Reducing Ferranti Effect in Transmission Line using Dynamic Voltage Restorer

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Abstract—As we are studied the Ferranti effect in transmission line through this paper. How we can reduce the Ferranti effect while transmission the current. Ferranti Effect is an increase in voltage occurring at the receiving end of a long transmission line, above the voltage at the sending end. This occurs when the line is energized, but there is a very light load or the load is disconnected. The Ferranti Effect will be more prominent the transmission line is longer and the voltage applied is on higher rate. The Ferranti effect is much more distinct in underground cables, even in short lengths, because of their high capacitance. Through this research work we are trying to increase the effectiveness of the transmission line while transmission of data as simultaneously increase the life of equipment. As this possible it will maintain the voltage applied on the line. We are using the Dynamic Voltage Restorer to control the voltage at the receiving end and decrease the Ferranti effect on transmission line. This paper presents an analysis of the effects of shunt and series line compensation levels on the transmission line voltage profile, transferred power and transmission losses for different static load models. For this purpose, a simple model is developed to calculate the series and/or shunt compensated transmission line load voltage. Consequently, different shunt and series compensation levels are used with several voltage sensitive load models for two different line models. It is observed that the compensation level is significantly affected by the voltage sensitivities of loads.

Keywords—Ferranti Effect, Series and Shunt capacitive compensation, Dynamic Voltage Restorer

I. INTRODUCTION

Power system should ensure good quality of electric power supply, which means voltage and current waveforms should be balanced and sinusoidal. Furthermore, the voltage levels on the system should be within reasonable limits, generally within 100±5% of their rated value. If the voltage is more or less than this pre-specified value, performance of equipments is sacrificed. In case of low voltages, picture on television starts rolling, the torque of induction motor reduces to the square of voltage and therefore there is need for voltage compensation. A compensation transformer will be series connected between power supply and load. Through its primary coil of the inverter, it can provide to the load side of same frequency, phase lock, amplitude variable compensate voltage to maintain the stability of output voltage. Power distribution systems, should ideally provide their customers with an uninterrupted flow of energy with a smooth sinusoidal voltage at the contracted magnitude level and frequency. However, in practice, power systems, especially distribution systems, have numerous nonlinear loads, which significantly affect the quality of the power supply. As a result of these nonlinear loads, the purity of the supply waveform is lost in many places. This ends up producing many power quality problems [6], [7]. An important percentage of all power quality problems are of the voltage quality type where what matters is the deviation of the voltage waveform from its ideal form. The best known disturbances of the voltage waveform are voltage sags and swells, harmonics, inter harmonics and voltage imbalances.

Issues occur in Ferranti Effect

Ferranti effect is due to the charging current of the line. When an alternating voltage is applied, the current that flows into the capacitor is called charging current. A charging current is also known as capacitive current. The charging current increases in the line when the receiving end voltage of the line is larger than the sending end. Capacitance and inductance are the main parameters of the lines having a length 240km or above. On such transmission lines, the capacitance is not concentrated at some definite points. It is distributed uniformly along the whole length of the line. When the voltage is applied at the sending end, the current drawn by the capacitance of the line is more than current associated with the load. Thus, at no load or light load, the voltage at the receiving end is quite large as compared to the constant voltage at the sending end.

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II. LITERATURE REVIEW

[1] Ankit Pandey, Rajlakshmi
This paper presents the study & analysis of DVR and power quality problems, voltage sag & swells with its application at Low Voltage and Medium Voltage level. DVR is always connected in series with the distribution feeder. The basic principle of a DVR is simple, by supplying a voltage of desired magnitude and frequency, the DVR restores the load voltage to a desired pre-sag voltage quantity even when source voltage is not balanced. Implementation of DVR has been proposed at both low voltage level as well as medium voltage level thus giving an opportunity to protect high power sensitive loads from voltage depletions.

[2] Jun Tan, Xinchun Lin, Yuping Duan, Jun Qiu
The dynamic voltage restorer (DVR) is designed to protect sensitive loads from the effects of voltage sags on the distribution feeder. The capability of DVR in compensating long-duration voltage sags is largely depended on the amount of stored energy within the restorer which is very expensive. In order to reduce the price of DVR, many control strategies have been implemented to make better use of the stored energy.

New scheme to control the two level VSI is presented in. detailed study of one of the SVPWM scheme i.e. seven segment space vector modulation (SVM) is done. Determination and realization of different switching states, sector value calculation, approximation of reference voltage vector and switching time calculation for linear modulation range is discussed. 

In this control algorithm in which the three D. Hongfaphase supply, is converted into synchronously rotating d-q reference frame. The component gives information for depth of sag and q-component tells us about phase shift information. The error generated is given to SVPWM for DVR operation.

III. PROPOSED SYSTEM

In this project we are using the Series and Shunt capacitive compensation. This method improve the power factor in transmission line. We are implementing this project using Series and shunt capacitive compensation is to get static voltage compensation under Flexible alternating current transmission system in shunt. This helps in lowering the voltage at the load end that may draw leading current either during charging the transmission line or during low loads. In this paper we make an electrical device which used to sustain, or restore, an operational electric load during sags, or spikes, in voltage supply. Often used in manufacturing areas requiring significant power to run tools/equipment, and utility plants, this custom device mitigates potential damage to equipment and undesirable slowdowns to the production line caused by an abrupt change in electric load.

COMPENSATION TECHNIQUES

1. SHUNT COMPENSATION

At buses where reactive power demand increases, bus voltage can be controlled by connecting capacitor banks into a parallel lagging load Kankar Bhattacharya and JinZhong,2001). Capacitor banks supply part of or full reactive power of load, thus reducing magnitude of the source current necessary to supply load. Consequently the voltage drop between the sending end and the load gets reduced, power factor will be improved and increased active power output will be available from the source (M.W. Gustafson and J.S. Baylor, 1988). Depending upon load demand, capacitor banks may be permanently connected to the system can be varied by switching ON or OFF the parallel-connected capacitors.

Following figure shows the single line diagram of a transmission line and its phasor diagram before the addition of the shunt capacitor and its phasor diagram.

2. SERIES COMPENSATION

When the line has high value of reactance to resistance ratio, the inductive reactance of the transmission line can be decreased by introducing series capacitors which results in low voltage drop (Rajesh Rajaraman et.al.,
1998). When a load with lagging power factor is connected at the end, voltage drop in the line is \((\cos \sin)\).

\[ V_D = I R_j + X_j V \]

If a capacitance ‘C’ with reactance \(Xc\) is connected in series with the line, then the reactance will be reduced to \((XL - Xc)\) and hence the voltage drop is reduced. Further the reactive power taken by the line is also reduced.

\[ j X_1 - j Xc \]

\[ j (X_1 - Xc) \]

Figure 2. Shows the single line diagram of a transmission line and its phasor diagram before the addition of the shunt capacitor and its phasor diagram.

Figure 3. Single line diagram of a shunt compensated transmission line and its phasor diagram.

Figure 4. Single line diagram of a series compensated transmission line and its phasor diagram.

It can be observed from the phasor diagram that line voltage drop is \(V_D = I (R \cos \varphi + (X_L - Xc) \sin \varphi)\). Thus the use of series capacitors is to reduce the voltage drop in the lines with low power factor and improve the voltage at the receiving end particularly with low power factor loads. For variable load conditions, the voltage can be controlled by switching in suitable series capacitors in the line. Under short circuit condition, the produced high voltage may damage the capacitor and so series capacitor has to be protected using a spark gap with a high speed contactor. The use of series compensation introduces few problems like Subsynchronous resonance, Ferroresonance and high recovery voltage.

Figure 5. Series and Shunt Waveform Comparison

IV. METHODOLOGY

This method uses critical devices such as an automatic Transfer switch and IGBT Modules in order to operate. We used this technique in a variety of transmission and distribution systems. It is a series compensation device, which protects sensitive electric load from power quality problems such as voltage sags, swells, unbalance and distortion through power electronic controllers that use voltage source converters (VSC).

The basic principle of the dynamic voltage restorer is to inject a voltage of required magnitude by keeping same frequency as the frequency of existing power, so that it can restore the load side voltage to the desired amplitude and waveform even when the source voltage is unbalanced or distorted. Generally, it employs a Thyristor (GTO) solid state power electronic switches in a pulse width modulated (PWM) switching structure.

The project can generate or absorb independently controllable real and reactive power at the load side. In other words, the dynamic voltage restorer is made of a
solid state AC to AC switching power converter that injects a set of three phase AC output voltages in series and synchronism with the distribution and transmission line voltages. Results show that voltage sensitivities of load have significant effects on receiving end voltage magnitude of the line, transferred power and power losses for different sizes of series and shunt capacitors. It is evident that load exponents have a significant influence on the required shunt capacitor sizes. Effects of shunt and series capacitors on the load voltage increase when voltage sensitivities of loads decrease. It is concluded that for a fixed load voltage level, the required shunt compensation.

Figure 6. Variation of the load voltage magnitude

V. DYNAMIC VOLTAGE RESTORER (DVR)

DVR (Dynamic Voltage Restorer) is a static var device that has seen applications in a variety of transmission and distribution systems. It is a series compensation device, which protects sensitive electric load from power quality problems such as voltage sags, swells, unbalance and distortion through power electronic controllers that use voltage source converters (VSC).

Figure 7. Dynamic Voltage Restorer

The basic principle of the dynamic voltage restorer is to inject a voltage of required magnitude and frequency, so that it can restore the load side voltage to the desired amplitude and waveform even when the source voltage is unbalanced or distorted. Generally, it employs a gate turn off thyristor (GTO) solid state power electronic switches in a pulse width modulated (PWM) inverter structure. The DVR can generate or absorb independently controllable real and reactive power at the load side. In other words, the DVR is made of a solid state DC to AC switching power converter that injects a set of three phase AC output voltages in series and synchronism with the distribution and transmission line voltages.

ADVANTAGE OF DYNAMIC VOLTAGE RESTORER

A dynamic voltage restorer (DVR) is a FACTS device used primarily in transmission lines to compensate for the voltage sag and voltage swell that occurs on it. FACTS is the acronym for Flexible Alternating Current Transmission Systems. A DVR is a circuit composed of power electronic components such as diodes and thyristors. It is widely used because of small size and efficient operation. Needless to say, it is indeed of great importance to ensure the voltage level in the transmission line within the specified limits as an overload condition on it may cause all the components connected to it to blackout. Dynamic voltage restorer using in manufacturing area requiring significant power to run tools, equipment and utility plants. It is also use in transmission and distribution coz it is series compensation devices.
In the above block the main aim is to control and keep balance the voltage across load. Initially controller check the incoming voltage coming from line with the help of ADC (analog to digital converter) present inside the Microcontroller. Our aim is to control a +ve as well as –ve half cycle of incoming AC for that a Firing angle control method is used. For controlling a firing angle of any AC voltage it is necessary to monitor every +ve/-ve half cycles, hence a Sine Wave Cycle Monitor (Zero Crossing Detector) block is used in our project, which informs a controller about start point of every cycle. Once controller knows the voltage across the load and signals from sine wave cycle monitor, controller calculate the firing angle and gives firing pulse to the AC to AC converter in which a static switch formed by a SCR/TRIAC is used. Static switch can operated on high voltage and high frequency as compare to the mechanical switches like relay. The output of AC to AC converter is further give to Reactor which is nothing but a type of single core step-up transformer.(220v to 300v transformer is used in our project), which gives a 220v output at140vAC input. The output of 220v is further used by a various load. The voltage across load is measured by the controller with the help of Potential Transformer (PT). Potential transformer is used to step down the voltage across the load to be measure and rectified to DC, because microcontroller can read a voltage upto 5vdc only. In our project we are using a Relay for tripping the input voltage in case of very high voltage and low voltage which is beyond control-able limits. The relay used in our project is of 12 volts and controller can give maximum of 5v, hence it is necessary to amplify the 5v to 12v for which a Driver circuit is used. Microcontroller requires a 5vDC to work, and same will be generated with the help of Power Supply which comprises of a Step down transformer, rectifier, filter and regulator. Transformer step down the 220vAC to 12vAC, rectifier and filter converts this 12vAC to12vDC, and regulator converts a 12vDC to a constant of 5vDC. Capacitor bank is a optional block which can be used in case of beyond limit regulation requires.

VI. CONCLUSION
This paper presents the study of a DVR and its application for the compensation of voltage sag for sensitive loads. Series and Shunt capacitive compensation which improve the quality of transmission line and the high voltage applied on receiver end and to increase the efficiency of transmission line. through which increase the life of equipments. And To control and maintain the receiving end voltage. This paper presents an analysis of the effects of shunt and series compensation levels on the transmission system voltage profile, transferred power, and line losses for different static load models.

REFERENCES