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Supercapacitor Based Power Conditioning System for Power Quality Improvement in Industries

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***Abstract*-- Transmission is mostly done by three phase four wire AC system carrying a very high voltage. To be economical and to reduce the various losses, power is transmitted at high voltage levels. Since the transmission of power is done in AC, there is a raise of reactive power problem. In addition to it, the varying load causes stability problems in the transmission line. A vast requirement is needed in power conditioning system to improve the power quality. A storage system can play a vital role to improve power quality. This paper proposes a Super Capacitor to improve power quality as well as reactive power correction. The transmission of electric power to industries with the help of Super Capacitor Bank improves the stability and the power distribution of the system. The proposed model is analyzed in MATLAB.**

Keywords--Super capacitor; Reactive power; Converter; Transmission Line; Transformer.

I. INTRODUCTION

When an electric power is transmitted from one point to another, there is always a power loss occurring in the system. Transmission of power is made in DC for longer distance since the power losses will be less when compared with AC system. Hence DC system is used for the long transmission purpose. While it is unprofitable to use DC for distribution since there will be requirement of many converters at the distribution end because of the usage of many converters which are needed to convert DC to AC. For smaller transmission also AC is more preferable than DC. The sending end voltage is never equal to the receiving end voltage because of the power losses that occur in the system. Some reactive power is always consumed by the transmission line which causes the decrease in the voltage level. Further 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 FACTS 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 supercapacitors which have less charging and discharging time can overcome this issue.

II.BLOCK DIAGRAM

The below block diagram describes the proposed model of power condition system for power quality improvement. The proposed model contains a supercapacitor connected in parallel with the transmission line. The supercapacitor is placed in the reactive power compensation devices. Supercapacitors 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.

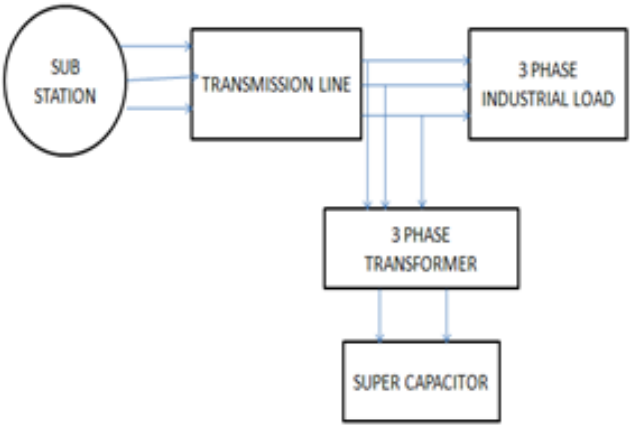

Fig 1: Block Diagram of Proposed Model

III. ANALYSIS OF POWER CONDITIONING SYSTEM

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 [2]. 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.

A.Reactive power compensation

Many industrial loads require reactive power to sustain magnetic power. Reactive power is the power that is used to produce the magnetic fields and does not do any work. This power is very essential for the operation of inductive loads. Inductive loads consume reactive power whereas a capacitor develops reactive power. With the increase in reactive power, the phase angle increases and the power factor decreases. Thus the efficiency of the system will be affected. In order to improve the power factor, reactive power has to be fed to the system. A device which is connected in series or parallel with load and capable of supplying the reactive power demand is known as Reactive power compensation device. It contains capacitor placed inside it. Capacitors provide the reactive power that is necessary for the inductive load to consume. The capacitor banks provide the necessary power that contains capacitors connected in series. But constant charging and discharging of the capacitor results in reduced lifetime. This problem is overcome by using supercapacitor in the battery bank.

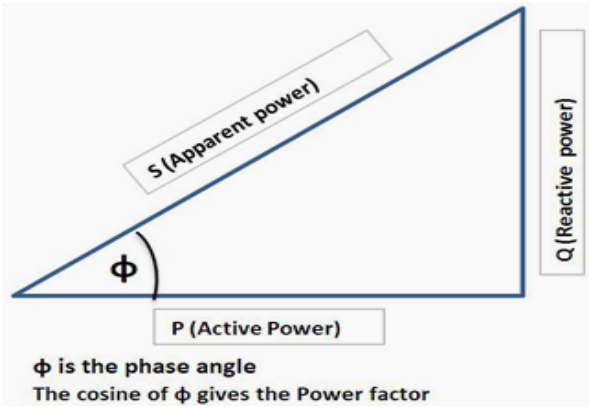

Fig2: Power Triangle

The comparison between super capacitor and ordinary capacitor values are identified and the diagrammatic representation of both capacitors is in Fig 3.

B.Comparison of super capacitor and electrolyte capacitor

Table 1:Super capacitor and electrolyte capacitor comparison

Function	Electrolyte capacitor	Super capacitor
Charging time	0.3 – 30sec	10^-3 to10^-4 sec
Discharging time	0.3 – 30sec	10^-3 to10^-4 sec
Temperature range	-20 to +70	-40 to+125
Cell voltage	2.3v to 2.7v	0.7v to 3.5v
Capacitance range	100 to 12000	<=1
Efficiency	95	99

Electrochemical Double Layer Capacitors (EDLCs) orsupercapacitors (SC) - are electrochemical capacitors that have high capacitance and high energy density when compared to common capacitors, and higher power density when compared to batteries. Their capacitance value ranges about 10,000 farads. These high capacity electrochemical capacitors are mainly used in rechargeable batteries.

They can tolerate many charges at a time and their discharge cycle is also good.The supercapacitor is ideal for energy storage that undergoes frequent charge and discharge cycles at high current and short duration.And also it has simple charge methods, that is no full-charge detection is needed or no danger of overcharge. They can operate under much higher temperature. They also have a very high efficiency.

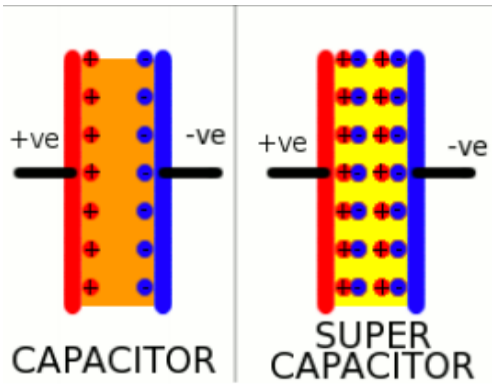

Fig 3: Charge Distribution Between Capacitor And Super Capacitor

IV. MATLAB MODELING

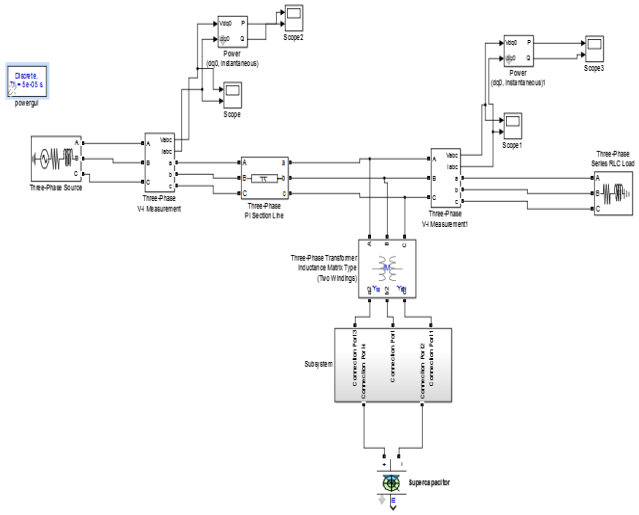

Fig 4: Conditioning System Model

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 pulse generator. 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 stablization and reactive power compensation occurs.

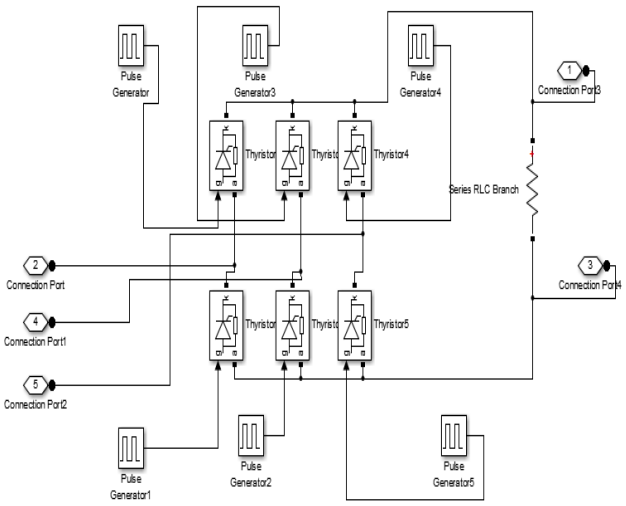

Fig 5: Converter model

Power conditioning systemcan be verified in the MATLAB by varying the inductive power and reactive power of the load.

The super capacitor characteristics can be changed by using ANSOFT MAXWELL and the internal parameter can increase the efficiency and performance than ordinary super capacitor. ANSOFT MAXWELL can be used to change the dielectric material.

V. SIMULATION ANALYSIS

A.Voltage and current analysis

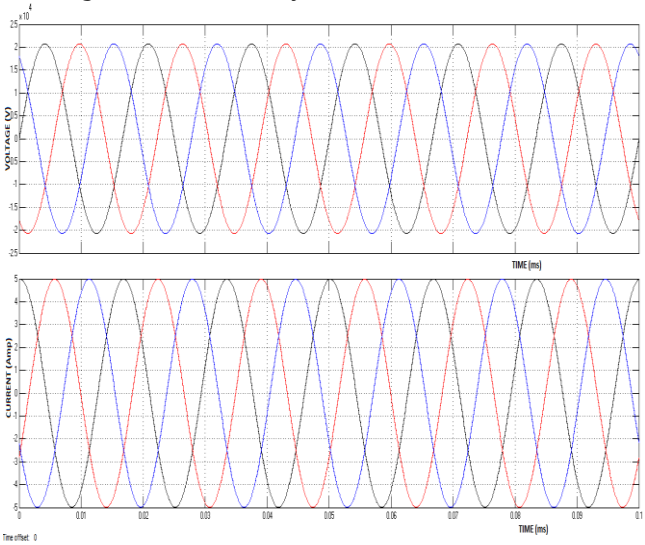

Fig 6: Input wave form from the sub station

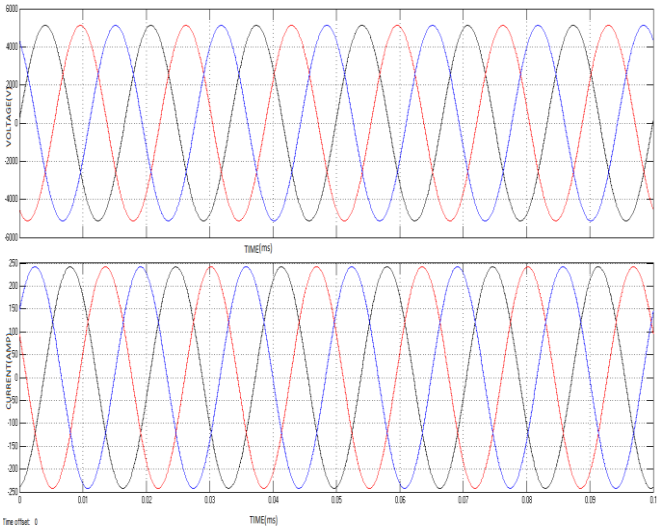

Fig 7: Output wave form from the load consumed side

The input and output waveform of voltage and current are compared with respect to time. It is clearly seen the output voltage is similar to that of input.The Supercapacitor added has increased the stability of the system. It also provides the necessary reactive power to the load. The distortion in the output is comparatively low. By varying the capacitance value, the power factor is improved and the efficiency of the system is increased.

B.Real and Reactive power analysis

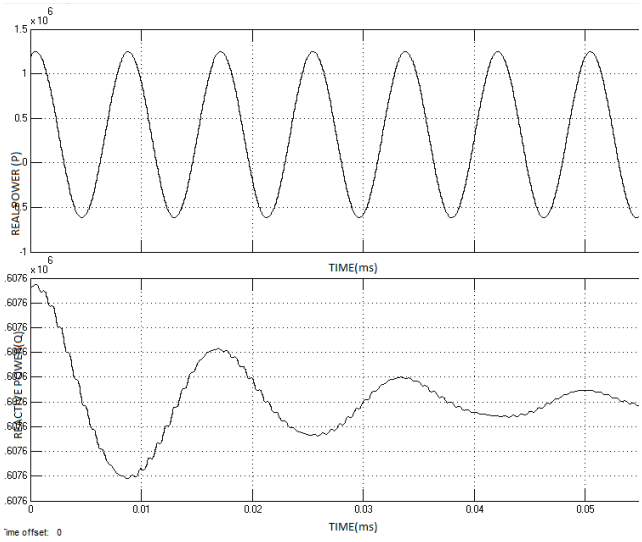

Fig 8: Input Wave Form of Real Power and Reactive Power

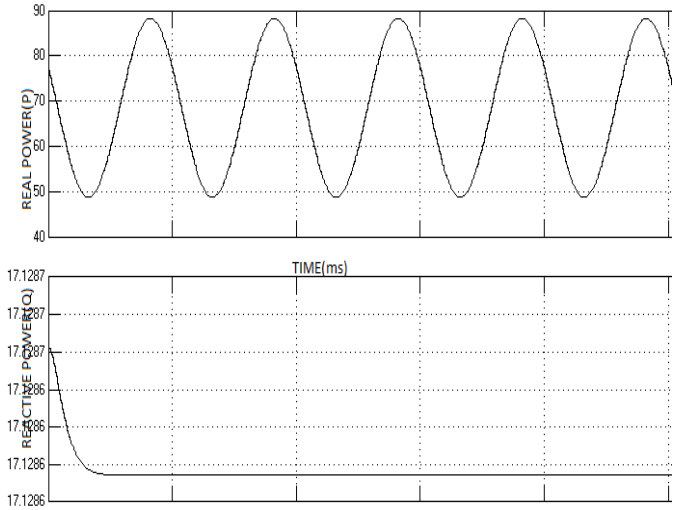

Fig 9: Output Wave Form of Real Power and Reactive Power

From this comparison real power and the reactive power varies linearly from the input to output with the help of super capacitor this will reduce the losses and increase efficiency [5].

VII. RESULTS AND DISCUSSION

The results show that the distortion in the output is very less and also the output voltage is same as that of the input voltage. The efficiency of the system is increased with the help of the supercapacitor bank. Reactive power compensation is also provided by the supercapacitor along with stabilization of the power system.

VIII. CONCLUSION

This paper provides the idea of power quality improvement of the AC transmission system by the help of using supercapacitor. The harmonics and fluctuations that occur in the system are overcome by using this. The MATLAB simulation shows us the input and output voltage variations and current variations. The proposed system operates with much higher efficiency and voltage stability. The system with supercapacitor is analyzed and the output graphs of the proposed model are examined.

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