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Power Loss Reduction by Line Reconfiguration for Efficient Operation of Power System

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Abstract: -- **Energy losses occur in the process of supplying electricity to consumers due to technical and non-technical losses. The technical losses are due to energy dissipated in the conductors and equipment used for transmission and distribution of power. These technical losses are inherent in a system and can be reduced to an optimum level. This paper presents a study on technical losses in distribution system and analysis of the impact of losses in power sector. The technical losses can be reduced by the Line Reconfiguration in distribution system. Line Reconfiguration can be accomplished by placing line interconnection switches into network.In the present work an attempt has been made Line Reconfiguration based upon the minimum peak power loss and minimum voltage regulation using MiPower software and the result obtained has been compared with conventional method.**

Keywords:— **Line reconfiguration, Loss reduction, optimal location, Voltage regulation.**

I. INTRODUCTION

India is world's 6th largest energy consumer, accounting for 3.4% of global energy consumption. Due to India's economic rise, the demand for energy has grown at an average of 3.6% per annum over the past 30 years. In March 2011, the installed power generation capacity of India stood at 173,000MW. The country's annual power production increased from about 190 billion kWh in 1986 to more than 680 billion kWh in 2006. The Indian government has set an ambitious target to add approximately 78,000MW of installed generation capacity by 2012. The total demand for electricity in India is expected to cross 950,000 MW by 2030.

Electricity losses in India during transmission and distribution are extremely high and vary between 30 to 45%. In 2004-05, electricity demand outstripped supply by 7-11%. Due to shortage of electricity, power cuts are common throughout India and this has adversely effected the country's economic growth. However, due to lack of adequate investment on transmission and distribution (T&D) works, the T&D losses have been consistently on higher side, and reached to the level of 32.86% in the year 2000-01.The reduction of these losses was essential to bring economic viability to the State Utilities.

High technical losses in the system are primarily due to inadequate investments over the years for system improvement works, which has resulted in unplanned extensions of the distribution lines, overloading of the system elements like transformers and conductors, and lack of adequate reactive power support.

II.LINE RECONFIGURATION:

System reconfiguration means restructuring the power lines which connect various buses in a power system. Restructuring of specific lines leads to alternate system configurations. System reconfiguration can be accomplished by placing line interconnection switches into network. Opening and closing a switch connects or disconnect a line to the existing network. Network reconfiguration in distribution systems is performed by opening sectionalizing (normally closed) and closing tie (normally open) switches of the network. These switching are performed in such a way that the radiality of the network is maintained and all the loads are energized. A normally open tie switch is closed to transfer a load from one feeder to another while an appropriate sectionalizing switch is opened to restore the radial structure. Branch exchange method which used to apply in this study starts with a feasible solution for distribution network operating in a radial configuration.

During applying reconfiguration technique, the tie switch has to be closed and on the other hand, the sectionalizing switch has to be opened in the loop created, which restores radial configuration. The switch pairs are chosen through heuristics and approximate formulas for the change in losses. Branch exchange process is repeatedly applied till no more loss reductions are available. A radial distribution network can be represented by several loops. This is because, when it is connected, one tie-line can only make one loop, the number of loops is equal to the number of tie-lines [3].

The benefits of feeder reconfiguration include: (i) restoring power to any outage partitions of a feeder, (ii) relieving overloads on feeders by shifting the load in real time to adjacent feeders, and (iii) reducing resistive line losses. There is a voltage difference across the normally open tie-switch in the tie-line. Optimal reconfiguration involves the selection of the best set of branches to be opened, one each from each loop, for reducing resistive line losses, and reliving overloads on feeders by shifting the load to adjacent feeders. However, since there are many candidate switching combinations in the system, the feeder reconfiguration is a complicated problem.

Network reconfiguration involves:

- Formation of new links to minimize the length of the trunk line
- Erection of interlinking lines to change the area of feed from one substation to another and balance the load among substations
- Division of existing feeder to form parallel paths of power flow the nodes to be linked have to be selected by taking the quotient of voltage difference and distance between nodes
- The links have to be chosen so as to create a tree structure.

Merits:

- Consumers can be fed from multiple sources by switching.
- Provides an option to effectively handle the demand.
- Cost effective and payback is also easy.

Improved reliability and power quality – Reliability is the measure of whether electricity is available to users. It includes two elements: 1) adequacy — sufficient powers supply to satisfy demand at all times and 2) security — the ability to withstand unplanned outages of the electric grid caused by events such as tree contact or failure of grid elements due to equipment malfunction or human error. Power quality - the shape of power waveforms is the suitability of electricity for servicing loads.

Power outages and power quality problems can cause severe financial losses for businesses through process disruptions, losses in finished products, equipment damage, lost productivity and failure to meet customer needs. DTC & Line Reconfiguration can provide the very high reliability and power quality that some businesses need, particularly when combined with energy storage and power quality technologies.

Distributed resources further increase reliability by reducing the distance the power must travel and the number of grid components that could fail along the way.

Peak shaving – To the extent that distributed generation operates reliably during standard peak periods, severe weather events and high market prices, it reduces demand on the utility system when power costs are highest and the grid is most congested. Customers can use their generators to participate in demand response programs. And utilities can make use of distributed generation to keep their costs down during the highest load hours of the year.

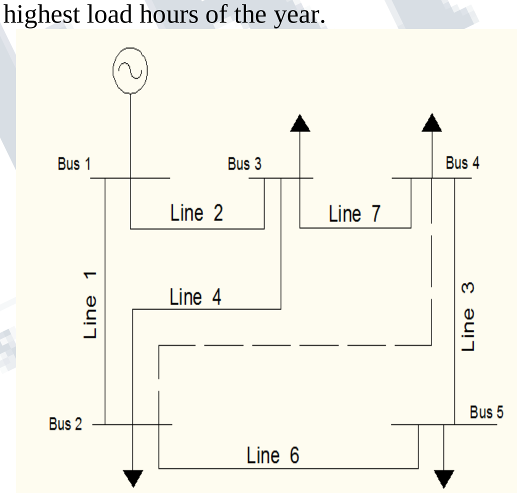

Fig.1 IEEE 5-Bus system

IV.METHODOLOGY

IEEE14Bus System:

Standard 14 bus test network is tested with and without line reconfiguration to investigate the system behaviors shown in Fig.2 and Fig.3 respectively. In the analysis bus 1 is taken as slack bus, bus 2 is voltage control bus and 3-14 are load buses.

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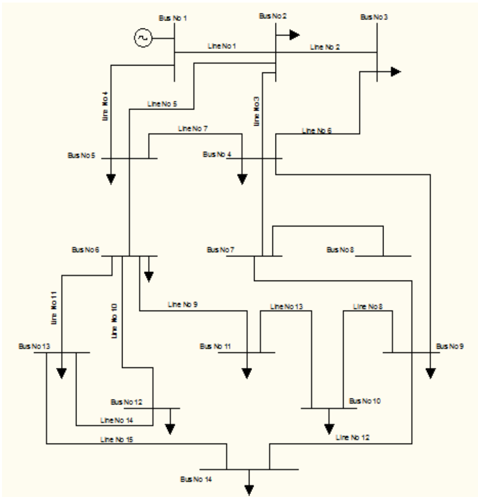

Fig.2 IEEE 14 bus without line reconfiguration

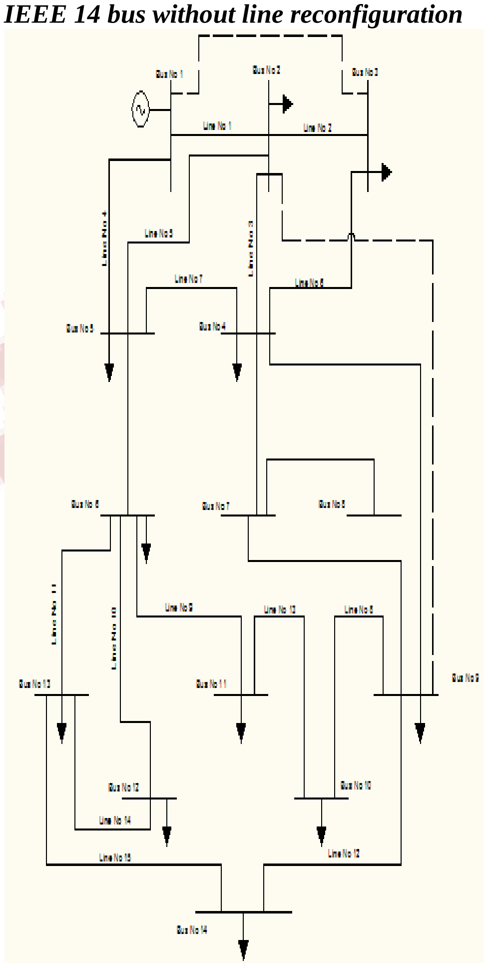

Fig.3 Fig.2 IEEE 14 bus with line reconfiguration

Table.I Ieee14 Bus System Voltage Profile With Different Transmission Line Placement Between Different Location

	Base case	1,2	1,5	2,3	2,4	2,5	3,4	4,5	4,7
Bus no.									
1	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06
2	1.0138	1.065	1.0914	1.0184	1.0054	1.001	1.0149	1.0126	1.0108
3	0.935	0.9887	1.0253	0.9964	0.9461	0.9323	0.9447	0.9351	0.9309
4	0.9506	1.0002	1.0431	0.9757	0.9781	0.9573	0.9455	0.9519	0.946
5	0.9633	1.0096	1.056	0.9828	0.9824	0.9762	0.9596	0.9587	0.9599
6	0.9029	0.954	1.0026	0.9259	0.9264	0.9148	0.8984	0.8997	0.901
7	0.9314	0.9829	1.0279	0.957	0.9592	0.9391	0.9262	0.9321	0.9397
8	0.9341	0.9857	1.0309	0.9598	0.962	0.9419	0.9289	0.9348	0.9424
9	0.902	0.9548	1.0012	0.9279	0.9299	0.9107	0.8968	0.9021	0.9032
10	0.8934	0.9465	0.9935	0.9192	0.921	0.9025	0.8882	0.8929	0.8942
11	0.8945	0.9466	0.9948	0.9186	0.9196	0.9055	0.8897	0.8923	0.8936
12	0.8857	0.9379	0.9872	0.9094	0.9101	0.8975	0.881	0.8828	0.8841
13	0.8802	0.9331	0.9821	0.9045	0.9053	0.8918	0.8755	0.8775	0.8791
14	0.8755	0.9289	0.978	0.9006	0.9019	0.8861	0.8705	0.874	0.8751
MW losses	28.4858	12.8637	11.4533	23.5415	25.5236	27.2945	27.7305	27.8431	28.3352

Table.2 Voltage and Power loss for IEEE 14 bus system

Bus no.	Base case	1,5	L 1-3,2-9
1	1.06	1.06	1.06
2	1.0138	1.0914	1.0881
3	0.935	1.0253	1.0509
4	0.9506	1.0431	1.0643
5	0.9633	1.056	1.0636
6	0.9029	1.0026	1.0325
7	0.9314	1.0279	1.0727
8	0.9341	1.0309	1.0758
9	0.902	1.0012	1.0684
10	0.8934	0.9935	1.0567
11	0.8945	0.9948	1.0369
12	0.8857	0.9872	1.0209
13	0.8802	0.9821	1.0209
14	0.8755	0.978	1.0269
MW losses	28.4858	11.4533	8.2305

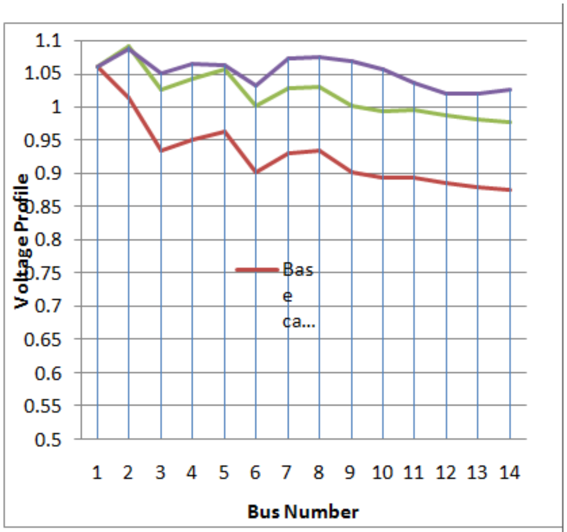

Fig.4 Voltage Profile

V. CONCLUSION

The present work mainly deals with verifying the optimal location line reconfiguration. Then the location corresponding to minimum loss was obtained by simulation using MiPower package. Then considering this location, the location corresponding to minimum voltage regulation was determined and the Line Reconfiguration corresponding to both minimum loss and voltage regulation is considered as Line Reconfiguration between two lines from its original position. In this work, there is a general formulation of the problem of feeder reconfiguration to reduce active losses and balance the load of a radial electric power primary distribution network under normal operating conditions. As the distribution system reconfiguration for loss minimization is a nonlinear optimization problem, it presents an enormous computational burden for even systems of moderate size.

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