flow solutions. This is helpful in distribution planning, automation, optimization and restoration. This paper presents an approach using graph theory to determine optimal path for power flow in the distribution network. Distribution automation is an essential part of development of an effective smart distribution system. The distribution network is modeled involving distributed generation. An attention is paid to the techniques that deal with balanced/unbalanced, radial/ meshed configuration, with and without Distributed Generation (DG). The method is tested on IEEE 5 and 14 bus systems to find the shortest path for the power flow with MATLAB graph theory function. The results obtained indicate the proposed method as yet another approach to find the optimal path for power flow in distribution network.

Keywords :Distribution system planning (DSP), optimal path power flow, Graph theory Dijkstra's algorithm.

INTRODUCTION

Distribution system planning is important to ensure the growing need of electricity and providing uninterrupted power to the consumers connected to the network. Efficient management of network shall follow the planning. The distribution network topology is becoming dynamic thus containing several routes for power flow. It is often necessary to determine alternative routes in the network, in the case of non availability of the shortest path due to overload, fault etc. Power system network can undergo outages leading to impaired services. To minimize the interruption period, proper switching of power lines is required. Identification of alternative paths is a potential challenge for the operational engineers in the load dispatch centre. Quite a few optimization techniques are used to solve the problem of feeder routing. In the past, mathematical approaches such as branch and bound method for the optimization of distribution system were implemented. In this paper Dijkstra's algorithm is used for finding the optimal feeder routes in the planning of the radial distribution system of IEEE 5 and IEEE 14 bus systems. Dijkstra's algorithm is shortest route algorithm that considers the determination of the minimum cost (distance) from an origin to a destination through some connecting links. Even in the expansion of the feeders the least cost algorithm is found feasible. The efficiency of the algorithm is proven in power system restoration including the event of the fault, isolated by and the supply is restored in the system. The Dijkstra's method is superior because it depends more on the number of arcs than nodes. The proposed algorithm works on directed weighted graph and the edges should be non- negative. The optimal routes are obtained, further to minimize the total cost.

LITERATURE SURVEY

There are many algorithms to find the optimal path for power flow in graph theory [1] out of which Dijkstra's algorithms' is too applied to for radial and mesh distribution systems. Shortest route from one to another point (node) is termed as the shortest path and able to determine alternative routes through the network, in the case of any of the shortest path is not available or busy. There are many techniques to find feeder routing in distribution system. Path Search Algorithm [2] the main objective of this method is to find the optimal route for each load point in large size electric power distribution system and to obtain the optimal radial network. A Technique of Global Optimal Solution for Radial Distribution [3] it proposes the application of Direct Approach algorithm for feeder routing of radial distribution system. For this a complete network of available routes is considered and the optimization goal is to find the routes that provide the minimum number of energizing nodes for existing network and load flow analysis for the same network. Direct Approach to Optimal Feeder Routing for Radial Distribution System [4] this paper proposes a simple direct solution that significantly reduces the inherent difficulties of finding the solution and ensures optimum solution at the same time. Distribution system planning considering reliable feeder routing [5] this paper presents an investigation on the role of reliability consideration in distribution system configuration and planning cost of radial distribution system. A direct search technique is applied for optimum planning which ensures only minimization of planning cost. Optimal feeder routing is an important part of the general optimal distribution network planning [6]. This paper proposes a new algorithm for the optimal feeder routing problem using the dynamic programming technique and geographical information systems (GIS) facilities. Teaching learning based optimization (TLBO) algorithm for reconfiguration of static primary power distribution system [7]. The objective of the TLBO is the minimization of operational cost and maximization of system availability. For feeder reconfiguration purpose the optimal possible connections between the buses are considered to be the design variables and this represents the discrete nature of problem statement.

PROPOSED ALGORITHM

The proposed method is the direct solution technique to get the solution based on searching the optimum path for a node among all the possible paths with graphical representation of the shortest path between any two nodes. Starting from a substation there may be many possible radial paths to reach a node. Then the minimum cost path among all the radial paths for feeding a particular node will be the optimum path for the node. For this Dijkstra Algorithm is used. This algorithm solves as a shortest-route problem that considers the determination of the minimum cost (distance) from an origin to a destination through some connecting graph. After tracing of nodes, load flow solution is used to find the optimal path for power flow. Henceforth the optimal route is formed by the proposed algorithm. This algorithm is implemented on IEEE 5 bus system and IEEE 14 bus system and it will identify all possible shortest routes between source node and the destination node with and without distributed generation for mesh/ radial systems.

RESULTS AND DISCUSSION

In order to validate the entire shortest path in the network, it has been applied to sample 5 and 14 bus system. The software is developed in MATLAB graph theory function for the entire shortest paths with their weights. The outputs of the simulation are shown below one by one. Table I and IV show the line impendence's (weights). Table II and V shows the bus impedance matrix. Table III and VI shows the shortest path between any two nodes with path node and weight of that particular path. The graphical representation of shortest path is shown in fig.4.

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RESULTS OF IEEE 5 BUS SYSTEMS

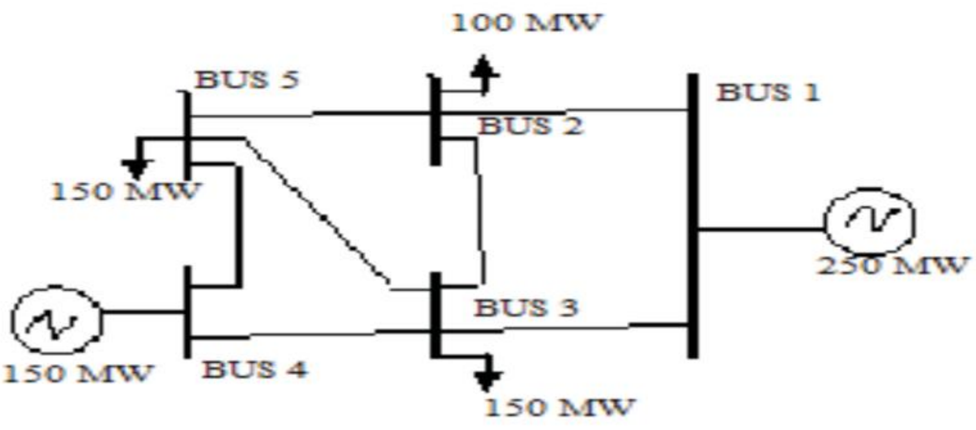

Fig 1: IEEE 5 bus system

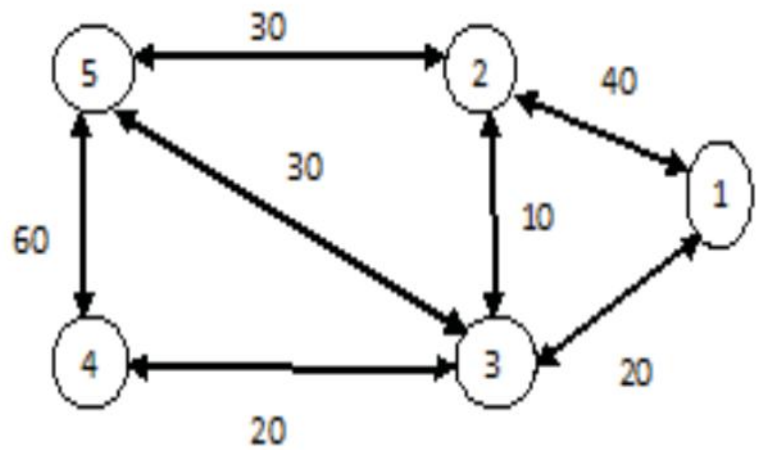

Fig 2: Oriented graph

Table 1. Line data's for IEEE 5 buses

Buses	Line data
1-2	40
1-3	20
2-3	10
2-5	30
3-4	20
3-5	30
4-5	60

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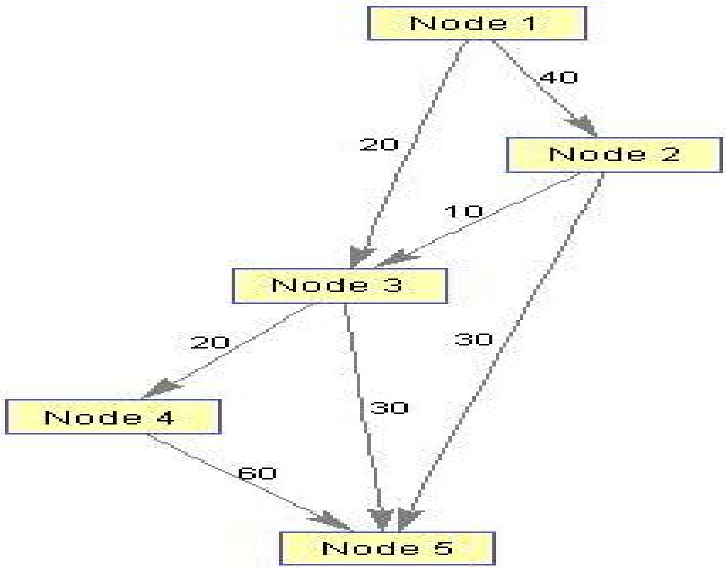


Fig 3: Simulated results of oriented graph with line impedances.

Table 2. Line impedances and bus impedance matrix.

DG =

(1,2)	40
(1,3)	20
(2,3)	10
(3,4)	20
(2,5)	30
(3,5)	30
(4,5)	60

0	40	20	40	50
Inf	0	10	30	30
Inf	Inf	0	20	30
Inf	Inf	Inf	0	60
Inf	Inf	Inf	Inf	0

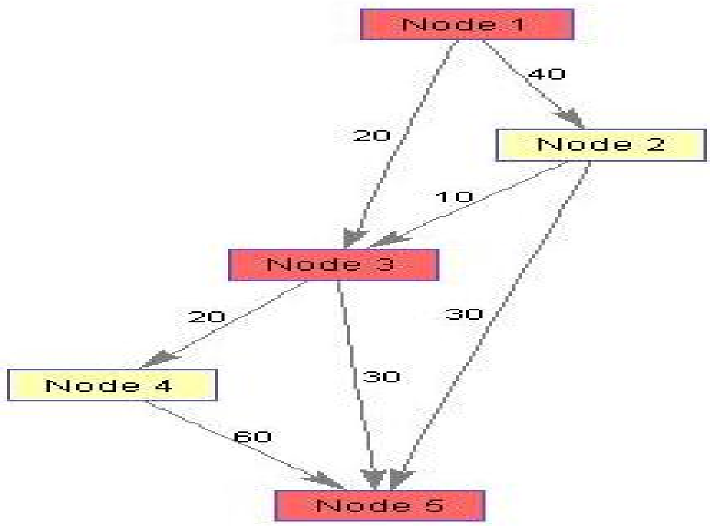


Fig 4: Simulated results of optimal Path of power flow

Table 3. Optimal path for IEEE 5 bus systems

Source and destination node	Optimal path	Lines weights
1 to 5	1-3-5	50
1 to 4	1-3-4	40
1 to 3	1-3	20
2to 5	2-5	30
2 to 4	2-3-4	40

RESULTS OF IEEE 14 BUS DISTRIBUTION SYSTEMS

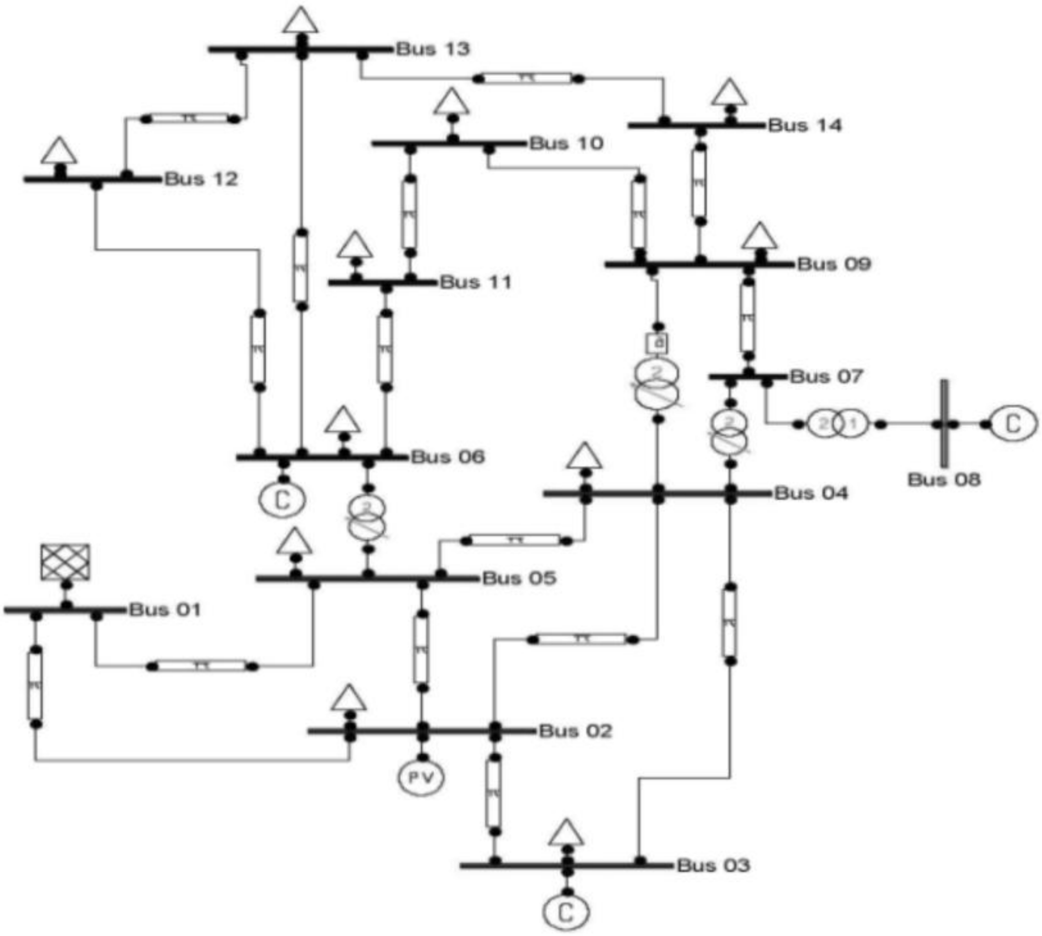


Fig 5: IEEE 14 bus distribution system

Table 4 Line data's for IEEE 14 bus distribution systems

Buses	Line Resistances R (p.u)	Line Reactance X (p.u)	Line Impendece Z (p.u)
1-2	0.01938	0.05917	0.0622
2-3	0.04699	0.1979	0.2034
2-4	0.05811	0.1763	0.1856
1-5	0.05403	0.2230	0.2294
2-5	0.05695	0.17103	0.1829
3-4	0.06701	0.17103	0.1836
4-5	0.01335	0.04211	0.04416
5-6	0.0	0.25202	0.25202
4-7	0.0	0.20912	0.20912
7-8	0.0	0.17615	0.17615
4-9	0.0	0.55618	0.55618
7-9	0.0	0.11001	0.11001
9-10	0.03181	0.08450	0.09028
6-11	0.09498	0.19890	0.2204
6-12	0.12291	0.25581	0.2838
6-13	0.06615	0.13027	0.09355
9-14	0.12711	0.27038	0.1797
10-11	0.08205	0.019988	0.8734
12-13	0.22092	0.19988	0.2979
13-14	0.2219	0.1988	0.3877

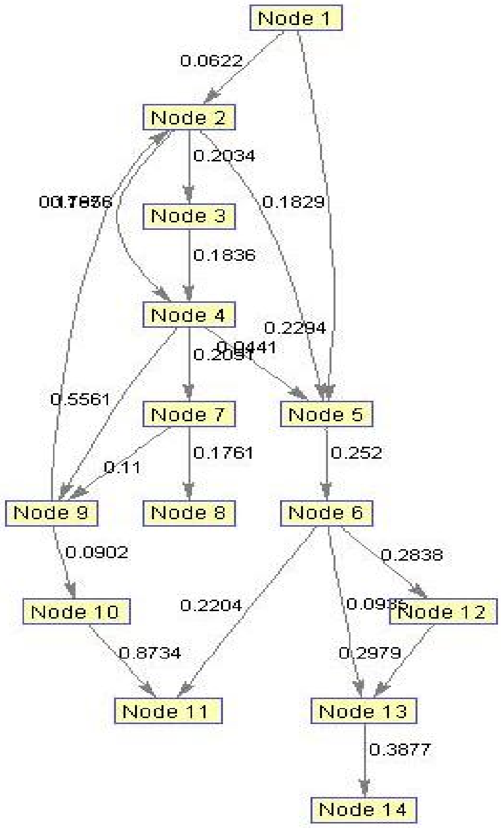
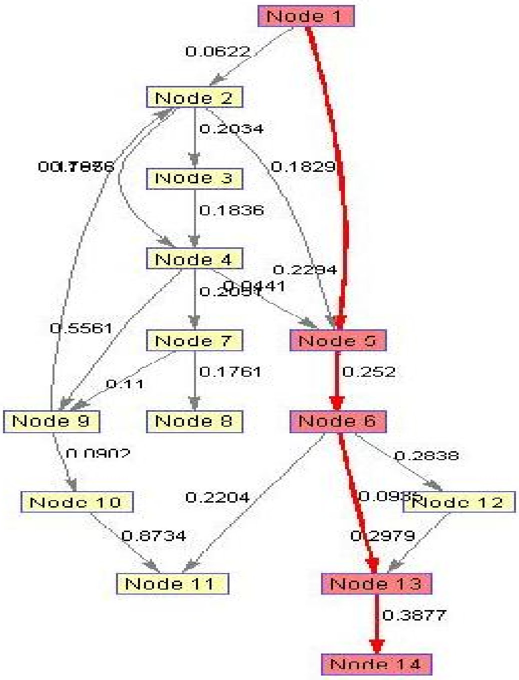


Fig 6: Simulated oriented graph of 14 bus distribution system



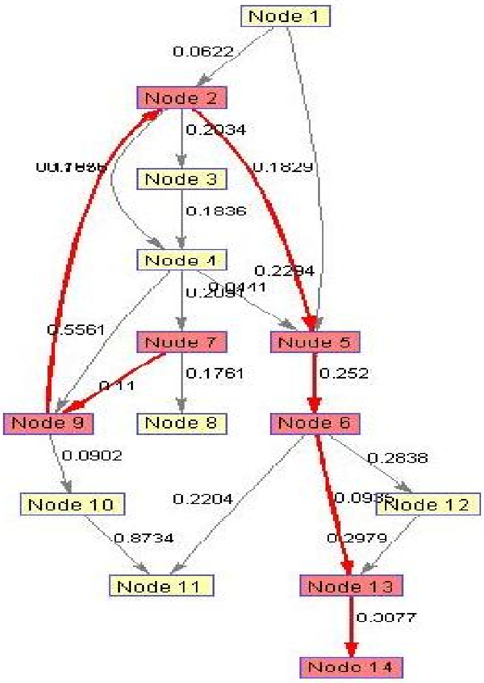


Fig 7: Simulated graph node 1-14 of 14 bus distribution system

Fig 8: Simulated graph node 7-14 of 14 bus distribution system

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Table 5. Line impedances and bus impedance matrix

(1,2)	0.0622
(9,2)	0.1797
(2,3)	0.2034
(2,4)	0.1856
(3,4)	0.1836
(1,5)	0.2294
(2,5)	0.1829
(4,5)	0.0441
(5,6)	0.2520
(4,7)	0.2091
(7,8)	0.1761
(4,9)	0.5561
(7,9)	0.1100
(9,10)	0.0902
(6,11)	0.2204
(10,11)	0.8734
(6,12)	0.2838
(6,13)	0.0935
(12,13)	0.2979
(13,14)	0.3877

0	0.0622	0.2656	0.2478	0.2294	0.4814	0.4569	0.6330	0.5569	0.6571	0.7013	0.7652	0.5749	0.9626
Inf	0	0.2034	0.1856	0.1829	0.4349	0.3947	0.5708	0.5047	0.5949	0.6553	0.7187	0.5284	0.9161
Inf	0.6324	0	0.1836	0.2277	0.4797	0.3927	0.5688	0.5027	0.5929	0.7001	0.7635	0.5732	0.9609
Inf	0.4383	0.7022	0	0.0441	0.2961	0.2091	0.3852	0.3191	0.4093	0.5165	0.5799	0.3896	0.7773
Inf	Inf	Inf	Inf	0	0.2520	Inf	Inf	Inf	Inf	0.4724	0.5358	0.3455	0.7332
Inf	Inf	Inf	Inf	Inf	0	Inf	Inf	Inf	Inf	0.2204	0.2838	0.0935	0.4812
Inf	0.2397	0.4531	0.4753	0.4725	0.7246	0	0.1761	0.1100	0.2002	0.9450	1.0034	0.8181	1.2058
Inf	Inf	Inf	Inf	Inf	Inf	Inf	0	Inf	Inf	Inf	Inf	Inf	Inf
Inf	0.1797	0.3831	0.3653	0.3625	0.6146	0.5744	0.7505	0	0.0902	0.8350	0.8534	0.7081	1.0958
Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	0	0.8734	Inf	Inf	Inf
Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	0	Inf	Inf	Inf
Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	0	0.2979	0.6856
Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	0	0.3877
Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	0

Table 5. Optimal path for IEEE 14 bus distribution systems

Source and destination node	Optimal path	Lines impedances (weights)
1 to 14	1-5-6-13-14	0.9626
1 to 10	1-2-4-7-9-10	0.6571
1 to6	1- 5 - 6	0.4814
1 to8	1 -2 - 4 -7 -8	0.6330
3 to 14	3-4-5-6-13-14	0.9609
5 to 14	5 -6-13-14	0.7332
9 to 14	9- 2- 5- 6- 13- 14	1.0958
7 to 14	7 – 9- 2- 5- 6- 13- 14	1.2058
…	…	…

CONCLUSIONS

This paper presents the use of Dijkstra's Algorithm to find the optimal path for the power flow in IEEE 5 and 14 bus systems under healthy and restoration path under fault condition. The need to provide a restoration plan in minimum time is argument in favor of this technique. By application of graph theory the process had been made simple and user friendly. In order to demonstrate the efficiency of dijkstra's Algorithm, it has been found that by application of dijkstra's algorithm the transmission losses can be reduced to significant extent. It is believed that the results from Dijkstra's algorithm in power system restoration results in better plan, so it can be considered for real time application. The simulation is done with MATLAB graph theory function to identify the optimal path in the distribution system.

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