First International Conference on Emerging Trends in Engineering, Management and Scineces, December 28-30, 2014 (ICETEMS-2014) Peshawar, Pakistan

Performance Evaluation/Analysis of 132kV Transmission System in on the Basis of Voltage Regulation, Voltage and Power Deviation Index and Voltage Stability Indices

Anis Ur Rehman
Department of Electrical Engineering, City University of Science and Information Technology, Peshawar,Pakistan
haroon.uetp@yahoo.com

Muhammad Jehangir khan
Department of Electrical Engineering, City University of Science and Information Technology, Peshawar,Pakistan
mjehangir_pk@yahoo.com

Muhammad iftikhar Khan
Department of Electrical Engineering, University of Engineering and Technology, Peshawar, Pakistan
Miftikhar74@gmail.com

Abstract

In today modern interconnected power system, High Voltage Transmission lines carries bulk power from generating Stations to Grid stations and also from Transmission grids to distribution Substations. Performance of these lines is considered better if the line losses and voltage drops are in limits. There is also less variation in Power delivered in some specific duration and low Voltage deviation index and system instability. Voltage drops and %regulation of Transmission line depends upon resistance and inductive reactance. Power delivered in MW varies due to load variation or then power availability on grid. Transmission system is imbalanced if there are unequal voltages on receiving side and currents of different magnitudes in three phase system. Peshawar Grids are interconnected to make them reliable and more efficient. This paper presents performance comparison of more than fifteen transmission lines on the basis of line % Regulation, Voltage drops, Voltage deviation and stability indices. Transmission lines with poor performance should be upgraded. Statistical data of all Transmission lines were simulated in commercially available MATLab environment to achieve results.

Keywords: Performance of Transmission lines, Line parameters, Voltage deviation index, line percent Regulation, stability indices**.**

1. Introduction

High Voltage transmission system is popular for transmitting bulk power from grid to grid located near to each other. In Pakistan we have EHV and High Voltage transmission system. Here the maximum voltage level is 500kV used for long or medium lengths and hundreds of MW transmission. While for short distances normally less than 80km (V. K Mehta, 2000)we prefer 132kV voltages that comes in HV category. Performance of these transmission lines should be such that system may be reliable and efficient. Transmission line performance is normally based on Line losses, Voltage drops, Transmission line efficiency and stability of line. In imbalance conditions with high line losses and voltage drops the transmission line performance becomes poor and availability and stability of the system is challenged.

Every transmission line exhibits many electrical properties, where the most common properties are inductance and capacitance. The capacitance and inductance in a transmission line depend on the line configuration itself. These two electrical properties are significant in the expansion of transmission line models used in power system analysis (HadiSadat, 2000). Capacitance is neglected in short transmission line but the inductance and resistance are the parameters which should be considered. Performance of the Transmission lines should be assessed in order to improve system efficiency and make the system stable and balanced by reducing unbalanced voltage drops.

In Peshawar more than fifteen such Transmission lines making a reliable and efficient Power system.This is fact about the Peshawar grids that more than 90 percent transformers and Transmission lines are overloaded according to (N-1) security criterion (H.Abdalla.Et al, 2010). Most transmission lines due to this overloading waste electrical energy in form of technical line losses, which increased very seriously with an increase in load current. There are thirteen 132kV Grid Stations in Peshawar to deliver average 400MW in summer. For performance based on stability we use different stability indices like L-index, power margin and Power transfer stability index etc. transmission lines indices are calculated by any of these methods and approaches and assessed that if the value is 0 means the voltage collapse occurred in case of power margin (D. Ananth, 2012). However in case of L-index and PTS index if the index value is 1 means that voltage collapse occurred. The values would be between zero and one.

In this paper the performance of 132kV transmission lines in Peshawar is presented from voltage drops, Voltage deviation index and stability indices perspective. From Line voltage drops the percent voltage- regulation were estimated for each transmission line. Line parameters were calculated by analytical approach and Voltage deviation and stability indices concepts applied to here to compare the voltage collapse and average deviation in bus voltages at receiving grids. Simulation was performed in MAT Lab environment. This is investigated that line with low VDI and low % V-regulation is performing better compared to other and stability indices are if poor, means that line is to be up graded.

2. Literature Review

A lot of related work has been done to investigate the performance of transmission line, system stability and imbalanced lines. For Voltage drops we have known parameters like Resistance and inductance. Transmission line parameters may be determined by an analytical method but it is long computational method, time consuming and difficult for complex and large systems. Finite element analysis (FEA) method proposed in (Azil ILLIAS, et al, 2012), that can also be used to calculate the inductance and capacitance of transmission lines in general

without the requirement of many complex calculations.In (Enrico, et al, 2010) Zio Enrico, P. Roberta D. Maurizio analysed the performance of Electric power transmission system under instable and uncertain load conditions. Load flow problems were studied in this article in presence of load and power generation uncertainties. Monte Carlo sampling techniques were used for accounting the line failure which alters the transmission system configuration.

Literature (Edwin B. Cano, 2011)presented the impact of modelling overhead Distribution feeders in parallel arrangement. The modelling of this kind of circuits are significant because such modelling can impacts technical line losses, voltage drops and voltage unbalance at receiving sides. In case study distribution feeders were taken individually as well as parallel circuits combined arrangement and were simulated. Edwin analyse line losses, line drops and voltage unbalance by load flow method.M. Nizam, Azah Mohamed and AiniHussain worked in (Muhammad Nizam, et al, 2006)to evaluate the performance of several voltage stability indices namely the power margin, L-index and VCPI used for the dynamic voltage collapse analysis in electric system. A new stability index, power transfer index was proposed which was compared with previous indices on 9 bus and 30 bus test system. Comparison shown that PTS index is better in prediction of dynamic voltage collapse.Julian al work (Julian, et al, 2000)discussed the power margin index used to track the closeness to voltage collapse. This index is formulated by distance of complex or apparent power of bus. Here the proximity to voltage collapse is expressed in terms of distance between two impedances curves or then voltage curves. Huang. G.M and N.K. Nair used the Line index (L-index) concept for the determination of dynamic voltage collapse in power system (Huang, et al, 2001).

3. Methodology and Implementations

Performance investigation of High voltage transmission lines is necessary for the efficient transfer of bulk power to load side. 132kV transmission lines performance can be investigated by several parameters but in this paper we are going to discuss the % voltage regulation, Line drops, Voltage deviation index and different stability indices like L-index and power margin. All these parameters are here formulated to evaluate the results for comparison of more than fifteen Transmission lines in Peshawar region. The line with low VDI and % regulation is considered in better condition and vice versa. Stability indices are evaluated to analyse the dynamic Stability voltage collapse. So if the indices values are higher it means that line performance is poor and the system is near to collapse.

3.1 Voltage Drops and % Voltage Regulation

Voltage drops are due to the Transmission line resistance, inductive reactance and capacitive reactance. Usually the 132kv transmission lines with less than 50km length have very low capacitance and this is why we neglect capacitive reactance effects in short transmission lines. When currents flows through these parameters there is voltage drop in each phase of the three phase transmission system. If the load is balanced, the voltage drops are balanced as well. Using eq. (1) we can assess voltage drops. % regulation is calculated on the basis of these drops in case of no load on the Transmission system and fully loaded transmission system or transformers. % regulation is calculated from eq. (2). It is the difference between No load voltage and Full load voltage divided by No load Voltage (V. K Mehta, 2000).

$$Voltage\ Drops = I(R + jX) \quad \text{Eq. (1)}$$

Where I is the full load current:R is the resistance of transmission line in Ω:X is the inductive reactance in Ω:

$$Vr = Vs - I(R+jX)$$

$$\%\ V\_Reg = \left(\frac{IRcos\,\phi r + IXsin\,\phi r}{Vr}\right) \text{Eq. (2)}$$

Utilizing these formulae all transmission lines voltage drops and % v-regulation is tabulated in Table 1. It presents eighteen 132kV transmission lines data about Line resistance, inductive reactance, and maximum load in Ampere recorded on line. The power factor of the transmission line showing nature of the load. % Voltage regulation was calculated and can be easily read out from table. Transmission line in double circuit form connecting Shahibagh with Peshawar city have very low % voltage regulation. It is also cleared that Line from Warsak power house to Peshawar Cantt have higher %regulation and it is unstated that line have high voltage drops.

3.2 Voltage Deviation Index

Voltage deviation index (H.Abdalla. Et al, 2010)provide information about the voltage variations between the nominal bus bar voltage in kV and actual voltage at the bus bar of grid. It is expressed in kV.Higher the VDI lower will be the grid performance in Voltage profile and vice versa. By following mathematical expression we can find VDI. It is the square root of the sum of all squares of the differences between bus bars nominal or rated voltage and bus bars actual voltages divided by total number of bus bars in grid.

$$VDI = \sqrt{\left(\sum_{1=1}^{n} \frac{(V-Va)2}{B}\right)} \quad \text{Eq. (3)}$$

Where, V is the bus nominal voltage in kV:Va is the bus actual voltage in kV: B is the total number of buses in grid:

3.3 Power Deviation Index

Power transfer through transmission line to the load varies instantly depends upon the availability of MW generation capacity. Power deviation is actually the variations in MW power on Grid. It is the difference between the average power in MW and deviation of line power at specific instant. Power Deviation index is the sum of all the deviations from average MW power of individual line divided by number of specific durations. Each Transmission line is used for export and import of bulk electric power. We investigated MW power on each line

at eight instants, from 00:11 to 21:11. The grid or line with higher variations in power delivered lower will be the performance of line and more will be the instability chance.

$$Avg.Power\ deviation\ index = \frac{Sum\ of\ all\ the\ deviations\ from\ Average\ MW\ power}{No.of\ durations\ per\ day}$$

3.4 Power Transfer Stability Index (PTSI)

Instead of using other approaches for voltage stability and collapse prediction it is better to use PTSI as discussed earlier. PTSI may be formulated as under based on the two buses consists of equivalent Thevenin voltage source, load and line Thevenin impedances and cosine of phase angles difference between Thevenin and load impedances. Its value may be between zero and one. The line with index value near to 1 is considered in poor condition because

TABLE. 1 TECHNICAL TRANSMISSION SYSTEM DATA OF PESHAWAR GRID

Name of 132kV T/Lines	***Load Current I (A)***	***Phase Voltages V_R (kV)***	***Percent Regulation***	**Voltage Deviation Index**	**Power deviation index**	**PTSI**
WSK-SBGH1	375	74.48	4.13	6.30	2.61	0.138091
WSK-SBGH2	300	74.28	3.78	4.00	5.50	0.110751
WSK-P_{CANTT}	450	73.9	5.18	6.30	6.77	0.18377
WSK-JMR	420	73.32	4.88	7.07	5.69	0.146777
S/M-MTN	250	76.787	1.89	4.95	2.21	0.088422
S/M-P_{CY}	285	77.36	0.99	4.24	11.15	0.001924
S/M-P_{IND}	280	76.498	2.53	8.10	3.17	0.01198
S/M-RHB	285	73.612	1.06	3.77	10.5	0.053192
S/M-P_{UN}	420	75.92	2.42	8.01	2.28	0.00194
JMR-P_{UN}	160	73.32	0.62	7.07	2.94	0.000412
P_{UN}-P_{CANTT}	180	74.478	1.49	6.30	N/A	0.054931

SBGH-PFT1	140	75.632	0.24	6.13	2.36	0.010476
SBGH-PFT2	110	75.632	0.18	6.13	2.5	0.008799
SBGH-DLZK	500	74.478	1.15	4.00	6.21	0.00038
P_{IND}-S/M	352	76.498	3.12	N/A	3.17	0.029381
JMR-HYTAB	220	75.63	0.49	6.60	2.91	0.019802
PUN-PIND	1.432	3.82	4.04	25.15	0.96	0.000819
PIND-S/M	3.156	8.428	9	26.928	0.88	0.003055

It is approaching voltage stability collapse and if value is zero then it is in no load condition while value between 0 and 1 shows stable power system (D. Novosel et al, 2000)

$$PTSI = \frac{2ZthS_L}{Eth^2}\{1+\cos(\beta-\alpha)\} \qquad \text{Eq. (4)}$$

Where, PTSI stands for Power transfer stability index: Zth and Eth are Thevenin equivalent impedance and Voltage source. Here we are applying this index of stability instead of using all stability indices to compare the performance of 132kV Transmission lines.

4. Results and Discussions

By analytical methods of calculating voltage drops, % line regulation, Voltage deviation index, power deviation index and finally voltage stability indices we compared all 132kV transmission lines and it is investigated that Transmission lines connecting Peshawar industrial Grid Station to Sheikh Muhammadi Grid Station have 8.01 VDI. Similarly the line connecting Peshawar University Grid with Sheikh Muhammadi as well as Peshawar industrial have 8.01 VDI and hence performance of these lines on the basis of Voltage deviation index is poor. The line Sheikh Muhammadi to Rahman Baba Grid have low VD index and better performance.

Figure. 1 clearly presented that double circuit Transmission line between Shahibagh and Peshawar Fort Grid have low % regulation and shown that here the voltage drops are lower than other lines of Peshawar transmission system. The 132kV H.V line carrying MW power from Warsak Power house to Peshawar Cantt have poor performance on the basis of % regulation, because showing 5.88 and is the highest value in all over Peshawar Grid.Power deviation index for the transmission line should be less for better performance.

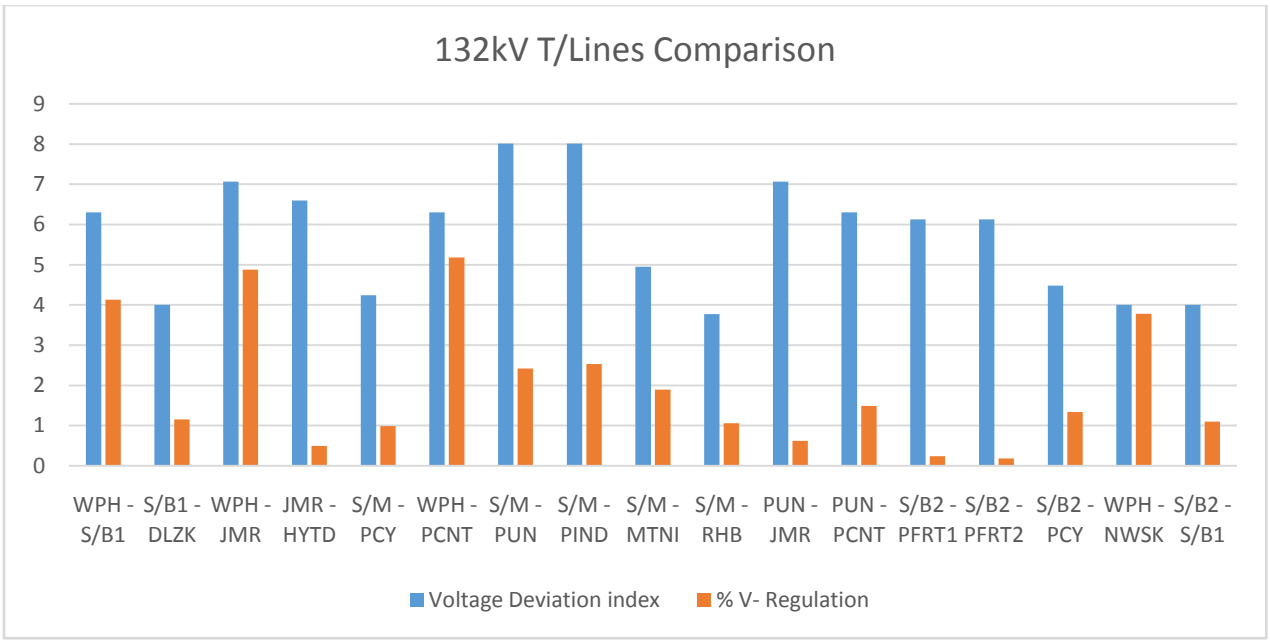

Figure.1 132kV Transmission Lines Comparison in terms of % regulation and VDI

From figure. 2 we have estimated two lines with high power deviation index and in specific durations of day MW varies which greatly impacts the efficiency of power line. Peshawar city and Rahman Baba both are Grids having greater than 10 of PDI. Both are importing power from Sheikh Muhammadi Grid and have 11.15 and 10.50 index respectively.The Figure. 2 discuss the Active power in MW deviation from average Power the Grid is Transmitting to Load through HV transmission Lines in Peshawar region. It is clearly declared that higher the Power deviation index values poor will be the transmission line performance.

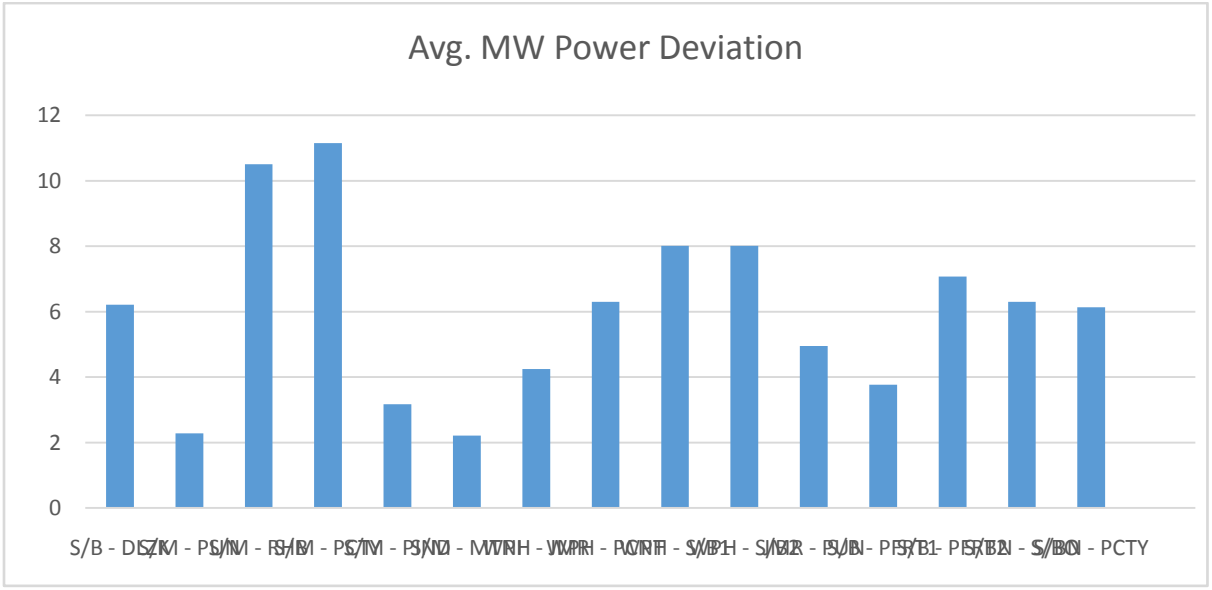

Figure. 2 132kV Transmission Lines comparison by Average MW Power Deviation

Here the Line connecting Sheikh Muhammadi Grid to Peshawar City Grid have PDI of 11.15 and HV Line Dispatching power from Sheikh Muhammadi to Rahman Baba Grid have 10.5 values. These values shown that here the power demand or power transfer capability is continuously varying during specified or selective period. Power Transfer Stability Index based comparison of Power carrying Overhead Lines is presented below in Figure. 3, which clearly demonstrated that Lines from Jamrud to Peshawar University,

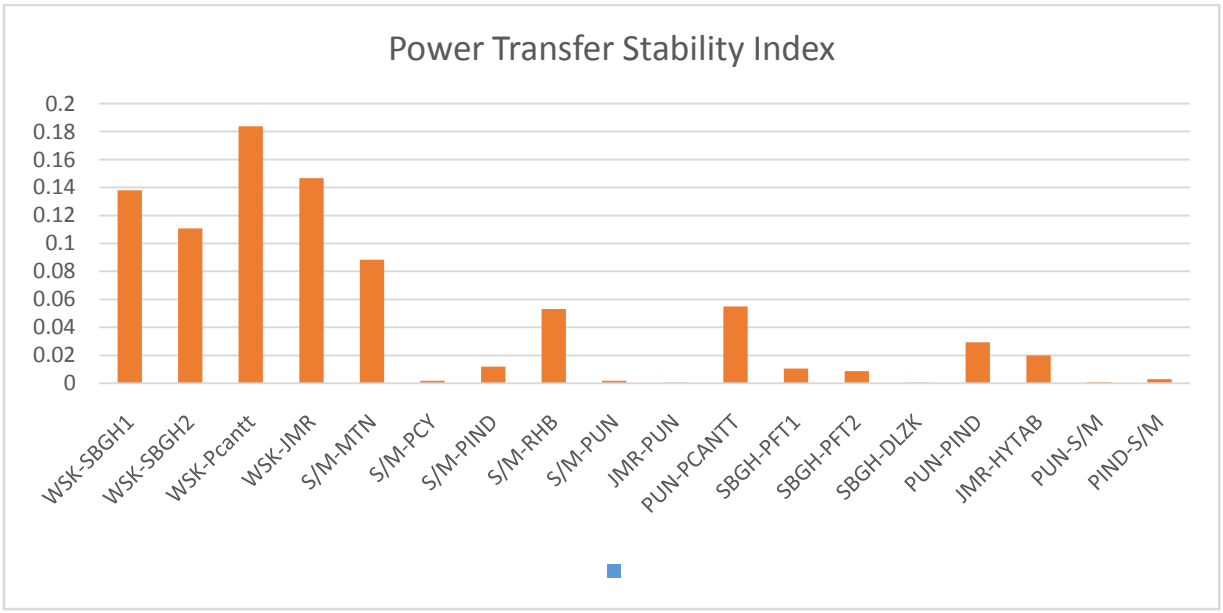

Figure. 3 Transmission Lines Power Transfer Stability index based Comparison

Sheikh Muhammadi grid to Peshawar University, Sheikh Muhammadi to Peshawar City, and Shahibagh to Dalazak have higher performance due to low values or values approaching zero. While some Lines have considerable values and greater than 0.15 of PTS index hence its performance is comparatively poor.

5. Conclusion

The performance analysis is necessary of high voltage transmission line in large interconnected transmission system connecting Grids. Performance of these lines is evaluated on the basis of different performance parameters. This research work presents such type of performance analysis of transmission system in Peshawar. The work is based on % voltage regulation of Transmission lines, Voltage deviation index in grids, Power deviation index and power stability index. Transmission lines with better performance means lower % regulation values, lower VDI, Low PDI and higher values of PTSI and vice versa. The work offers opportunity for future work to analyse the distribution system performance on the basis of above mention performance parameters and also considering Losses and efficiency of distribution feeders in Peshawar.

References

V.K Mehta and Rohit Mehta, (2000) "Principle of power system"2nd edition,

Hadi.Sadat, Power System Analysis,(2000).2nd edition. McGraw-Hill

HazleeAzil ILLIAS, AbHalim ABU BAKAR, Hazlie MOKHLIS, SyahirahAbd HALIM, (2012), "Calculation of inductance and capacitance in power system transmission lines using finite element analysis method"(Electrical Review), ISSN 0033-2097, R. 88 NR 10/a.

Omar H.Abdalla, Hilal S. AI-Hadi, and Hisham A. AI-Riyami, "Performance of Oman Transmission System with Distributed Generation". IEEE transaction, 2010.

D.V.N.Ananth, (2012) "Some Studies Based On Red, Load Modelling, Line Outage Using Voltage Stability Analysis", International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-3, July.

Zio Enrico, P. Roberta D. Maurizi0, (2010), "Performance Analysis of a power transmission system under uncertain load conditions and network configurations", SSARS 2010, summer safety and Reliability Seminars, June 20-26, 2010,Polamd.

Edwin B. Cano, (2011) "Line losses, voltage drop and voltage unbalance on Parallel overhead distribution lines".

Muhammad Nizam, Azah Mohamed and AiniHussain, (2006) "Performance evaluation of voltage stability indices for dynamic voltage collapse prediction", Journal of Applied Sciences 6 (5), 1104-1113.

Julian, D.E, R.P. Schultz, K.T. Vu, W, H, Quittance, N.B. Bhatt and D. Novosel, (2000). Quantifying proximity to voltage collapse using the voltage instability predictor, PROC.IEEE, PES summer Meeting, Seattle WA, 2:931-936

Huang, G.M and N.K.C. Nair, (2002).Detection of dynamic voltage collapse. Power System Engineering research Centre. www.pserc.wisc.edu/ecow/get/publication/2002 public dynamic_summer.pdf.