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AdvantageOf DG To Mitigate Voltage Collapse over Facts Devices

***SoumeshChatterjee, **Sharmistha Sharma**
*PG Scholar , Department of Electrical Engineering , NIT Agartala , India
** Assistant Professor , Department of Electrical Engineering , NIT Agartala , India

Abstract :
This paper solely discusses the voltage instability with the increment of load in a radial distribution system with Distribution Generation(DG) and compared to the system with Facts. The active and reactive power support from DG makes the system more reliable to voltage collapse. FACTS are also very good in reactive power compensator for the "sagging" voltages during the voltage collapse. The focus onto the identify the advantage and disadvantage of DG from several voltage collapse indices and compare it with the Facts devices(Power Capacitor and Static VarCompensator).The simulation is done with ETAP 7.5 and Newton Raphson load flow technique. The study of voltage instability with DG opens new ability of power system.

1. Introduction :

The voltage instability is a common issue for today's heavily stressed power system, voltage stability may lost any part of the power system generation side, transmission side or distribution side. The basic overview is described in [1]. Some noticeable phenomena regarding voltage collapse(black outs) is mentioned below ---

1. New York city in 1970 ;
2. Zealand in Denmark in 1979 ;
3. Be Hydros, Canada in 1979 ;
4. Belgiam in 1982 ;
5. Czechoslovakia in 1985 ;
6. Western France in 1987 ;
7. Southern Finland August, 1992 ;
8. WSCC USA July, 1996 ;
9. Northern Grid India, January, 2001 ;
10. New Delhi India, July, 2012 ;

So the above list says voltage collapse is a critical issue and can happen anytime. The incident that lead to a real voltage collapse(black outs) of the system are rare but when they occur they have large repercussion on the stability of the power system. In the past years different cases of voltage collapse have been studied in power system and analysed profoundly, all they are characterised by a progressive voltage drop in some buses when the load suddenly increases in relatively small quantity in a strongly loaded power system. Inadequate reactive power support from generators, reactive sources and transmission line can lead to voltage instability. The aim of this paper is to show the effect and advantages of Distribution Generation over conventional reactive power sources power capacitor and static var compensator.

2. *Voltage Collapse Definition and Causes :*

There are several definition of voltage collapse in the literature, but all the definition considers different issues according to the author. According to definitions presented by IEEE voltage collapse is a process by which voltage instability leads to voltage drop in a significant part of the power system.

Several reasons are there which leads to typical voltage instability in the power system, may be static or dynamic. Some of the mechanics described below –

2.1 *Increase In Inductive loading :*

Power system loads are generally composed of residential load and industrial loads. Residential loads do not have much effect in voltage drop, because residential loads are mostly resistive in nature and so voltage decrease means real and reactive power also decreases. For this reason residential loads are sometimes called "Self-correcting", but the industrial loads are inductive in nature(mostly induction motors) and tend to draw more current when voltage decreases. So voltage decreases and current increases at faster rate this results increase in power demand and tremendous drop in voltage[2].

2.2 *On-load tap changer Operation :*

At the time of voltage drop in power system automatic on-load tap changer(OLTC) continues to raise the secondary voltage and Primary voltage continues to fall[3]. Further lowering on high voltage side may be dangerous(because transformer does not have reactive power generation capability) if the system is near "bifurcation" point. Increase in voltage in the secondary side also increases the inductance, for this reason compensation with OLTC is limited for 3.7%.

2.3 Generator Outage :

One of the major symptoms of voltage collapse is inadequate reactive power support in a heavily loaded system. When the voltage is below the desired value the generator reactive power capability must be available to limit voltage decline[4]. The generator will have the capability to simultaneously Produce 0.395 MVar for each MW[5].

3. Voltage Collapse Mitigation Techniques :

3.1 Power Capacitor :

Power Capacitor are used for improving power factor for a power system when the load is inductive, as stated before most of the loads are industrial loads and are inductive in nature; these results lowering of power factor in the nearby distribution zone. Some of the electrical authorities made compulsory to install power capacitor in the industrial loads.

3.2 Static Var Compensator :

Reactive power is latent soul of power system, balance of it is very important. Being a combination of capacitor and reactor SVC can inject or absorb reactive power dynamically[6]. When a system is close to collapse, smaller increase in load will result in relatively large increase in reactive power absorption in the system. Now if that increased reactive power absorption is not supplied by the dynamic resources of reactive power of that region the system will surely go to voltage collapse. SVC in that response proved as very good reactive power source[7].

3.3 Distribution Generation :

The electrical power system through the world is deregulating and DG is predicted to play an important role in the next coming years. DG technology includes Photovoltaic cell, wind turbine, fuel cells, micro-turbine etc. The advantages of DG in the field of voltage control, power quality improvement, Var control, stability are already accepted it also promotes renewable energy. DG can provide bulk-energy to sub-transmission or distribution network. DG is preferred to locate at the customer meter side[8,9,10]. In the time of short-term or long-term stability fast reactive power support(recovery) is essential in this respect DG can play an important role in the system. In [11] a computer monitoring system with DG is suggested which is very effective in voltage collapse.

4. Problem formulation and Test system :

For analysing the effect of DG, SVC and power capacitor a 33 bus radial distribution test system is considered with 32 branches and one source generator Fig.1(Appendix A)[14]. The system has active load of 3.715 MW and reactive load of 2.3 MVar. For the simulation process ETAP 7.5 software with Newton Raphson(99 iteration) load flow technique is used. The objective is to compare the simulation result for the above mentioned devices. The placement of DG also has a great importance on the system. Improper placement may result huge line losses[12]. So for the placement of DG [10,13] is followed. The placement of SVC is done through [6] same for the power capacitor. The system is considered under voltage collapse if post disturbance voltage values are violating the limit.

5. Result and Analysis :

The voltage collapse can be described by PV curve or by QV curve or both. In this paper only PV curve is selected because this gives reliable results and easy to draw. The below steps are followed to draw PV curve -

Step1 . Run the load flow and get the voltage magnitudes for each bus.

Step2 . Now increase the load of each bus and run the load flow.

Step3 .Follow the bus voltages and see the limit.

Step4 . Repeat Step1 to Step3 until any of bus voltage magnitude falls below 0.8 pu or more below than that.For smother curve more readings can be taken.

For the test system each load is incremented by 0.05 MW(when the load is increasing the voltage is decreasing for each bus; to draw a clear PV curve we will consider the bus whose voltage magnitude first goes below 0.8pu). After increment of 0.2 MW for each bus the voltage magnitude goes down to 0.7 pu for bus no. 18. The Fig. 2(Appendix A) shows real collapse phenomena.

Now SVC placed in the system in the same way the load is increased. The system with SVC shows some improvement , the voltage magnitude goes 78% to 87% at 0.2 MW load increment.

The system with Power capacitor shows almost the same characteristics as SVC.The voltage magnitude at bus no. 18goes from 0.6 pu to 0.7pu for 0.4 MW load increment , further load increased to get clear PV curve.

Now as [13] the DG is placed in bus 18. It was 0.8pu when there was no recovery system(normal load) but after placing the

DGnot only the voltage magnitude of bus no 18 improved to 1 pu but overall system voltage also improved. As the DG placed at bus no. 18 so it is needless to draw comparison with bus 18, because the voltage magnitude will always 1 pu with DG. So next lower voltage magnitude bus no. 16 is considered. The Table 1 (Appendix B) shows the voltage profile of bus no 16 with DG, SVC and Power capacitor. Fig. 3(Appendix A) shows the overall voltage collapse mitigation. This is obvious that during increment of load the voltages of other buses also goes down below violating limit, still if the total care is provided to the system the voltage instability can be avoided. Table 2 (Appendix B)shows the magnitude of voltage of buses after increment of 0.8 MW for each bus. The voltage magnitude of bus no 16 with power capacitor goes to 52% even at 0.8 MW load increment. The lowest voltage bus with SVC is bus 13 and voltage magnitude is 0.5 pu , in case of DG lowest voltage bus is 13 but voltage magnitude is 65%.That is much better than other two. This describes that the system is much more stable, reliable with DG.

6. Conclusion :

Studies shows that operating technique is not alone sufficient to ensure stability of the power system some special control and protection schemes also necessary to mitigate voltage collapse. Several type of procedures like shedding of load, reactive power reserve,protective relay architecture are also very much helpful during the time of voltage collapse/instability. The approach described in this paper not only solves the problem of voltage instability but also improves the reliability of system. Computer monitoring can be done in future so that combination of the DG,SVC and Power Capacitor can be used as requirement, because the way of treating the short-term and long-term voltage stability is different.

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Appendix A :

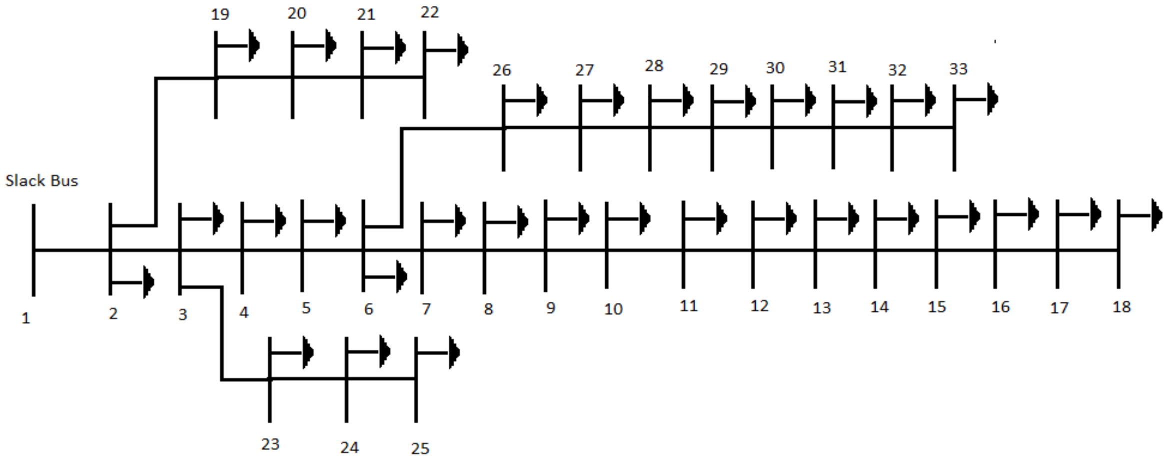

Fig. 1.33 bus radial distribution system

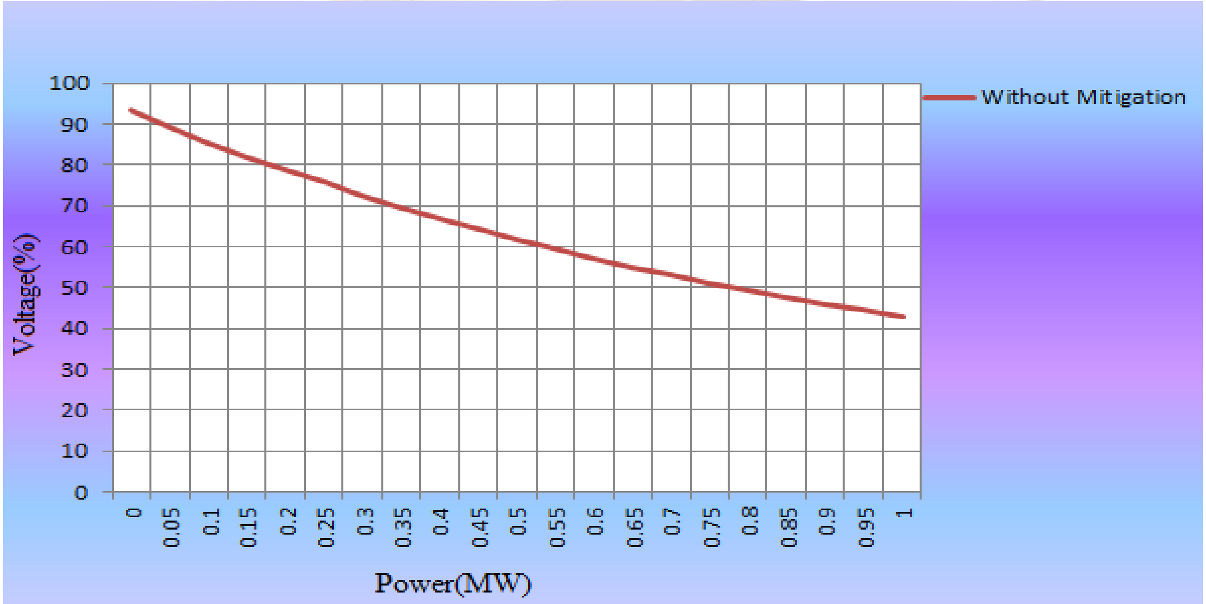

Fig. 2 Voltage Profile of Bus no 18

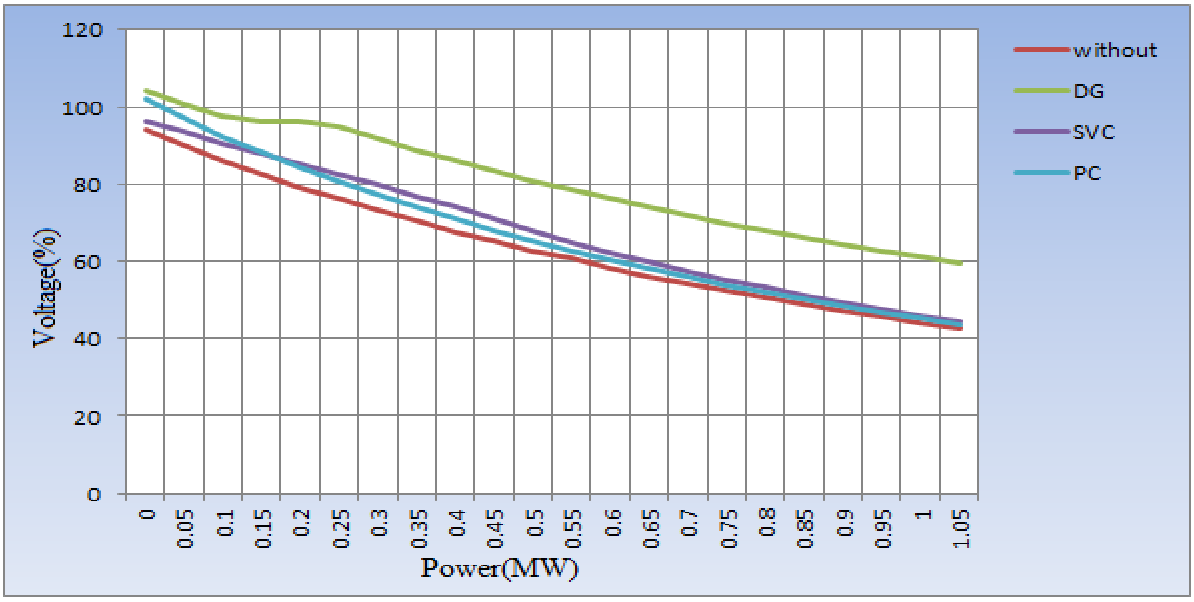

Fig. 3Voltage Profile of Bus 16

Appendix B :

Mitigation Type	V% at Normal Load	Increase Load By 0.05 MW	Increase Load by 0.1 MW	Increase Load by 0.2 MW	Increase Load by 0.35 MW	Increase Load by 0.45 MW	Increase Load by 0.55 MW	Increase Load by 0.65 MW	Increase Load by 0.9 MW	Increase Load by 1.05 MW
Without	93.93	89.93	86.14	79.18	70.38	65.12	60.8	56.12	47.21	42.82
SVC	96.16	93.44	90.7	85.17	76.94	71.43	65.04	59.82	49.34	44.35
PC	101.81	96.94	92.39	84.18	74.03	68.09	62.82	58.13	48.49	43.81
DG	104.4	100.68	97.74	96.07	88.72	83.31	78.4	73.95	64.5	59.74

Table 1. Voltage Magnitude at Bus no. 16 at different loads for DG, SVC and PC

Bus No.	Without	SVC	Power Capacitor	DG
1	100	100	100	100
2	98.3800	98.3100	98.3700	98.4200
3	91.4300	90.9800	91.3600	91.7100
4	87.4000	86.6800	87.2900	87.8900
5	83.4300	82.4400	83.2900	84.1600
6	74.8800	73.5800	74.7600	76.6000
7	73.5100	72.6000	73.5400	76.2000
8	65.6100	64.3300	65.7300	70.6600
9	61.5300	60.2800	61.7600	68.2000
10	57.9100	56.9100	58.3000	66.3600
11	57.3400	56.2800	57.7200	66.0200
12	56.3900	55.2400	56.7800	65.5400
13	53.1300	53.0400	53.8800	65.4800
14	52.1100	53.1200	53.1700	66.2200
15	51.2800	53.0800	52.5700	66.9500
16	50.5000	53.1500	52.0400	68.0300
17	49.5900	55.6400	52.0200	71.8400
18	49.3400	56.5800	52.0800	100
19	97.9200	97.8500	97.9100	97.9700
21	94.8600	94.7900	94.8500	94.9000
22	94.3000	94.2400	94.2900	94.3500
23	93.8400	93.7700	93.8300	93.8800
24	90.3200	89.8700	90.2500	90.6000
25	88.6300	88.2000	88.5700	88.9100
26	87.8000	87.3700	87.7400	88.0800
27	74.0700	72.7900	73.9500	75.7700
28	73.0800	71.8100	72.9600	74.7500
29	69.6300	68.4200	69.5200	71.2200
30	67.4100	66.2400	67.3000	68.9500
31	66.3500	65.2000	66.2400	67.8600
32	64.9100	63.7800	64.8000	66.3900
33	64.5800	63.4600	64.4800	66.0600

Table 2 Voltage magnitude at all buses at Load 0.8 MW