International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-9 Issue-2, July 2020

Voltage Profile Improvement & Loss Reduction using Optimal Allocation of Svc Based on Fvsi

Srilakshmi R, Chayapathi V, Anitha G S

Abstract*; Power sector is one of the factors that play an eminent role in the economic progress of a country and India has got a distinguished power sector with sources of power generation from feasible renewable energy resources to non-renewable energy resources. Owing to the fact of increasing day to day demand in power sector, integration of renewable energy sources, increased usage of non linear loads etc. results in voltage fluctuations, which in turn affects most of the customer's load and their electricity bills too. If these voltage problems are not treated properly it may lead to serious conditions like voltage instability. Hence firstly in order to meet the increase in demand either new transmission line should be opted or the existing transmission line should be analyzed whether it is capable of handling increased load or not. Secondly to resolve Voltage fluctuation issues compensating devices should be used. Hence in this paper an effort is made to address both of the aforementioned issues, a 10-bus system is checked for existing transmission line performance under normal condition then for increased load condition , followed by an effort to shed light on the voltage profile improvement and loss reduction using SVC and also enlightens about the optimal allocation of SVC based on FVSI in a compact form.

Keywords: FACTS, FVSI, Load flow Analysis, Optimum allocation, SVC, voltage profile

I. INTRODUCTION

With different operating conditions and varying load, the voltage profile monitoring , loss reduction and there by improving the performance of the power system has become one of the challenge to power system engineers.

With the technical advancements, many FACTS devices are available which can handle the power system issues. One such FACTS device is SVC (Static Var Compensators).SVC is a shunt connected FACTS device that improves bus voltage profile [2].The Performance of SVC can be maximized if it's allocation is done properly [1].This paper gives a complete analysis of how the allocation affects the performance of SVC using a 10-bus system. Proper allocation has been done using FVSI, VPII indices [5] and a load flow analysis is carried out on MI power platform.

Manuscript received on May 25, 2020.
Revised Manuscript received on June 29, 2020.
Manuscript published on July 30, 2020.

***** Correspondence Author

Srilakshmi R*, Department of Electronics & Communication Engg., Jyothy institute of technology, Bangalore, Indis. srilakshmi.r@jyothyit.ac.in

Dr.Chayapathy V, Department of Electrical & Electronics Engg. RVCE, Bangalore, India. chayapathiv@rvce.edu.in

Dr.Anitha G S, Department of Electrical & Electronics Engg. RVCE, Bangalore, India. anithags@rvce.edu.in

II. METHODOLOGY

This section gives a brief idea of the procedure followed throughout this work.

1. Firstly the load flow analysis (Newton Raphson method) is carried out for the test system under normal load and overloaded condition.The results of this gives information about load bearing capacity of each bus and will be helpful in loading the power system in a better way.
2. Calculation of FVSI indices and weak buses are identification.
3. The test system was then tested by allocating SVC at each of the identified weak bus and also VPII and loss reduction is calculated.
4. Depending on the VPII and loss reduction values the optimum bus location is identified for placing SVC.

III. DESCRIPTION

This part of the paper gives a brief description of the test system considered(10-Bus system) its specifications followed by a small explanation of SVC and finally the indices used to identify the weak buses and for voltage improvement along with the corresponding formulae.

A. Static var compensator

SVC is a Shunt connected FACTS device that improves the voltage profile of the system. To maintain proper system voltages, SVC either absorbs or injects reactive power into the system.

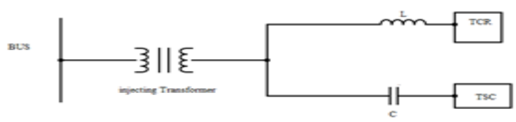

Fig 1. Static Var Compensator

B. Fast voltage stability indices (FVSI)

Based on the results of power flow studies of a transmission line, a researcher named Musirin derived these Indices.

In an interconnected network this indices would determine voltage collapse point, weak bus and most critical lines.

For instant if we consider a 2-bus system bus i, bus k then FVSI index is given by

$$FVSI = \frac{4Z^2Q_K}{V_i X} \rightarrow (1)$$

Where Z is impedance of the transmission line in ohms, Qk is reactive power at Bus k, Vi is the voltage at bus I, X is reactance of transmission line. For a particular line FVSI is calculated using (1) and if FVSI value is nearer to unity it indicates line is vulnerable that is stability limits are violated and that particular bus is considered to be weak bus.

Thus for a healthy line the FVSI value should be as low as possible.

C. Voltage profile improvement indices (VPII)

Proper allocation is very important for the effective performance of SVC.Voltage profile improvement index is used to determine the proper location point of SVC.

$$VPII = \frac{(VP_0)withSVC}{(VP_0)withoutSVC} \quad (2)$$

Where, $VP_0 = \frac{1}{n}\sum_{i=1}^{n} VP_i \qquad (3)$

VPi is the voltage profile at considered ith bus, Where VPo is complete system VP index & n is the load buses number in the network. If the VPII value is less than 1, then it indicates drop in the Voltage Profile & if it is greater than 1, it indicates enhancement of Voltage profile with the usage of SVC. If VPII is equal to 1, then it indicates there is no effect of SVC on the network. Greater the VPII directs healthier the Voltage Profile.

D. Test system

A 10 bus test system is simulated in MI power as shown in the fig 2. The test system consists of three generators, seven transmission lines, three transformer and three loads. Per unit transmission line series impedance and shunt susceptances are given on 100MVA. Bus 1 is the 16.5kv, Bus 2 is 18kv, and Bus 3 is 13.8kv, voltage of bus number 4 to 10 or 230 kV as shown in Table–I. System frequency is 50Hz. Bus 1 is considered as slack bus. Load flow analysis is done using Newton Rapshon method, with tolerance value of 0.001 for normal case. Over loading case when reactive power is 475mvar.

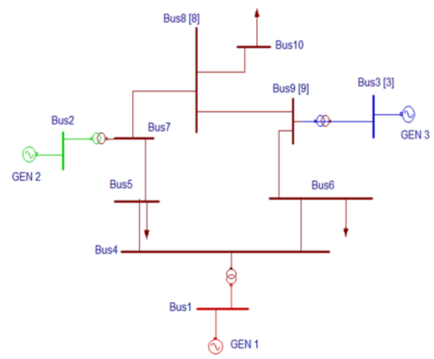

Fig 2. 10-bus test system

Table- I: Buses with nominal operating voltages

Bus Number	*Bus name*	*Nominal Voltage,kv*
1	BUS 1	16.5
2	BUS 2	18
3	BUS 3	13.8
4	BUS 4	230
5	BUS 5	230
6	BUS 6	230
7	BUS 7	230
8	BUS 8	23
9	BUS 9	230
10	BUS 10	230

IV. LOAD FLOW STUDIES

The 10 bus power system is used for the study, at first the system was studied under normal operating loads and all constraints were within the limits and there was no need of any compensation. Then load flow studies were done for overloaded condition by increasing the load beyond normal limits. Overloaded condition lead to unstable operation which can cause damage to the equipment connected in the system. So it is very much essential to keep the system operating parameters within limits under varying load conditions. In order to overcome this, compensation has to be provided at desired location. The load on 10 bus power system is increased up to 150% to investigate the system performance at highly loaded condition.

The result of the load flow analysis for normal and overloaded conditions was carried out using Newton Raphson method in Mi-power tool and the results are as shown in Table-II.

Table- II: simulation results for normal and overloaded condition

SL.NO	*BUS NAME*	*VOLTAGE(in P.U) NORMAL LOAD*	*VOLATGE(in P.U) OVER LOAD*
1.	BUS 1	1.0400	1.0400
2.	BUS 2	1.0250	1.0250
3.	BUS 3	1.0250	1.0450
4.	BUS 4	0.9784	0.9352
5.	BUS 5	0.9634	0.8967
6.	BUS 6	0.9618	0.9225
7.	BUS 7	1.0111	0.9908
8.	BUS 8	1.0012	0.9701
9.	BUS 9	1.0188	1.0018
10.	BUS 10	1.0009	0.9695

In order to enhance the power system enactment (i, e VP improvement & total system power losses reduction) it is necessary to provide compensating devices like FACTS. Installation of this device at random location cannot give satisfactory results so it is essential to get the optimum allocation where the connection of SVC would result in satisfactory performance. Weak buses in the system are to be found out so that optimum allocation of SVC can be determined. This can be done using FVSI as shown below

Table- III: FVSI values indicating weak buses

LINE	*FVSI*
7-8	0.002974
7-5	**0.511448**
5-4	0.004287
6-4	0.004479
9-6	**0.320948**
8-9	0.004344
8-10	0.002314

As seen from Table-III, it is clear that transmission lines with buses 5, 6, 7 and 9 are having large FVSI(highlighted) value compared to other buses. Larger the value of FVSI, weaker the bus is.

V. RESULTS AND DISCUSSIONS

Figures from 3 to 6, shows the circuits where the SVC are connected to different weak buses as determined from FVSI calculations. The corresponding results obtained after simulation of these circuits are shown in Table-IV, According to which the Bus 9 is the optimum location for the SVC as it has the best voltage profile improvement and overall loss reduction is also good(Refer Table-V).

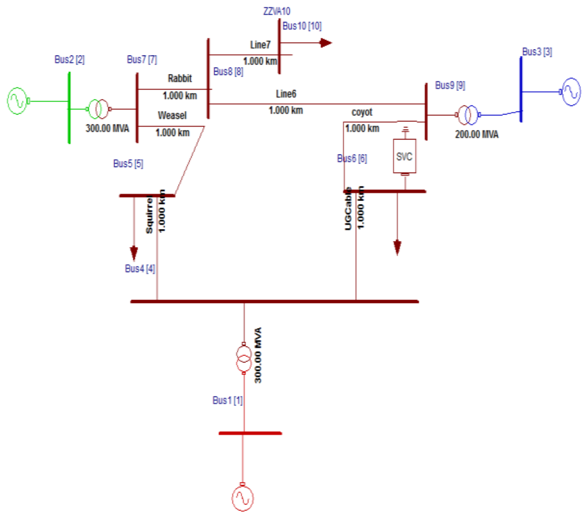

Fig 3. SVC allocation at Bus 5

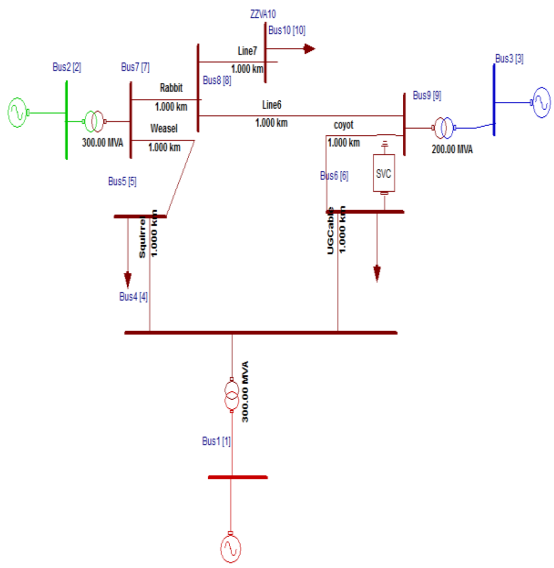

Fig 4. SVC allocation at Bus 6

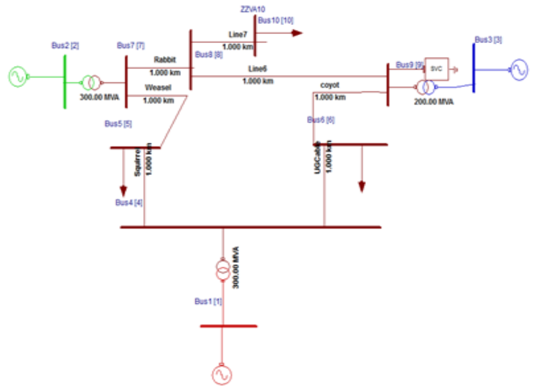

Fig 5. SVC allocation at Bus 9

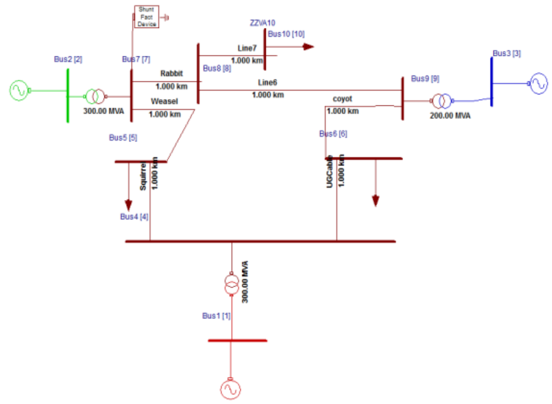

Fig 6. SVC allocation at Bus 7

After carrying out a detailed literature survey and simulating the system in MI-power and analyzing, it is seen from Table 4 and Table 5 that allocating the SVC at Bus 5 would result in better voltage profile improvement and loss reduction too when compared with the other buses.

Table- IV: FVSI values indicating weak buses

S.L NO	*BUS NAME*	*%ΔPL*
1	BUS 5	4.45
2	BUS 6	3.79
3	BUS 7	4.49
4	BUS 8	4.27

Table- V: buses with percentage loss reduction

S.L NO	*BUS NAME*	*VPII IN P.U*
1	BUS 5	1.1129
2	BUS 6	1.0438
3	BUS 7	1.0142
4	BUS 8	1.0111

VI. CONCLUSION

In this paper an effort is made to address issues caused by both increasing demand and voltage fluctuation issues by analyzing the load capacity of existing power system with the help of load flow analysis under normal condition and increased load condition to check whether existing power system can handle increased demand. Also to overcome the voltage fluctuation issues SVC is used and also an effort is made to enlighten how the proper allocation of SVC will result in better improvement of voltage profile and loss reduction in transmission line.

Hence this paper will be helpful for those researchers/students to know the entire basic procedure of load flow analysis, voltage profile calculation of each bus in a power system, identification of weak bus, percentage loss calculations in a quick and compact manner.

ACKNOWLEDGMENT

The author wish to thank, my parents, Dr.Sudharshan B G for their moral support and Dr.Chayapathi V ,Dr.Anitha G S for their valuable suggestions and inputs through out this work.

REFERENCES

1 ShraddhaUdgir, SarikaVarshney,Laxmi Srivastava"Optimal Placement and Sizing of SVC for Voltage Security Enhancement", International Journal of Power System Operation and Energy Management, Volume-1, Issue-2, pp: 54-58, 2011.
2 Ranjit Kumar Bindal: "A Review of Benefits of FACTS Devices in Power System", International Journal of Engineering and Advanced Technology (IJEAT), Volume-3, Issue-4, pp. 105-108, April 2014
3 R. Mohan mathur, Rajiv k. Varma "Thyristor-based facts controllersFor electrical transmission systems", A John Wiley & Sons, Inc. Publication
4 Sandesh Jain, Shivendra Singh Thakur: "Voltage Control of Transmission System Using Static Var Compensator", International Journal of Science and Engineering Applications (IJSEA) Volume 1, Issue 2, pp. 107-109, 201
5 Claudia Reis, F.P. Maciel Barbosa: "A Comparison of Voltage Stability Indices", IEEE Melecon 2006, May 16-19, pp. 1007-1010.
6 H. Iyer, Student Member, S. Ray: "Voltage Profile Improvement with Distributed Generation", IEEE 2005, pp. 1-8.
7 A.A. Alabduljabbar, J.V. Milanovic: "Assessment of techno-economic contribution of FACTS devices to power system operation", Electric power Systems Research 80, Elsevier, pp.1247–1255, 23 May 2010.

AUTHORS PROFILE

Srilakshmi R obtained her Bachelor degree in Electrical & Electronics Engineering from SSIT, VTU, Masters from GCE, VTU. She has 13 years of experience at under graduate level of Engineering as Assistant professor. She has guided more than ten projects at under graduate engineering level. Her areas of interests include Power system, control systems, Network theory, Signals & systems, Wind and solar power systems, Electrical machine design. She has the Honors of GRET Citation Award for The Paper entitled "Simulation studies on wind farms using PSCAD//EMTDC" was presented at the International Conference on "Future Trends in Electrical & Electronics Engineering" and is a member of IEI.

Dr. Chayapathy V obtained his Masters from Bangalore University, MS from BITS pilani and Ph.D. from VTU. He has 37 years of experience at under graduate and post graduate level of Engineering and 16 years of experience in R & D. as Associate professor. He has guided more than 30 projects at under graduate & more than 11 projects at post graduate engineering level. His areas of interests include Voltage collapse, Power Electronic system design using ICs, Software Engineering, Software Architecture, Object Oriented Analysis and Design. He has the Honors of expert lectures to various institutions, written text book and is a member of IEEE.

Dr. Anitha G S obtained her Masters from Bangalore University and Ph.D. from Avinashilingam University for women. She has 35 years of experience at under graduate and post graduate level of Engineering and 13 years of experience in R & D. as Associate professor. She has guided more than 30 projects at under graduate & more than 16 projects at post graduate engineering level. Her areas of interests include Renewable Energy sources, High Voltage Engineering, Power systems and Power electronics. She has the Honors GUEST OF HONOR at second international conference(ICMCECE) organized by Bangalore Technological Institute in association with Institute for Exploring Advances in Engineering (IEAE), Honored at world Education congress as PROF.INDIRA PARIKH 50 WOMEN IN EDUCATION leaders and is a member of MIE,MISTE