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Harmonics Voltage Stability and Power Quality Improvement Using PWM Compensation Technique

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Abstract—*This PWM method has better convergence properties the overall converter, the control of the reactive power is done by adjusting the amplitude of the fundamental component of the output voltage which can be modified with the PWM Technique The stability of is guaranteed and its Harmonics voltage Stability are analyzed when compared to its predecessors. is simple and effective in extracting fundamental and harmonic current information from nonlinear load currents. The extracted fundamental or harmonic currents therefore can be used as the reference signals for power quality improvement, harmonic selective cancellation or reactive power compensation. The method is also phase-independent and can thus be easily applied to single- or three-phase unbalanced systems. Simulation and experimental results verify the good performance of this improved Harmonics voltage Stability and Power Quality Improvement in harmonic selective cancellation and reactive power compensation. Due to its superior performance when regulating sinusoidal waveforms and the possibility to compensate for low order harmonics.*

Keywords-*PWM, Harmonics, Rectifier, Filter.*

1. INTRODUCTION

Compensation is defined as the management of Reactive power to improve the performance of ac power Systems. The concept of VAR compensation embraces a wide and diverse field of both system and customer problems, especially related with power quality issues, since most of power quality problems can be attenuated or solved with an adequate control of reactive power [1]. In general, the problem of reactive power compensation is viewed from two aspects: load compensation and voltage support. In load compensation the objectives are to increase the value of the system power factor, to balance the real power drawn from the ac supply, compensate voltage regulation and to eliminate current harmonic components produced by large and fluctuating nonlinear industrial loads [2], [3]. Voltage support is generally required to reduce voltage fluctuation at a given terminal of a transmission line. Reactive power compensation in transmission systems also improves the stability of the ac system by increasing the maximum active power that can be transmitted. It also helps to maintain a substantially flat voltage profile at all levels of power transmission, it improves HVDC (High Voltage Direct Current) conversion terminal performance, increases transmission switched capacitors is used, the reactive power is divided into a suitable number of steps and the variation will therefore take place stepwise. Continuous control may be obtained with the addition of a thyristor-controlled reactor. If it is required to absorb reactive power, the entire capacitor bank is disconnected and the equalizing reactor becomes responsible for the absorption. By coordinating the control between the reactor and the capacitor steps, it is possible to obtain fully step less control. Static compensators of the combined TSC and TCR type are characterized by a continuous control, practically no transients, low generation of harmonics (because the controlled reactor rating is small compared to the total reactive power), and flexibility in control and operation. An obvious disadvantage of the TSC-TCR as compared with TCR and TSC type compensators is the higher cost. A smaller TCR rating results in some savings, but these savings are more than absorbed by the cost of the capacitor switches and the more complex control system There are two bearing principles of the TCSC concept. First, the TCSC provides electromechanical damping between large electrical systems by changing the reactance of a specific interconnecting power line, i.e. the TCSC will provide a variable capacitive reactance. Second, the TCSC shall change its apparent impedance (as seen by the line current) for sub synchronous frequencies such that a prospective sub synchronous resonance is avoided. Both these objectives are achieved with the TCSC using controls that operate concurrently.

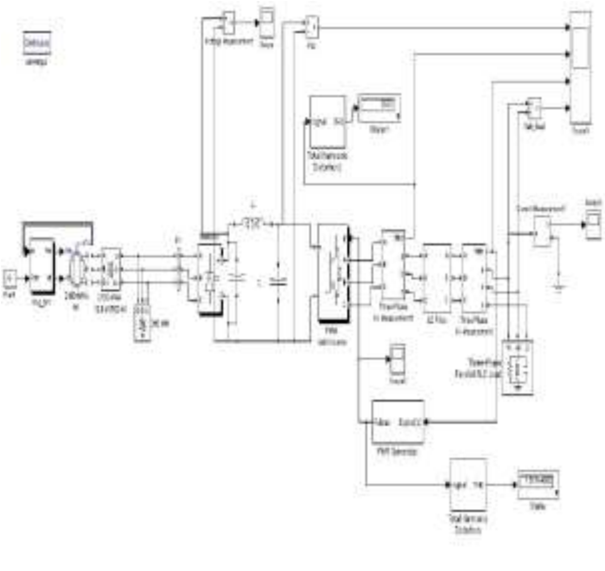

Figure 1. Harmonics voltage Stability and Power Quality Improvement Simulink Model

The controls will function on the thyristor circuit (in parallel to the main capacitor bank) such that controlled charges are added to the main capacitor, making it a variable capacitor at fundamental frequency but a "virtual inductor" at sub synchronous frequencies. For power oscillation damping, the TCSC scheme introduces a component of modulation of the effective reactance of the power transmission corridor.

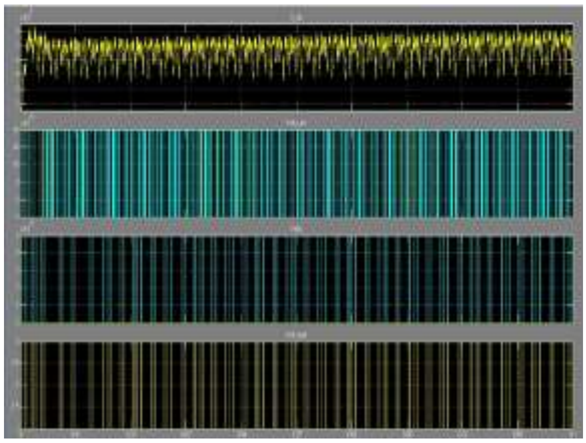

Figure 2. Harmonics distortion & Improve results

By suitable system control, this modulation of the reactance is made to counteract the oscillations of the active power transfer, in order to damp these out Due to the development of new grid codes, power converters' output signal harmonic control is currently becoming extremely important in medium and high-power applications. By taking this new scenario into account, a new method to generate switching three-level pulse width-modulation (PWM) patterns to meet specific grid codes is presented. The proposed method, which is named selective harmonic mitigation PWM, generates switching three-level PWM patterns with high quality from the point of view of harmonic content, avoiding the elimination of some specific harmonics and studying all harmonics and the total harmonic distortion as a global problem by using a general-purpose random-search heuristic algorithm. This fact leads to a drastic reduction or even avoidance of the bulky and costly grid connection tuned filters of power systems. Any harmonic shaping can be considered due to the flexibility of the method. Power devices switching constraints are considered to obtain directly applicable results. As a practical example, limits from one actual grid code have been used to get the experimental results by means of a 150-kVA three-level diode-clamped converter test bench. Comparisons between the proposed technique, optimized PWM and Selective Harmonic Elimination methods have been carried out.

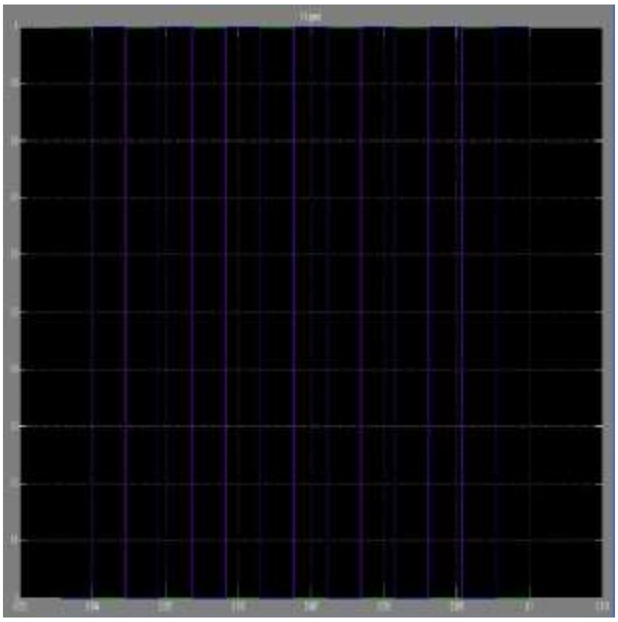

Figure 3. Optimized PWM results

The results obtained with this new method greatly improve previous ones. The traditional way to develop the transmission network in order to achieve better linkage between generation and demand was to reinforce of the grid, mainly by installing new lines and substations. However, in recent years substantial changes were implemented in the traditional structures of electric power systems throughout the world. The general reason for this is to improve efficiency, and the main tools are deregulation and privatization i.e. the introduction of market rules to the electrical sector. In consequence the transmission system must be adapted to the new conditions of open access and open trading. This adaptation requires the construction of new interconnections between regions and countries. The other important element is the necessity to adapt transmission systems to changing generation patterns. Manufacturers of electrical equipment must be prepared to meet these new requirements, where relocatability and flexibility will be the critical factors. The flexibility of the system also means shorter planning and decision-making, with the consequence that shorter delivery times are requested. Transmission of electric energy at EHV (extra high voltage) over a long distance by means of alternating current (AC), requires some kind of reactive compensation. This is due to the inherent distributed series reactance and shunt susceptance of the long AC transmission line. If suitable means for reactive compensation are not installed, operation of the EHV power system for different steady state and dynamic conditions becomes difficult and even impossible. Basically, reactive compensation may be applied to the power system in two ways: series compensation and shunt compensation. Usually, shunt compensation is employed for voltage control and series compensation to control the longitudinal behavior of the network. The series capacitor is a special case of controlling the power transmission system through control of a longitudinal element, i.e. an element that is placed lengthwise in the transmission line. This is in contrast to shunt element controls, such as the control of generation, of loads or using static var compensators. However, each type of compensation affects, to some extent, both the voltage control and the stability limit. In an actual long distance EHV AC transmission system, means for series and shunt compensation are often combined in order to achieve the optimal result. Application of Series Capacitors The property of the series capacitors is that it provides a method of controlling the longitudinal behavior of the network while providing reactive power. This form of compensation is very effective in certain situations. The Series Capacitor reduces the total reactance of a transmission line and thus makes the line electrically shorter. To summarize, the main reasons for incorporating series capacitors in transmission systems will be To increase the power transfer capability as a result of raising the transient stability limit To improve the voltage profile of the system To reduce transmission system losses by optimizing the sharing of active power between parallel lines To reduce the cost of power transmission by making power transfer with fewer parallel lines and less required shunt compensation possible. Series compensation in a system improves voltage control and reactive power balance because the reactive power generation in a series capacitor increases as the transmitted power increases. In this respect, the series capacitor is a self-regulating device. The important features of series capacitors as a part of the transmission system is high reliability and proper protection arrangement. High reliability means that the series capacitor is designed in such a way that its availability is at least as great as that of the other vital parts of the system (lines, breakers, transformers, etc.). The protection demand implies that the series capacitor has to be provided with a protective system which quickly and safely by-passes the capacitor in a situation where faults in the surrounding parts of the power system give rise to conditions which might cause damage to the series capacitor. However, the same protective system also has to allow the series capacitor to be reinserted into the power system with a minimum of delay as soon as the fault in the surrounding network has been cleared. To summarize the application of SVC gives the following benefits. In power transmission: Stabilized voltages in weak systems Reduced transmission losses Increased transmission capacity, to reduce or remove the need for new lines Higher transient stability limit Increased damping of minor disturbances

Voltage Control and Stability:

- Power swing damping
- In power distribution:
- Stabilized voltage at the receiving end of long lines
- Increased productivity as stabilized voltage better utilizes capacity
- Reduced reactive power consumption, gives lower losses and eliminates higher or penal tariffs
- Balanced asymmetrical loads reduce system losses
- Fewer stresses in asynchronous machinery
- Enables better use of equipment (particularly transformers and cables)
- Reduced voltage fluctuations and light flicker
- An SVC typically comprises a transformer, reactors, capacitors and bi-directional thyristor valves. There is a variety of main circuit arrangements. Figures 4 and 5 show two common schemes:
- FC/TCR – Fixed Capacitor (filter) / Thyristor-Controlled Reactor
- TSC/TCR – Thyristor-Switched Capacitors/Thyristor-Controlled Reactor

With the advent of thyristor control, the usefulness of series compensation has been augmented further. Applications not spoken of hitherto in conjunction with series compensation such as active power flow control, damping of power oscillations, and last, bust not least, mitigations of sub-synchronous resonance, are all now a practical reality. The latter item, in particular, had for a long time been in search of a good and practicable solution, and with sub-synchronous resonance no longer an obstacle, it can be expected that the usefulness of series compensation will be appreciated even more than before and the technology put to even more widespread Use If damping is poor over a transmission line, minor system disturbances can get active power oscillations started between generator systems at either ends of the line. These oscillations, usually appearing at low frequencies (<1 Hz), as a rule are more pronounced at higher loads than at lower loads and as a matter of fact act as a limitation on effective power transmission capability of interconnections between generating areas. This could be a serious drawback for instance in conjunction with power corridors between countries or between regions within countries. The plant can in most cases be designed completely without harmonic filters. In some cases where the requirements on high order harmonics are very stringent a small high pass link may be necessary. The risk for resonant conditions is therefore negligible. This property makes the SVC Light suitable for easy relocation to other sites at changing network demands.

IGBT Valves:

The converter bridge consists of three phases, with two IGBT valves per phase. The corresponding AC phase is connected between the two valves, which enables the three phases to create a symmetrical DC voltage with opposite polarities, with respect to the midpoint grounded DC capacitors. Each valve consists of a number of IGBT's, determined by the DC voltage level, which in turn is directly proportional to the DC power level. The IGBT's are switched on and off with a constant frequency of about 2 kHz.

Phase Reactors:

These are standard single phase air cooled reactors. They are used for controlling both the active and the reactive power flow, as well as for smoothing of the current, and reducing the inrush currents upon energization from the AC side. The reactors are essential for both the active and reactive power flow, since these properties are determined by the power frequency voltage across the reactors.

DC Side Capacitors:

On the DC side there are two capacitor stacks of the same size, one from each one of the poles to ground. The size of these capacitors are depending on the required DC voltage. The purpose is to keep a stable DC voltage at the desired level. The capacitors stacks are being charged to opposite polarities by the high frequency switching IGBT's.

AC Filters:

The AC voltage output contains harmonic components, derived from the switching of the IGBT's. These harmonics have to be taken care off, preventing them from being emitted into the AC system or the air, causing malfunctioning of AC system equipment or radio and telecommunication disturbances. One single HP filter branch is enough to take care off these low energy harmonics.

2. CONCLUSION

The Power Quality (PQ) problems in power distribution systems are new but only recently the effects of these problems have gained public awareness. Advances in semiconductor device technology have fuelled a revolution in power electronics over the past decade and there are indications that this trend will continue. However these power equipments which include pwm Technique electronic power supplies, Direct Current (DC) electronic ballasts are responsible for the rise in related PQ problems. These non-linear loads are constructed by nonlinear devices in which the current is not proportional to the applied voltage. Non-linear loads appear to be prime sources of harmonic distortion in a power distribution system. Harmonic currents produced by non-linear loads are injected back into power distribution systems through the Point of Common Coupling (PCC). These harmonic currents can interact adversely with a wide range of power system equipments, most notably capacitors, causing additional losses, overheating and overloading. Traditionally, current harmonics caused by non-linear loads have been dealt using passive filters consisting of capacitors, inductors and damping resistors. They provide simple solutions but very often have large size and weight, hence they cannot provide flexible compensation. Moreover, the passive filters are known to cause resonance, thus affecting the stability of the power distribution systems.

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