HVDS Concept for Distribution Feeder Loss Minimization

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Abstract: In India the quality of power distribution should be improved which is often plagued by increasing load day by day. This paper presents one of the methods to reduce transmission and distribution (T&D) Losses in distribution feeder. High Voltage Distribution System (HVDS) is proposed to reduce T&D losses HVDS proposes to reduce the long length of low tension (LT) lines, encouraging installation of small capacity transformers nearer to users thereby reducing the probability of reducing power theft. The analysis reveals that by converting Low Voltage Distribution System (LVDS) to HVDS considerable losses are reduced.

Keywords: FR, LVDS, HVDS, LT Lines, HT Lines, T&D.

Introduction

Electric Power Distribution system is an important link that connects various stages of power sector such as Generation, Transmission and end users. Being epicenter of power sector distribution system is always in need to maintain balance between generation and increasing load growth. It is because of this reason distribution licensee are always challenged to improve their performance as well as reliability. In order to suffice the ever increasing load growth it is necessary to upgrade distribution infrastructure too. The performance of distribution network is also affected by uncontrolled load growth. To improve this existing distribution system should be analyzed and such provisions should be made so that it can cater future load growth reliably with decreased losses

Power Distribution system has direct impact on commercial sector which indirectly affects consumers who are the users and payers of electricity. In India the generation capacity till January 2016 according to reports of Central Electricity Authority was 91.691 BU's and the Transmission and Distribution Losses for the year 2013-2014 were 21.46% which are much higher. Numerous works are done to reduce losses like feeder reconfiguration, optimal capacitor placement etc.

A number of researches are continuously being done to reduce distribution losses in Distribution system. Feeder reconfiguration for loss minimization was first proposed by Merlin et al [1] which used discrete branch and bound technique involving approximations. Bhavesh Vyas et al [2] have suggested Minimum power flow methodology for reconfiguration of distribution feeder exploring the unique property of current that it flows in path having least impedance. They have proposed the algorithm for same and implemented the same on distribution network of Jaipur City. Salem Elsaiah et al [3] have proposed FR on radial distribution feeder by opening and closing tie switches to attain spanning tree network considering all the constraints such as voltage limits, current carrying capacities and topological constraints of distribution feeder. Yan Xu et al [4] have proposed Mixed Integer Linear Programming (MILP) for optimal capacitor placement. Net present value analysis is also done to estimate cost benefit analysis for the same. Vahid Farhani et al [5] suggested Genetic Algorithm approach to minimize losses in distribution system by optimally placing capacitor along with conductor replacement. L. Ramesh et al [6] have reviewed various techniques which can be applied to reduce power loss in distribution system. K Amaresh et al [7] proposed HVDS technique on Radial Rural Distribution feeder of Andra Pradesh for loss minimization. Md Sarwar et al [8] have proposed HVDS as a measure to reduce distribution losses along with its economic viability on a rural distribution feeder. Various papers have been published dealing with High Voltage Distribution system for rural and urban feeders. [9]-[11]

In the reference of above developments, the paper attempts to apply High Voltage Distribution System on a rural feeder. It tries to explain feeder restructuring under balance load condition thereby reducing technical losses applying HVDS concept. The network losses are analyzed and studied using E-Tap 12.6.

High Voltage Distribution System (HVDS)

The existing Power Distribution system in India consists large 3phase 11kV distribution feeders with 3 phase lines and 11/0.4 kV three phase distribution transformers. Distribution of power on Low Voltage side is done by 3 phase 4 wire, single phase 2 wire lines. The ratio of Low Voltage (LV) and High Voltage (HV) line lengths is approximately 2:1 which causes LT faults and increased losses. As the length of LT is long this leads to decrease in voltages at end which increases losses. In order to improve quality, reliability of supply the LT length should be minimized and HT length should be maximized. As HT will be extended nearer to load with small capacity transformers the losses will reduce. Due to LT 3Phase 4 wire being replaced by

Aerial Bunched Cable unauthorized hooking by consumers is avoided. In the HVDS, long LT lines are converted into 11kV HT mains by installing the small capacity distribution transformer nearer to the load point and the supply is provided to the consumer. By converting the LT lines into HV system, the current flowing through the lines is reduced which reduces I2R losses and brings down the technical losses. HVDS system is one of effective method in reducing the technical losses and improving the power quality.

Merits and Demerits of HVDS in comparison to 3 phase LV system

1. **Line Losses:** The losses in HVDS for distribution of same power are less than that of LVDS due less LT line involved. Thus, the losses in LV side are negligible reducing the total energy losses.
2. **Voltage Drop**: The voltage drop for distribution of same power in HVDS is less than that of LVDS which ensures proper voltage profile at consumer ends.
3. **System Power Factor**: The single phase motors have built in capacitors and PF is more than 0.95. This high PF causes low energy losses and better voltage profile.
4. **Failure of Distribution Transformers**: The failure of distribution transformers due to LV line faults is eliminated as the length of LT lines is minimized and usage of Aerial Bunched Cables (ABC) system. The over loading of transformers is also avoided
5. **Theft of Energy**: The LT lines are virtually eliminated and even short LT lines required are with AB Cables. This makes direct tapping very difficult.
6. **End Use Equipment:** Due to better voltage profile, the efficiency of end use equipment is high, thus leading to energy conservation.
7. **Reliability of Supply**: The failure of transformer will affect only a small number of consumers served by it, thus the reliability of supply is maintained as only small portion of consumers are affected.
8. **Voltage Fluctuations:** As voltage drop on LV lines is negligible and voltage profile is very stable. Any voltage fluctuations occurring can be remedied by installations of Automatic Voltage Regulators on HV line.

Test Case

For implementing the HVDS Concept, an 11kV Mixed Load Feeder of Dadra Nagar Haveli is considered. The feeder being Mixed Load feeder feeds 35 distribution transformers having 183 peak amp peak load with a length of 29 kms with total connected load of 6.845 MW. Fig 1 shows the feeder under consideration for the study.

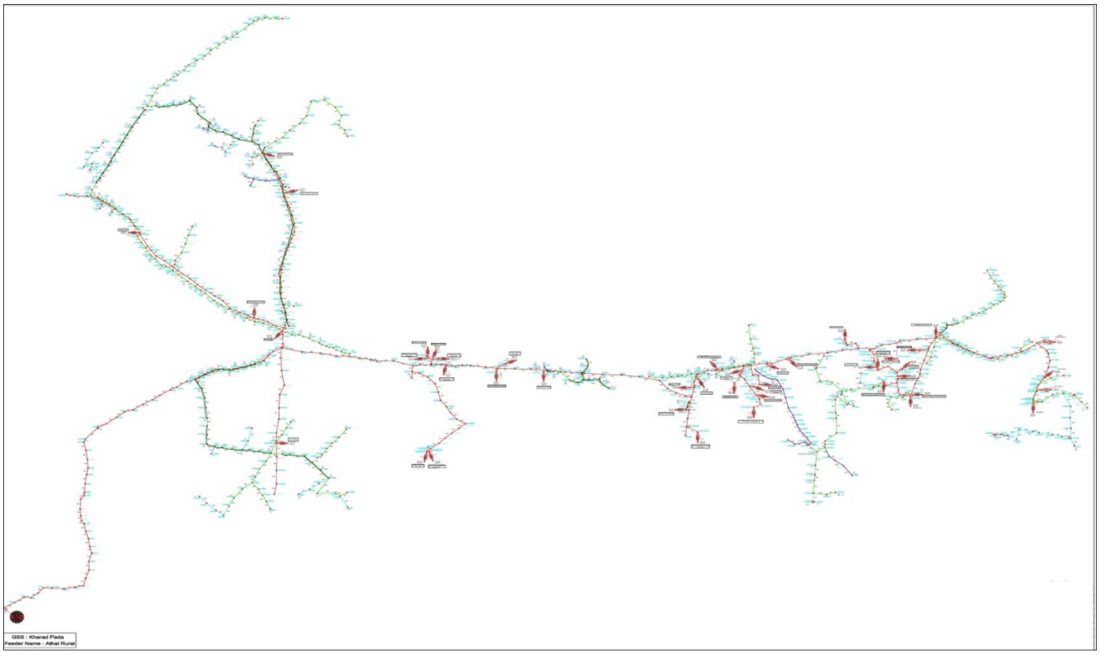

Fig. 1 Actual 11kV Feeder Map

Feeder Network along with LT lines will be modeled in E-Tap. The existing lines feeding the consumers will be converted to 11kV line on existing poles by modifying the fixtures with consumers fed through low capacity transformers 10/16/25kVA Rating. The loads on transformers are considered balanced ones for analysis purposes.

Converting the existing feeder to proposed HVDS the numbers of Distribution transformers have increased along with increased length of HT.

Test Results

The Load flow analysis is performed to evaluate the technical losses for the existing network and the proposed HVDS scheme under different loading conditions considered.

Distribution Network Analysis

The analysis of existing system in E-tap12.6 is shown. The simulation model of the existing feeder and modified feeder are run for Adaptive Newton Raphson load flow analysis in E-tap. The analysis shows that due to long lengths of LT the voltage profile of tail end consumers is low which leads to increase in the technical losses in the feeder. Fig.2 shows the HT Bus voltage profile of existing feeder and Fig.3 shows the LT Bus Voltage Profile.

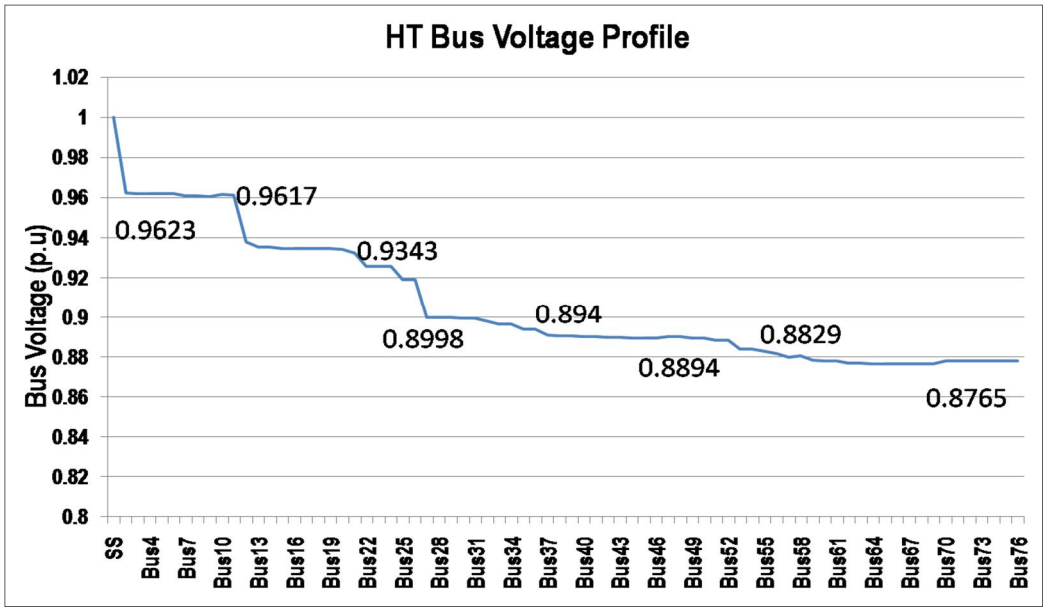

Fig. 2 HT Bus Voltage Profile of Existing Feeder

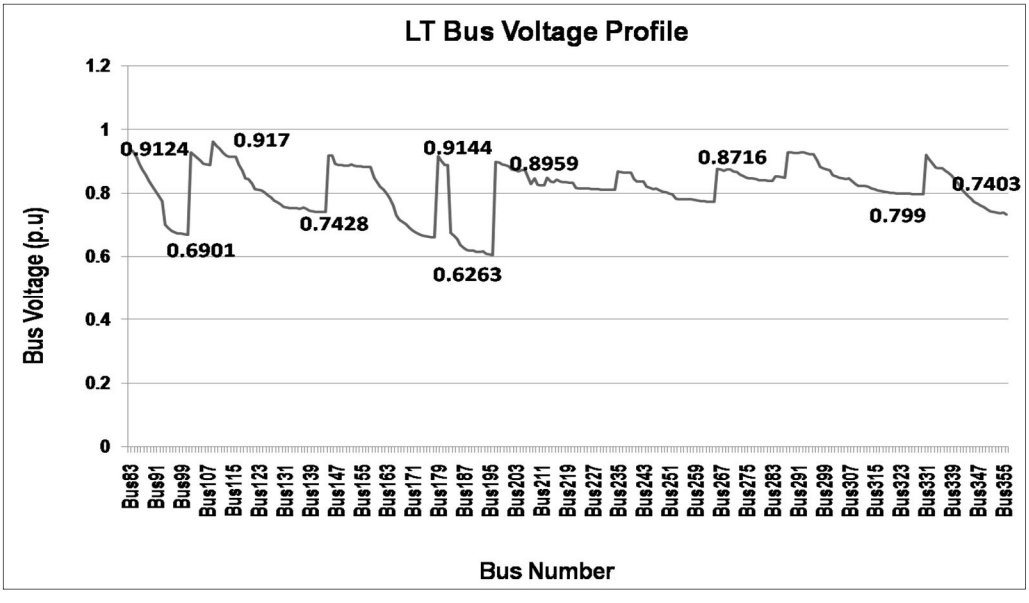

Fig. 3 LT Bus Voltage Profile of Existing Feeder

Due to increase in HT line length and reduction in LT lines the voltage profile at tail end consumer in proposed scheme shows improvement which is presented graphically. Fig 4 shows the HT bus profile and Fig 5 shows the LT bus profile respectively of proposed HVDS System.

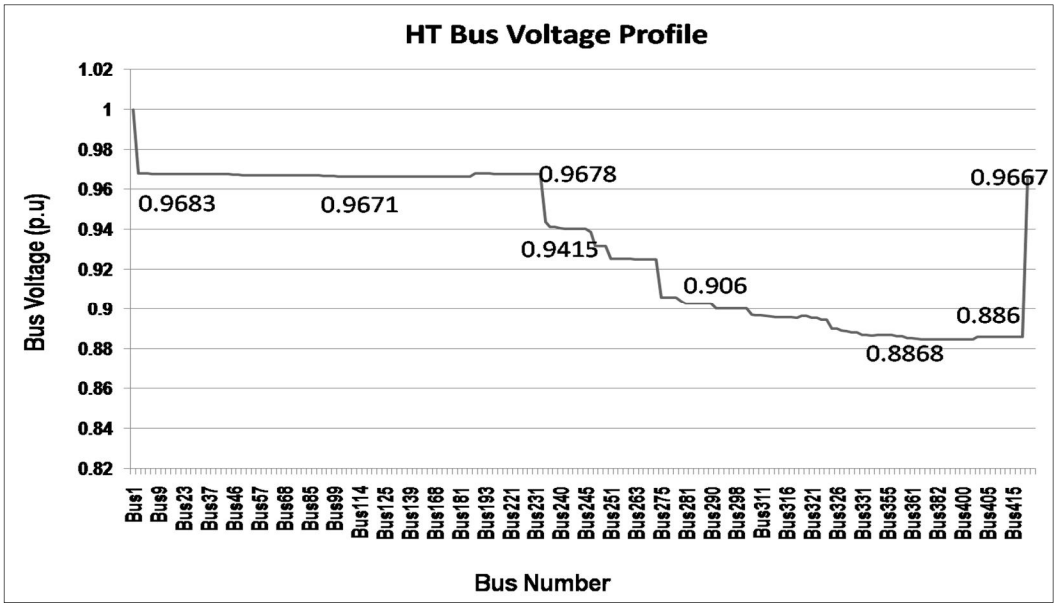

Fig 4 HT Bus Voltage Profile of proposed HVDS

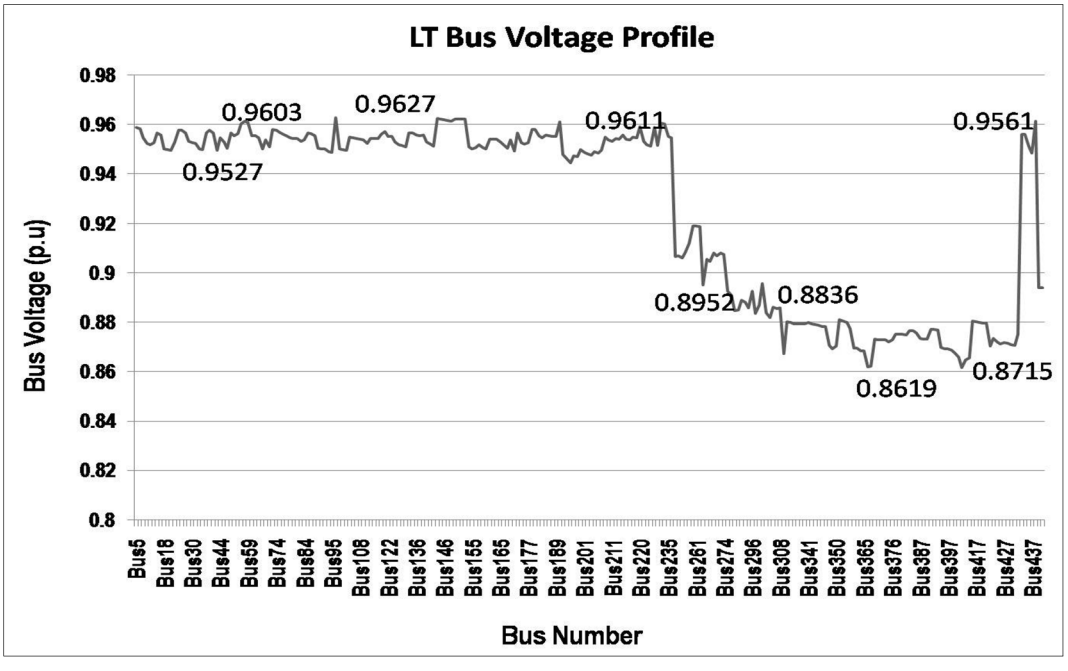

Fig. 5 LT Bus Voltage Profile of Proposed HVDS

As can be seen from the Figure 3 and figure 5 there is a considerable improvement in Voltage at the LT side. This improvement ultimately leads to improved voltages at tail end consumers thus improving efficiency. Conversion of Existing Feeder to Proposed HVDS resulted in decrease in transformer loadings as well as line loadings.

Analyzing the existing and proposed HVDS scheme shows net reduction in distribution line losses is shown in Fig 6. It can be seen from graph that existing feeder losses at full load are 18.63% which get reduced to 15.05% in proposed scheme. Similarly at 70% loading the losses decreased from 11.15% to 9.15% and at 50% from 8.20% to 6.18% respectively.

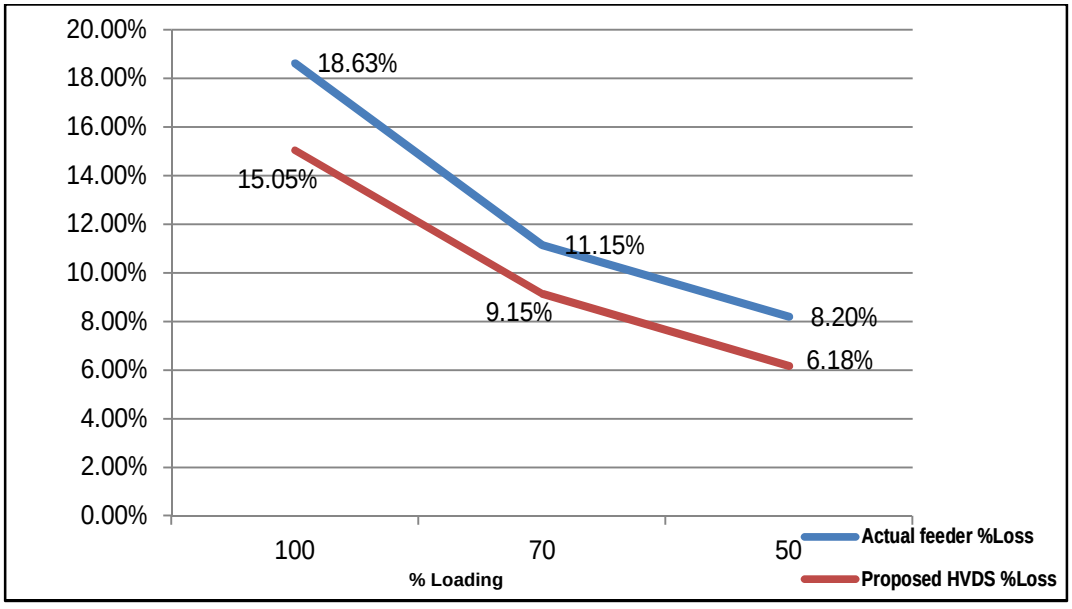

Fig 6 Loss Analysis at various loadings

Conclusion

The paper tries to describe HVDS system for minimization of distribution losses. HVDS led to development of new methodology of energy management for loss minimization. Adopting HVDS for the case study lead to efficient energy distribution and proper utilization of electricity. From Loss Analysis it can be shown that by converting existing feeder to HVDS there is considerable reduction in losses and pilferage. The study can be further extended to calculate Economical and Commercial feasibility of proposed scheme.

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