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Reactive Power control in HVDC System using Multi Level Current Reinjection Converters

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Abstract:

Multilevel Voltage Source Converter(VSC) configurations have been presented as possible alternatives to PWM-VSC Transmission, but their structural complexity has been the main obstacle to their commercial implementation. Due to their structural simplicity and four quadrant power controllability, pulse width modulation (PWM) conversion has so far been the preferred option for self-commutating medium power HVDC transmission.

However, this technology is less suited to large power ratings and long distances, due to higher switching losses and to the rating limitations of its main components (namely the power transistor switch and underground cable). Thus the interchange of large quantities of power between separate power systems and the transmission of power from remote generating stations are still based on the principle of line-commutated current source conversion.

A recent proposal, the multilevel current reinjection (MLCR) concept simplifies the converter structure and permits the continued use of conventional thyristors for the main converter bridges This project describes a new concept applicable to large power converters consisting of two series-connected twelve-pulse groups. It is based on the use of a controllable shift between the firings of the two twelve-pulse groups in opposite directions, a new concept that provides independent reactive power control at the sending and receiving ends. PID Controller is used in this paper and Simulation is carried out using MATLAB/SIMULINK software and results shows the Effectiveness of the proposed system.

Index Terms:

HVDC transmission, multilevel conversion, reactive power control.

I. INTRODUCTION:

This technology is less suited to large power ratings and long distances, due to higher switching losses and to the rating limitations of its main components (namely the power transistor switch and underground cable). Thus the interchange of large quantities of power between separate power systems and the transmission of power from remote generating stations are still based on the principle of line-commutated current source conversion.

Multilevel VSC configurations have been presented as possible alternatives to PWM-VSC Transmission, but their structural complexity has been the main obstacle to their commercial implementation. A recent proposal, the multilevel current reinjection (MLCR) concept, simplifies the converter structure and permits the continued use of conventional thyristors for the main converter bridges.

The main advantage of self over natural-commutation in HVDC transmission is the ability to control independently the reactive power at each end of the link, a property that cannot be achieved by MLCR-based (or any other multilevel) configuration when using only one double-bridge converter group. However, interconnections of large power ratings will normally use two or more 12-pulse converter groups and these can be controlled independently from each other without affecting the output voltage waveform.

This fact constitutes the basis of the new control scheme proposed here. When the operating condition at one end of the link alters the reactive power balance at this end, the firings of the two groups at the other end are shifted with respect to each other in opposite directions to keep the power factor constant. The new control concept gives the MLCR configuration described in the flexibility until now only available to PWM–VSC transmission.

II. INTERDEPENDENCE OF THE REACTIVE POWER UNDER CONVENTIONAL CONTROL:

PWM provides fully independent controllability of the converter voltages (and therefore reactive power transfers) on both sides of the link. This capability is not available to multilevel configurations under the present control strategies. For instance, if extra reactive power is needed at the receiving end to maintain the ac terminal voltage constant, the firing angle is increased and, therefore, the dc voltage reduced. To continue transmitting the specified power under this condition, the sending end station must also reduce its dc voltage. The dc voltage reduction is implemented by a corresponding increase in the firing angle of the two converter groups; this action will force an unwanted extra injection of reactive power and, thus, an increase of ac terminal voltage at this end. Such condition would not occur if some PWM control were to be added to the multilevel configurations. However the use of PWM is currently limited to three levels and is only used in voltage source conversion schemes. In multilevel CSC HVDC interconnections with two twelve pulse groups per terminal (such as shown in Fig. 1) the same current waveform is produced by each of the 12-pulse converter groups, and thus the total output current waveform remains the same if a phase-shift is introduced between the firings of the two groups constituting the converter station.

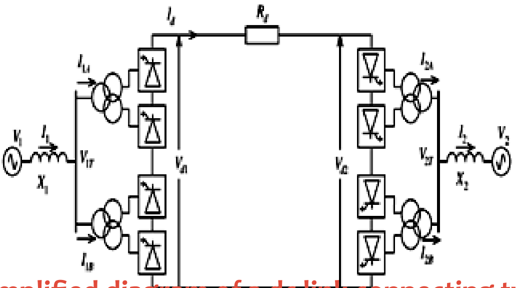


Fig.1 Simplified diagram of a dc link connecting two ac systems.

When a change of operating conditions at the receiving end demands more reactive power from the converter, and thus reduces the dc voltage, shifting the firings of the two sending end converter groups in opposite directions provides the required dc voltage reduction, while maintaining the reactive power constant (due to the opposite polarity of the two firing angle corrections). A relatively small change of active power will be caused by the variation of the fundamental current produced by the shift, but this change can be compensated for by a small extra correction of the two firing angles. For a converter to operate in the firing-shift mode (which in the above example is the sending end converter), the firing instants of one group (say group A) is kept on the positive side (thus providing reactive power), while the second group (say group B) may act as a source or sink of reactive power (i.e., the firing angle may be positive or negative).

III. CONTROL STRUCTURE:

For complete flexibility the sending end needs to control real and reactive power and the receiving end keep the converter dc voltage constant (so as to minimize dc current for a given real power setting) and control the reactive power. With reactive power control at both ends, the controllers can easily be configured for optimum power transfer at the system level depending on operating objectives, which usually involves providing constant power factor at the sending end and constant ac terminal voltage at the receiving end. In order to control the real and reactive power over the complete operating range the converter response needs to be linear. Standard PID controllers are unsuitable for this application as their gain is static, and although they may give suitable performance over a narrow band, the latter is not acceptable over the complete range. This is explained in more detail later. Given the aforementioned controller surfaces, it is difficult to visualize how the controller must perform, especially since the controller firing angles are expected to operate equally well in the positive and negative regions. As mentioned earlier, conventional controller operation is confined to a relatively small range and functions with a fixed gain, thereby assuming that the system is linear over the small range. As the reactive power circulation is confined to the ac system side, the magnitude of the ac current in each converter group determines the level of reactive power controllability in the ac system.

IV. SIMULATION RESULTS:

The test circuit is a simplified HVDC link configuration with the two interconnected systems represented as Thevenin equivalents. As shown in Fig. 1, each terminal consists of two five-level MLCR converter groups. Using 1000 MW and 220 kV as base values, the source voltages are set at 1.06 and 1.02 p.u. at the sending and receiving ends, respectively. The series impedances at the sending and receiving ends are set to 0.2 p.u. to represent systems with SCRs of approximately 3.1, and the transformer leakage reactance of all converter transformers is equal to 0.1 p.u. The dc line is represented by a resistance of 0.2 p.u. in series with a 2H smoothing inductor.

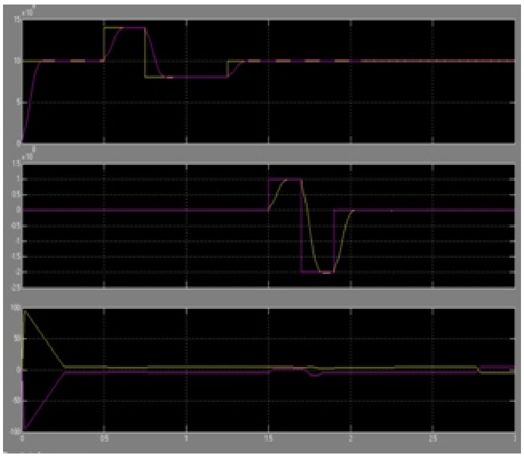


Fig.2 Real and reactive power changes at the sending end.

The active power transfer and reactive power are the controlled variables at the sending end; at the receiving end the controlled variables are the dc voltage and the reactive power order. As the secondary control objective is to maintain dc voltage constant, a maximum step of 100 MVAr is possible at the receiving end. This is because the receiving end terminal voltage decreases as more reactive power is required by the converter, which further contributes to the decrease in dc voltage for a given firing angle. The dynamic simulation in MATLAB/SIMULINK features the effect of four separate controllers, one for each of the reactive powers, and one for the sending end real power and receiving end dc voltage. By adding an extra controller to each of the reactive power orders, it is possible to control the system to provide unity power factor and constant terminal voltage over the complete real power operating range.

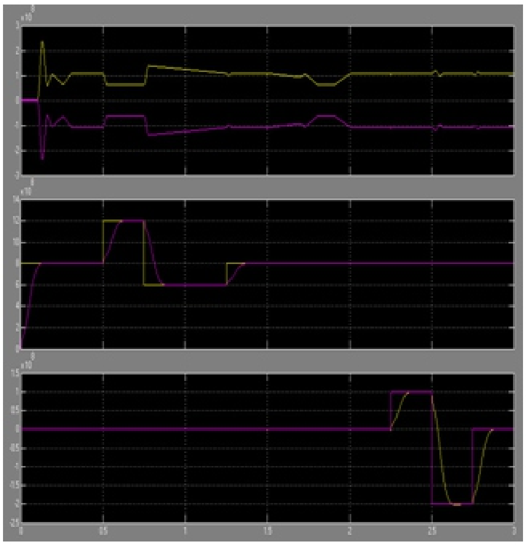
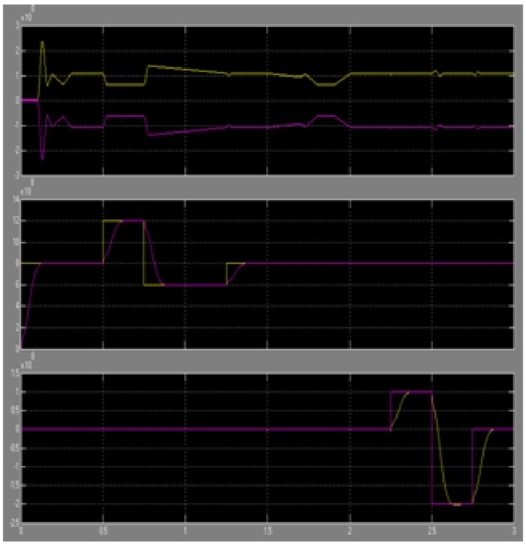


Fig.3 Real and reactive power changes at the receiving end

The sending end correction is made from the point of view of the ac system, so the converter controller is configured to maintain the power factor of the main supply transmission line as well. In practice it may not be possible to calculate the impedance of the supply in all cases, and an approximation would have to be made about a "nominal" correction point. At the receiving end, the control of the terminal voltage should be easier to achieve, as the nominal supply voltage would be known, or could be calculated. This could also be adjusted manually by the system operator to provide additional voltage support as necessary.



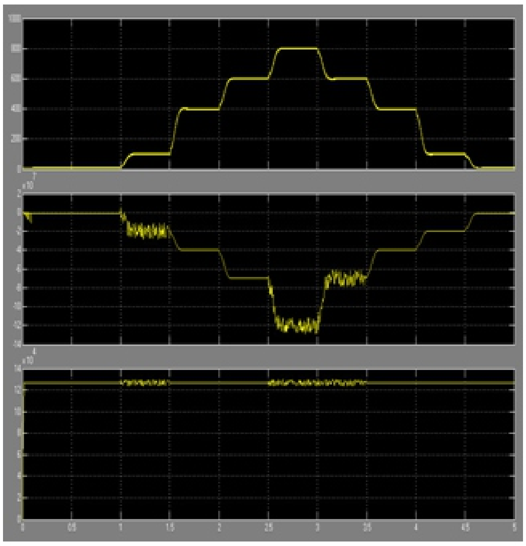


Fig.4 Reactive power responses under power factor and terminal voltage control for a series of step changes to real power.

V. CONCLUSION:

A new type of converter control has been developed, applicable to multilevel HVDC schemes with two or more 12-pulse groups per terminal. It has been shown theoretically, and verified by MATLAB simulation using an MLCR configuration, that the use of a controllable shift between the firings of the series connected converter groups permits independent reactive power control at the two dc link terminals. This provides four quadrant power controllability to multilevel current source HVDC transmission and, thus, makes this alternative equally flexible to PWM-controlled voltage source conversion, without the latter's limitations in terms of power and voltage ratings. It can be expected that MLCR, combined with firing-shift control, should compete favorably with the conventional current source technology for very large power applications.

REFERENCES:

[1] G. Asplund, K. Eriksson, and O. Tollerz, "Land and sea cable interconnections with hvdc light," presented at the CEPSI Conf., Manila, Philippines, Oct. 2000.

[2] G. Asplund, K. Eriksson, and K. Svensson, "DC transmission based on voltage source converters," presented at the CIGRE SC Colloq., Johannesburg, South Africa, 1977.

[3] Cigre SC-4 WG 37, VSC Transmission Final document. Paris, France, 2004.

[4] G. Jung et al., "A general circuit topology of multilevel inverter," in Proc. IEEE Power Electronics Specialist Conf., 1991, vol. PESC 91 Rec., pp. 96–103, Mass. Inst. Technol..

[5] L. B. Perera, N. R. Watson, Y.-H. Liu, and J. Arrillaga, "Multi-level current reinjection self-commutated HVDC converter," Proc. Inst. Elect. Eng., Gen., Transm. Distrib., vol. V152, no. 5, pp. 607–615, Sep. 2005.

[6] J. Arrillaga, Y. H. Liu, L. B. Perera, and N. R. Watson, "A current reinjection scheme that adds self-commutation and pulse multiplication to the thyristor converter," IEEE Trans. Power Del., vol. 21, no. 3, pp. 1593–1599, Jul. 2006.

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