www.ijraset.com Volume 5 Issue IV, April 2017
IC Value: 45.98 ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Power Quality Improvement using Super Capacitor for an Isolated Power Generation

Mr. S. Jawahirullah[1], Mr. T. Elavarasan[2], Mr. S. Edward Wilson[3]
[1,2,3]*Electrical and Electronics Engineering, Anna University Chennai*

Abstract: Power generation will be formed in many weak distribution networks, after renewable energy sources are connected to them. It is very important to increase the reliability and efficiency of using these renewable energy sources. By using super capacitor, the power quality problem in distributed power generation (e.g. voltage fluctuation) can effectively be solved. In this project, super capacitor based energy storage will be used as the peak power unit, to ensure the power quality on the short time and longtime duration. High power quality can be achieved in isolated power generation with the presented systems. The transmission of electric power to industries with the help of super capacitor improves the stability and power distribution of the system. A simulation system is established on the MATLAB/SIMULINK for the correctness and effectiveness of the proposed control strategy.
Keywords : Dynamic Voltage Restorer; MATLAB SIMULINK; PI Controller.

I. INTRODUCTION

Nowadays energy market is directed towards renewable energies. The facts of running out of conventional fuels like coal and oil beside the high rates of carbon-di-oxide emissions have been forced many countries to concentrate their research and future power generation planes in the field of clean renewable energies. So people are encouraged to use renewable energy sources (e.g. solar energy, wind energy, Tidal energy). The reasons are that renewable energy sources are clean and infinite. They can replace some of fossil energy sources to reduce greenhouse gas emissions and air pollution. A drawback of these renewable energy sources is their high initial installation cost. But using renewable energy source in rural countryside is likely a cheap solution in comparison with developing a complete electrical network.

In order to improve the reliability and efficiency of distributed power generation, the renewable energy source systems need to be connected to the electrical network. This means that most of renewable energy sources will first be connected to the weak distribution networks. But the distribution networks are not initially designed for the structure of distributed power generation. Power quality, in particular voltage quality will be decreased. Using Super Capacitor is a very effective solution to solve the above problems (e.g. voltage fluctuation). Here the VSI (voltage source inverter) connected to AC grid in series. Due to the transmission of power occurs at high voltage level, there is a stability problem occurring in the system. These are overcome by using the electronic devices which uses capacitor banks to improve power quality and reactive power compensation.

But the usage of capacitors for long operation and high voltage level can cause problems and decrease the life span of capacitors. Use of super capacitors which have less charging and discharging time can overcome this issue. In industries voltage flickering, voltage sag and harmonics may occur in any time. This may affect the instrument in the industries. To prevent this harmony super capacitor is used to improve constant frequency and to increase efficiency.

II. POWER FLUCTUATIONS

Power fluctuations, where the supply does not match the demand, need to be dealt with properly to ensure that electrical devices connected to the grid don’t receive too little or too much power. These fluctuations can arise from variations in supply, such as when a power plant stops producing output, or from variations in demand, when consumers require more or less power than is being supplied.

III. CURRENT METHODS FOR MITIGATING POWER FLUCTUATIONS

Current methods for mitigating power fluctuations primarily involve the use of additional So-called ’peaking’ power plants – fast start (typically gas turbine) generators which can be turned on to meet short term spikes in demand – and by increasing the output power provided by power plants already in operation. In addition, the grid can purchase power from France, Northern Ireland and the Netherlands via underwater cables.

Volume 5 Issue IV, April 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

A. Spinning Reserve

A number of power plants generating electricity for the National Grid are running at only a fraction of their total capacity. This extra capacity is kept available in order to use when needed, to cover supply shortages that the base load cannot handle. However, running power plants at less than 100% capacity typically results in losses of efficiency, as generators are usually optimized to run at full load. A typical coal plant might have a thermal efficiency of 40% at full output, but only 35% at half load. The full efficiency is usually only achievable after a long period of warming up (around 8 hours), so this method is not ideal for handling shorter term fluctuations.

B. Short Term Operating Reserve

Certain types of electricity generators such as gas turbine plants or hydroelectric dams (termed 'pumped storage') are very quick to produce electricity when needed. The National Grid keeps a selection of these plants on standby for use at short notice. The use of gas turbine plants is expensive, as they substitute fuel efficiency for a quick reaction time, a bit like a supercharger in a race car. A gas turbine plant may only have a thermal efficiency of around 30%. A hydroelectric dam has an operation time limited to the amount of water available to produce electricity from, and so is only available after a suitable resupply period after its last use, and for a limited amount of time.

C. Frequency Response

The National Grid has commercial agreements with large electricity consumers to limit their use in times of high demand or low supply where spinning reserves are unable to cope. Consumers willing to take part in this are most likely to have electricity use patterns which aren't adversely affected by short periods of loss of supply, such as steel works (where the furnace can take days to heat up with an induction heater) or cold storage facilities.

IV. PROPOSED SYSTEM

This system describes the proposed model of power condition system for power quality improvement. The proposed model contains a super capacitor connected in parallel with the transmission line. The super capacitor is placed in the reactive power compensation devices. Super capacitors are capable of providing the reactive power that is essential for the control of reactive power. The load may be an inductive or capacitive load.

A. Frequency Response

The block diagram of proposed system is figure 1 to show.

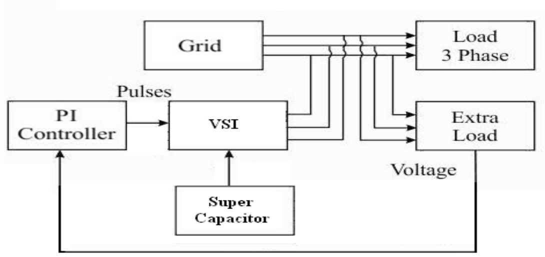

Fig. 1 Proposed Block Diagram

The three phase source acts as a grid from where the power is to be transmitted. A three phase measurement block is used to measure the input voltage and current. The transmission lone is modelled by using the pi section line. A three phase transformer is used to step-down the voltage and it is converter by using a converter system. The transformer used is made of two winding transformer. The converter station contains six thyristors to which the AC voltage is applied. The firing pulse of the thyristor is produced with the help of controller. The three phase load connected is made to be a combination of resistive and inductive. A super capacitor bank is connected to the output of the converter system. It is there the voltage stabilization and reactive power compensation occurs.

In industries voltage flickering, voltage sag and harmonics may occur in any time. This may affect the instrument in the industries. To prevent this harmony super capacitor bank is used to improve constant frequency and to increase efficiency. Transmission line has minimum resistance and maximum inductance. Inductance will have more losses in transmission line. To reduce this losses a capacitor is connected in parallel to the line.

V. PI CONTROLLER

PI controller will eliminate forced oscillations and steady state error resulting in operation of on-off controller and P controller respectively. However, introducing integral mode has a negative effect on speed of the response and overall stability of the system. Thus, PI controller will not increase the speed of response. It can be expected since PI controller does not have means to predict what will happen with the error in near future. This problem can be solved by introducing derivative mode which has ability to predict what will happen with the error in near future and thus to decrease a reaction time of the controller. PI controllers are very often used in industry, especially when speed of the response is not an issue. A control without D mode is used when:

Fast response of the system is not required

Large disturbances and noise are present during operation of the process

There is only one energy storage in process (capacitive or inductive)

There are large transport delays in the system.

Proportional–integral (PI) control combines the advantages of integral control (zero steady-state error) with those of proportional control (increasing the speed of the transient response). The control input is the sum of the proportional and integral terms. For proportional control, the control input is proportional to the control error, and for integral control, the change in control. The control actions of the proportional or integral controllers are based on the current error or past errors. In derivative control the controller output is proportional to the rate of change of the error. The idea behind derivative control is that the controller should react immediately to a large change in the control error; in essence, predicting that the error will continue to increase (or decrease) and act accordingly. Where the derivative control gain KD defines the ratio of the input magnitude to the change in the error. Since the derivative controller adjusts the control input according to the speed of error variation, it is able to make an adjustment prior to the appearance of even larger errors. Practically, the derivative controller is never used by itself since if the error remains constant, the output of the derivative controller would be zero.

VI. SUPER CAPACITOR

Super capacitor makes a bridge between electrolytic capacitors and the rechargeable batteries. They typically store 10 to 100 times more energy per unit volume or mass than electrolytic capacitors, can accept and deliver charge much faster than batteries, and tolerate many more charge and discharge cycles than rechargeable. They are however 10 times larger than conventional batteries for a given charge.

Super capacitors are used in applications requiring many rapid charge/discharge cycles rather than long term compact energy storage: within cars, buses, trains, cranes and elevators, where they are used for regenerative braking, short-term energy storage or burst-mode power delivery. Smaller units are used as memory backup for static random-access memory (SRAM).

VII. CONTROL PRINCIPLE OF STANDALONE SERIES VSI WITHOUT DC/DC CONVERTER

The configuration of a standalone series VSI without the DC/DC converter connected to the super capacitors is presented. Similar to the configuration in the subsection B, the series inverter can inject a voltage to the AC grid to achieve the function of dynamic voltage restoring. Without the DC/DC converter, the DC bus voltage is dependent on the voltage of the super capacitors. Although the DC bus voltage can be maintained by using the series inverter in this configuration, but the big voltage variation on the DC bus is allowed to efficiently use the super capacitor based energy storage. On the other hand, the big voltage variation on the DC bus (in particular low voltage of the super capacitor) will limit the bandwidth of the output voltage of the series inverter. If above tradeoff can be adjusted, also with the consideration of the ratio of the series transformer, then this configuration will be a simple solution to solve the short time duration voltage fluctuation. Therefore, we present our control principle of the series inverter with super capacitors for the configuration in Fig. 3.

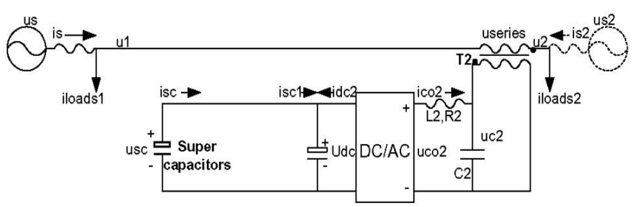

Fig. 3 Standalone series VSI without DC/DC converter

Volume 5 Issue IV, April 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

VIII. SIMULATION RESULT AND DISCUSSION

The three phase source acts as a grid from where the power is to be transmitted. A three phase measurement block is used to measure the input voltage. The transmission line is modeled by using the pi section line. A three phase transformer is used to step-down the voltage and it is converter by using a converter system. A super capacitor bank is connected to the output of the converter system. It is there the voltage stabilization and reactive power compensation.

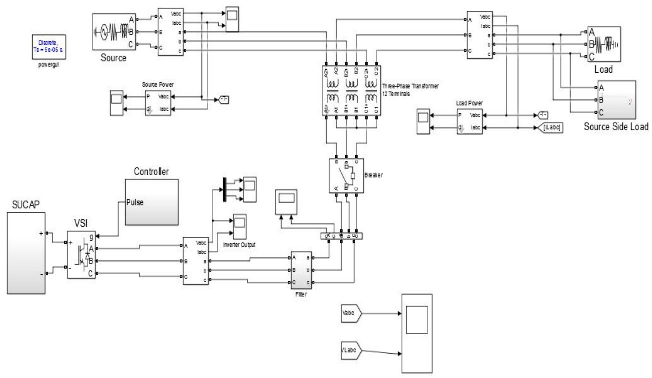

Fig. 4 simulation model of super capacitor based energy storage system

A. *Test1 without Super Capacitor based Energy Storage on DC Bus*

This test was done while the stepwise increasing load current on the left side loads and on the right side of the system (but the DC/DC converter was not enable). We can see the load current on the right side iloads2 have strong influence on the voltage though the voltage on the right side u2 was compensated by the series converter. The voltage on the left side ul dropped about 15% in both cases, but the load current on the right is much lower than the load current on the left side in the similar events. This is because the shunt part needed to provide much power (via the DC bus) to the series part while the stepwise load current on the right side. If the load current on the right side is too high, then even the series part still cannot completely compensate the excessive voltage. The DC bus voltage will be decreasing. This is because the power might not be able to be supplied from the DC bus without additional effort. For instance, adding a power feed forward signal to the control system of the shunt converter. But this will cause the voltage on the right side even worse. The shunt converter will draw too much current from the AC grid in order to provide the power for the series converter. This is not a perfect solution.

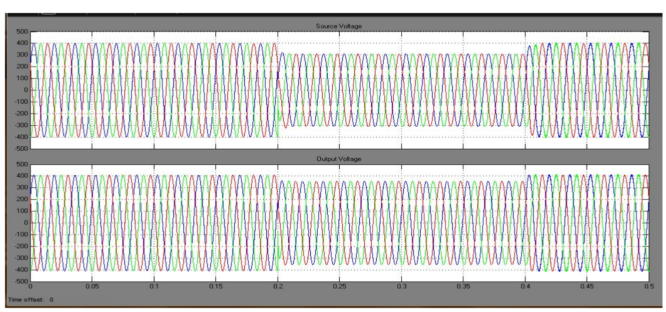
Fig. 5 Simulation output voltage waveform without using super capacitor

B. *Test2 with Super Capacitor Based Energy Storage on DC Bus*

In order to further improve the power quality, super capacitor based energy storage was installed on the DC bus. We can see that the shunt converter will not draw too much current from the AC grid at beginning after a stepwise current was increased on the right side of the system. This will not further decrease the voltage on the left side up. The quality of the voltage on the right side can be ensured. We cannot see any excessive voltage on the DC bus. If the excessive load current on the AC grid will not last too longer, then the output power of the series converter can be completely provided by the super capacitor based energy storage.

Volume 5 Issue IV, April 2017
ISSN: 2321-9653

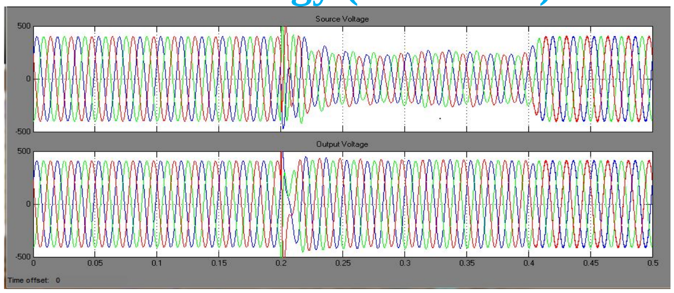

Fig. 6 Simulation output voltage waveform with using super capacitor

TABLE I. RESULT ANALYSIS

s.no	applied load (kw)	without SC (voltage)	without SC (current)	with SC (voltage)	with SC (current)
1	20	360	98	400	108
2	25	350	94	400	108
3	40	320	85	400	108
4	50	300	80	400	108

IX. CONCLUSION

To overcome the drawbacks of Battery storage system, this project proposes Super capacitor based energy storage. The Super capacitor based energy storage system was designed for power quality improvement of a decentralized power generating plant. Super capacitors energy storage system has been used as a storage device and deliver the real power into distribution network for higher rate of change of dynamic conditions in case of transient conditions as well as for average power demand in case of steady conditions. The harmonics and fluctuations that occur in the system are overcome by using super capacitor. Reactive power compensation is also provided by the super capacitor along with stabilization of the power system. The MATLAB simulation shows the input and output voltage variations.

REFERENCES

[1] D. Casadai, G. Grandi, (2007)”Power Quality and Reliability supply improvement using a power conditioning system with energy storage capability”, IEEE Transaction on Power Electronics, Vol. 5, no. 3, pp. 1135- 1149.

[2] Marian K. Kazimierezuk, Robert C. Cravens, (2009)”Application of super capacitor for voltage regulation in Aircraft Distributed power system”, IEEE Transaction on power electronics, Vol. 6, no. 5, pp. 835- 850.

[3] Rahul Nema, Anuraj Trivedi, (2013)”Applications of super capacitor based Energy storage system for Power Quality improvement of a Decentralization power plant”, International Electrical Engineering Journal(IEEI), Vol. 4, no. 1, pp. 846- 855.

[4] Miguel Castrila, Jaume miret, (2014)”Voltage support control strategies STATCOM under unbalanced voltage sags, IEEE Transaction on Power Electronics, Vol. 61, no. 2, pp. 808- 820.

[5] K.Yukita, Y. GotoMember, K. Ichiyanagi, T.Ota, Y.Shimizu, T.Ichikawa, T. Takeda, (2009) “Load Frequency Control using Storage System for a Micro Grid”. IEEE T&D Asia pp. 1-7.

[6] Arjan M. van Voorden, Laura M. Ramirez Elizondo, Gerard C. Paap, Jody Verboomen, Lou van der Sluis, (2007)“The Application of Super Capacitors to relieve Battery-storage systems in Autonomous Renewable Energy Systems” IEEE pp. 978

[7] Mairaj ud din Mufti, Shameem Ahmad Lone∗, Shiekh Javed Iqbal, Muzzafar Ahmad, Mudasir Ismail, (2009) “Super-capacitor based energy storage system for improved load frequency control”, Electric Power Systems Research Vol. no. 79 pp. 226–233

[8] Kuldeep Sahay; Bharti Dwivedi, “Design and Implementation of Super capacitors Energy Storage System for Management of Power System Network” Journal of Electrical and Control Engineering Aug. 2012, Vol. 2, no. 4, pp. 20-25

[9] Kuldeep Sahay; Bharti Dwivedi, (2009) “Design and Analysis of Super capacitors Energy Storage System for Energy Stabilization of Distribution Network” Electrical Power Quality & Utilization Journal Vol. XV, no. 1, pp. 49-56.

[10] Jan Leuchter, Pavol Bauer, Petr Bojda, Vladimir Rerucha, “Bi-Directional Dc- Dc Converters For Super capacitor Based Energy Buffer For Electrical Gen-Sets” University Of Defence, Delft University Of Technology, Project No – 105/05/P001.

[11] Kuldeep sSahay, Bharti Dwived, (2010)“Super capacitor Energy Storage Based DSTATCOM Modeling and Simulation for Distribution System”, Journal of Electrical Engineering Vol. 10, no. 3, pp. 1-8