DYNAMIC STABILITY ANALYSIS OF 1000MW PV SOLAR POWER PLANT

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ABSTRACT: Direct interfacing of PV solar plant on a large scale with the National Grid put the security and stability of the whole power system at risk. Despite being a rich source of active power it does not provide enough reactive power due to its zero inertia which reduces the voltage profiles of the nearby grids and in case of outage the motor speed recovery is not achieved. So in order to fulfill the reactive power demand and attain the motor speed recovery, Static VAR Compensator is installed with the depressed voltage grid. It provides the dynamic support and reactive power compensation to the system. STATCOM can also be used instead of SVC to attain better stability and reactive power compensation.

1.0 INTRODUCTION

These days solar is getting a lot of attention all over the world because of its abundant availability and non-corrosive nature [1]. Solar technology is on its way to play a vital role in revolutionizing the power industry. It is offsetting the exhausting fossil fuels. All over the world countries are investing a huge amount to exploit the solar energy. At distribution level solar energy is being utilized over the decade and now it is making its way to a transmission level as well.

Owing to ever rising energy crisis, Pakistan is also concentrating on solar energy. It is one of the hopes for the revival of failing power sector of Pakistan. The Government of Pakistan is spending a huge amount of funds to exploit the solar energy in Pakistan because it is freely and abundantly available in most parts of the country and if this natural source of energy is utilized wisely and with proper planning; it will be helpful to overcome the severe energy crisis in Pakistan [2], [3] & [4].

Solar energy like other renewable energy sources (wind etc.) too comes with number of complications and challenges. The interfacing of a large PV power plant with the National Grid gives rise to many issues like voltage fluctuations, intermittency problems, reactive power deficiency etc. [5] & [6]. This paper focuses on the problem of reactive power deficiency which is a big challenge to the dynamic stability and security of the whole power system. In case of a severe fault, PV power plant cannot provide inertial support to the system like other heavy generators because PV power plants are inertialess. FACTS devices like SVC and STATCOM can be interfaced with the National Grid where PV power plants are installed. These devices provide virtual support to the system in case of any outage or fault.

2.0 METHODOLOGY

A real model of National Grid of Pakistan is simulated by using PSSE (Power System Simulation for Engineering) software. This tool is used worldwide to carry out the load flow studies. Average loading of the month of June, 2014 is used to analyze the worst scenario because in this month demand is maximum. 1000MW Quaid E Azam PV Solar Power Plant (QAPVSPP) is interfaced with the National Grid of Pakistan in order to analyze the dynamic impact of QAPVSPP on the stability of the National Grid. This impact is minimized through virtual inertial support by installing FACTS like SVC at various locations near QAPVSPP.

The dynamic analysis is carried out by applying a three phase fault on the most critical transmission lines connected with QAPVPP in order to observe the response of system in the worst scenario. The waveforms are analyzed through PSSPLT program of PSSE. The pre, present and post fault duration are kept 1 sec, 100ms and 10 second respectively for dynamic simulation activities. In order to observe the dynamic stability, motor speed recovery of the motor loads of the nearby areas is considered as a bench mark to check that the system is stable or not. If the motor speed is recovered then system is stable and vice versa.

3.0 DISCUSSION

When 1000MW QAPVSPP is interconnected with the National Grid in Bahawalpur region, it adversely affected the speed of dynamic loads of nearby areas. As mentioned already QAPVSPP is inertialess so it does not provide any inertial or dynamic support to the system which leads to system imbalance and instability. Figure 1 shows that a three phase fault is injected on 132kV Karor Pacca-Lal Sohanara circuit i.e. the interconnected circuit with 1000QAPVSPP. Then tripping occurred on that circuit and fault is removed. The said Figure -1 clearly shows that after fault interruption on 1.1 second, the motor speeds of all the interconnected areas i.e. Mailsi, Jahanian, Kroro Pacca, Chak 211 and 132kV Garh More do not recovered.

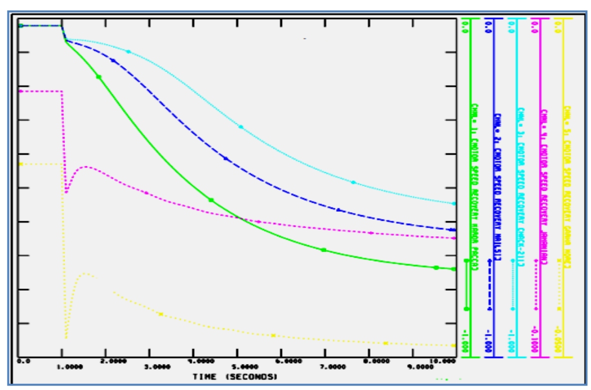

Figure 1: Impact of 1000MW QAPVSPP on the Motor Speed of nearby grids.

This adverse effect of integration of a large scale solar power plant can be nullified by installing Static VAR Compensator (SVC) with the nearby grids of QAPVSPP. A 50 MVAR SVC is installed at 132kV Mailsi grid and 75MVAR SVC

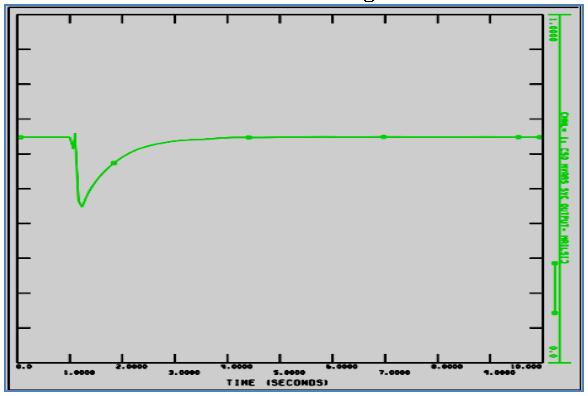

Figure 2: Dynamic Response of 50 MVAR SVC at 132kV Mailsi Grid.

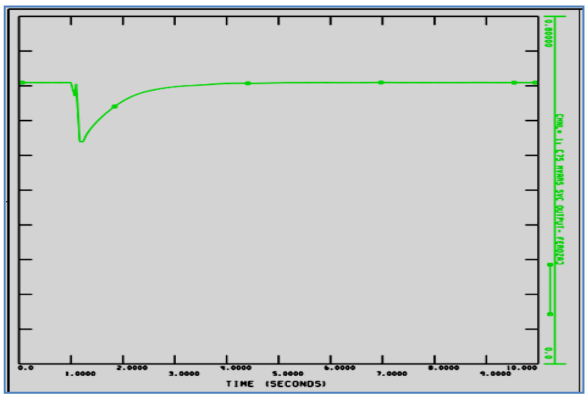

Figure 3: Dynamic Response of 75 MVAR SVC at 132kV Feroza Grid.

installed at 132kV Feroza grid. To further investigate the post effect of 50 and 75 MVAR SVCs on the National Grid, first the dynamic response of the aforementioned SVCs is investigated by applying fault and by keeping the same pre, present and post fault scenarios as used in the previous case.Figure 2 and Figure 3 show the dynamic response of 50 MVAR SVC installed at 132kV Mailsi and 75 MVAR SVC at 132kV Feroza grid after fault injection where QAPVSPP is connected.

After fault injection for 0.1 seconds, the SVCs stabilized themselves within a few seconds. If, in case of fault the installed SVCs could not meet up to stabilization, the system stability might be at risk.

Now the impact of 50 and 75MVARs SVCs is analysed on the nearby areas/grids by monitoring the speed recovery of dynamic loads. Figure 4 shows the motor speed recovery of 132kV Karor Pacca, 132kV Mailsi, 132kV Jahanian, 132kv Garha More and 132kV Chak 211 grids whereas the Figure 5 shows the motor speed recovery of 132kV Liqatpur, 132kV Khanpur, 132kV RYK, 132kV RYK II, 132kV MWQ and 132kV Khal Bela grids. The Figure 4 and 5 proves that in the post fault condition, the motor speed is completely recovered at the mentioned grids.

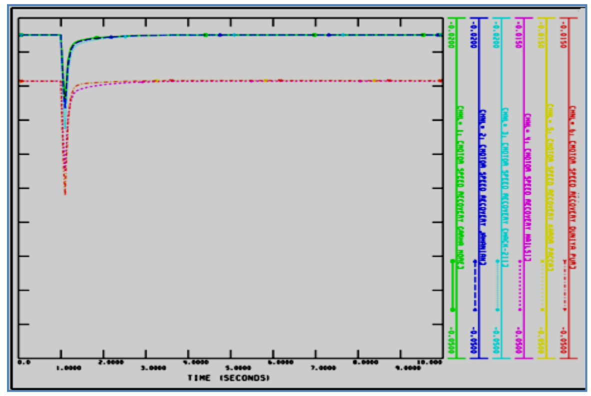

Figure 4: Motor Speed Recovery due to 50MVAR SVC at 132kV Mailsi Grid.

Studies have proven that STATCOM is better than SVC in case of power measurement, compensating reactive power

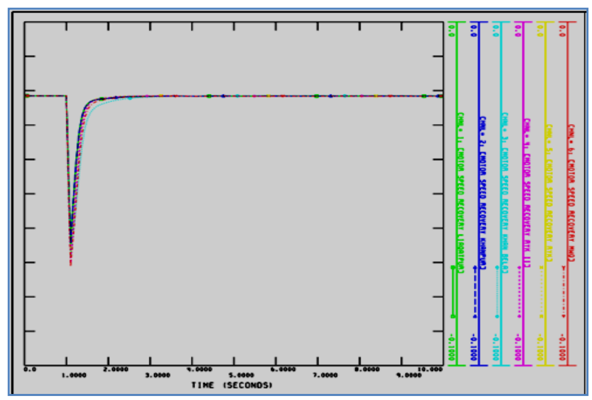

Figure 5: Motor Speed Recovery due to 75MVAR SVC at 132kV Feroza Grid.

and maintaining system voltage [7]. The impact of 1000MW QAPVSPP can also be nullified by replacing SVC with STATCOM of less than half of the ratings of SVCs. Therefore 50MVAR SVC installed at 132kV Mailsi is replaced with 10MVAR STATCOM and 75MVAR SVC at 132kV Feroza grid is replaced with 25 MVAR STATCOM. The dynamic response of 10 and 25 MVAR STACTOMs are shown in Figure 6 and Figure 7.

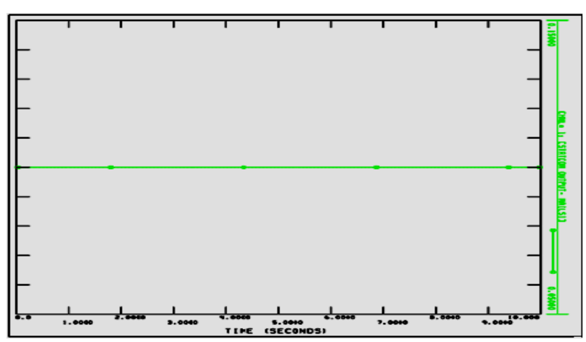

Figure 6: Dynamic Response of 10 MVAR STATCOM at 132kV Mailsi Grid

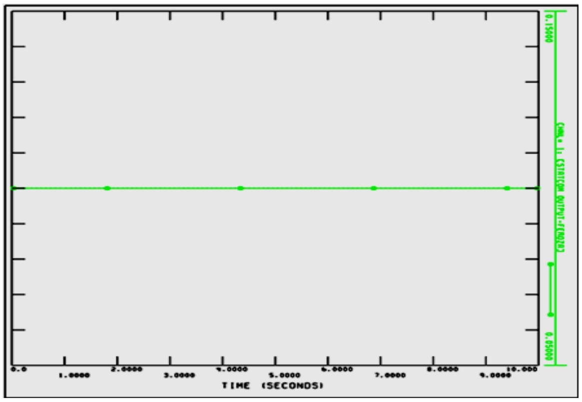

Figure 7: Dynamic Response of 25 MVAR STATCOM at 132kV Feroza Grid

The dynamic response of STATCOMs shown in Figure 6 and Figure 7 present their fast switching than that of SVCs. The response of STATCOMs during fault conditions were like pre fault conditions which show their fastest switching responses during fault.

After observing the dynamic response of 10 MVAR and 25 MVAR STATCOMSs in the system, the motor speed recovery of the connected grids is analyzed. Figure 8 shows the motor speed recovery of the allied grids previously shown in Figure 4 after replacing 50MVAR SVC with 10 MVAR STATCOM. Whereas Figure 9 shows the motor speed recovery of allied grids shown in Figure 5 after replacing 75 MVAR SVC with 25 MVAR STATCOM.

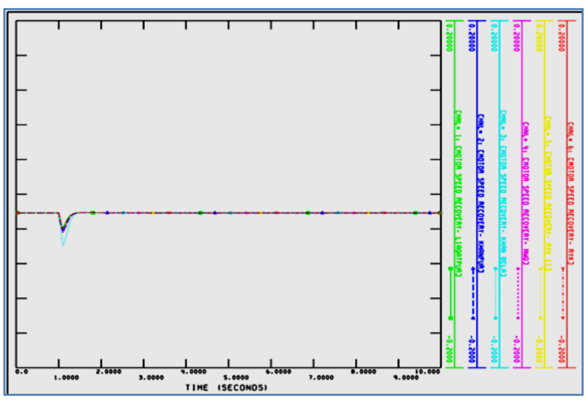

Figure 8: Motor Speed Recovery due to 10 MVAR STATCOM at 132kV Mailsi Grid.

From Figure 8 and Figure 9, it is clear that the installation of STATCOMs by replacing SVCs have not only reduced the size but also provided better dynamic stability than that of SVCs.

4.0 CONCLUSION

From the above discussion it can be concluded easily that addition of 1000MW QAPVSPP in the power system affects the speed recovery of dynamic loads due to its inertialess nature. However, this impact can be minimized by interfacing SVC and STATCOM with the National Grid. These devices improve the dynamic stability of the system. The performance of STATCOM is far better than SVC
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Hence, by virtual support of SVC and STATCOM, 1000MW

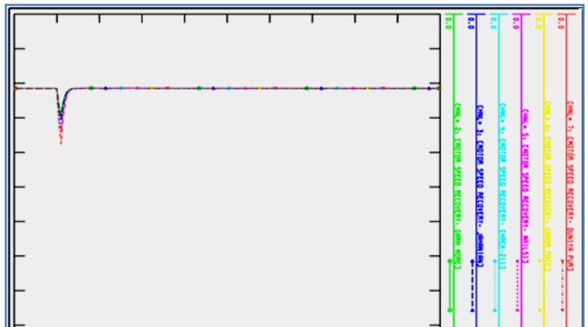

Figure 9: Motor Speed Recovery due to 25 MVAR STATCOM at 132kV Feroza Grid.

QAPVSPP meets the dynamic stability criteria.

5.0 REFERENCES

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