

## THE VSC-HVDC ELECTRIC POWER QUALITY ANALYSIS AND RESEARCH

Yifan Zhu

Electric Power Research Institute, Shanghai Municipal Electric Power Company – China

[dsy\\_zhuyf@ec.sgcc.com.cn](mailto:dsy_zhuyf@ec.sgcc.com.cn)

### ABSTRACT

*New energy technology application will occupy more and more of the important position in the future of the electric power development. Traditional transmission mode has become the bottleneck which restricts the mass construction of the new energy electric power plant. The flexible DC transmission technology has more advantage than the traditional transmission technology in the application of new energy and distributed energy electric power system. This paper is based on study of electric power quality in VSC-HVDC and synthetically analyses on the electric power quality suppression. This paper expounds the conventional HVDC electric power quality characteristics. Analysis the application of VSC-HVDC to implications electric power quality after through comparing measure data between VSC-HVDC put operation and no put operation. On the basis of the analysis this paper put forward improving suggestions.*

### INTRODUCTION

The continuous progress of the process of urbanization and the rapid development of the socio-economic urban in line with the continued rapid growth in electricity load center for the city to provide quality, reliable electricity will face increasing difficulties. Flexible DC transmission technology, applications can make use of its transmission capacity, the trend is quickly controlled the power shortage situation can be characterized by solution to the load centers. In the continuous application of the flexible transmission of Liu in the new energy access and urban micro-network access, send electricity power quality become more and more focus.

The main work of this article is the study of a flexible DC power transmission system of power quality, power quality measured by the Shanghai Nanhui flexible DC demonstration project to demonstrate the flexible DC power quality characteristics and suggest improvements.

### FLEXIBLE HVDC SYSTEM

Flexible HVDC transmission is a will shut off the power electronics device into dc transmission areas of new type HVDC technology. Its main characteristic is used with the ability to shut off the all-controlling semiconductor device IGBT constitute a voltage source converter, replace conventional dc transmission of the application of half control based on thyristor device of

current source converter. In the power grid technology flexible HVDC system has can quickly independent control, reactive power ability, can realize the convenience of the trend of the reverse, can effectively improve the communication system of transmission ability and the power-angle stability, which can realize quickly restored power supply and black start to passive and power supply etc. Characteristics. In the economic and environmental impact on flexible HVDC system also has cover an area of an area small, construction period is short, low electro magnetic interference, etc. <sup>[1]</sup>

### FLEXIBLE HVDC SYSTEM HARMONIC SOURCE ANALYSIS

Similar to the traditional thyristor-based HVDC transmission system, due to the non-linear converter, voltage source converter AC side voltage and current waveforms are not sine wave DC voltage and current waveform is not smooth constant DC they contain a variety of harmonic components. In other words, the voltage source inverter in the AC side and DC side will produce harmonic voltage and harmonic current. The Voltage source converter is also the main harmonic source of the flexible HVDC transmission project.

The amplitude of the voltage source inverter in the AC side voltage harmonics and harmonic frequency depends on its design and structure. Voltage source converter of flexible direct current transmission project has many models and types are divided into two level voltage source converter and multi-level voltage source converter. Two level voltage source converter easy to control, but the accuracy of inverter parameters of a structural high demands. Using multi-level voltage source converter can reduce the relative accuracy of structural parameters of the converter, also put forward higher requirements of the modulation controller. Figure × is a modular multi-level structure based on IGBT module series.

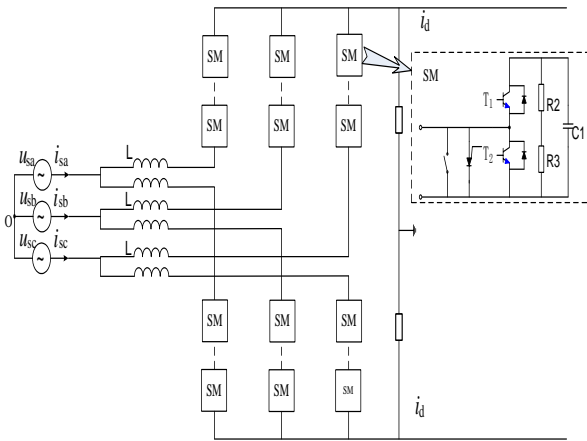


Figure x The modular multi-level voltage source inverter topology

Figure x shows the use of modular multi-level structure of converters in the AC side voltage output waveform under ideal conditions.

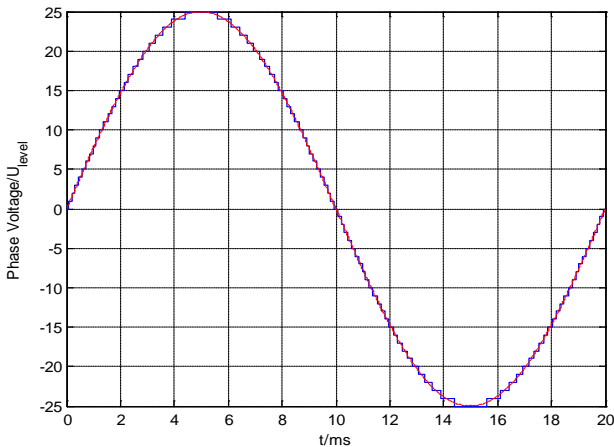


Figure x The ac voltage output waveform

In the actual running of the system, not only the magnitude and phase of the characteristic harmonics may be have some differences related to the theoretical ideal conditions , but also produce many non-characteristic harmonics. Among them, the sub-module capacitor voltage imbalance is to generate non-characteristic harmonics is an important factor. Greater volatility of the sub-module capacitor voltage imbalance and sub-module capacitor voltage will cause great impact on the converter output voltage harmonic characteristics.

### FLEXIBLE HVDC SYSTEM HARMONIC MEASUREMENT

#### Shanghai Nanhui flexible HVDC demonstration project

Shanghai Nanhui flexible HVDC demonstration project is a 35 kV voltage grade transmission engineering of the trial. The project uses a flexible DC transmission line to replace the existing AC line. New dc lines and the

original another ac line common will nanhui wind farms 35 kV ac system access. Figure x shows the structure of this project.

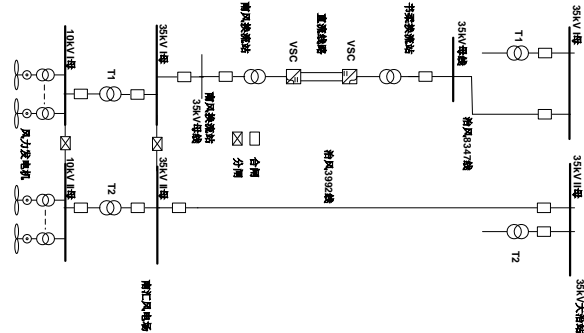


Figure x the structure of Shanghai Nanhui flexible HVDC demonstration project

Shanghai Nanhui flexible HVDC demonstration project has a variety of operation modes. Nanhui wind farms can not only access the 35kV AC system through the DC line but also can through an exchange line access 35kV AC system. In order to research the flexible HVDC system of electric energy quality characteristics, the selection of the dc lines of the inverter converter 35 kV bus and 35 kV ac outlet as a test of the power quality test site.

### Harmonic

#### Harmonic voltage

Measure harmonic voltage of flexible HVDC when the system put operation and no put operation. And analysis the two operation mode of 35 kV bus voltage results from 3 times harmonic to 50 times harmonic .Figure \* shows the harmonic voltage composition 95% probability value comparison chart .

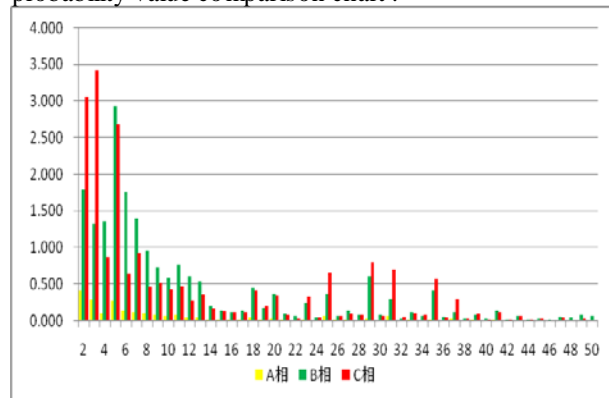


Figure \* 35 kV bus harmonic voltage value 95% probability of spectrum(%)

According to the test results, it is known that in flexible HVDC system not operation mode the voltage harmonic 25 times harmonic content is the largest,the highest content harmonic reached 2.344%, and 35 kV total harmonic distortion rate reached 3.389% ; in flexible HVDC system operation mode the voltage harmonic 25 times harmonic content evidently decreased , total 35

kV harmonic distortion rate THD are reduced, at 2.887%.

### Harmonic current

Through measure the harmonic current of 35 kV sent line current for 24 hours in the flexible HVDC system full power operation, and the result of the test has been analysed from 3 times harmonic to the highest 50 times harmonic. Figure \* shows the harmonic current component 95% probability value spectrum diagram.

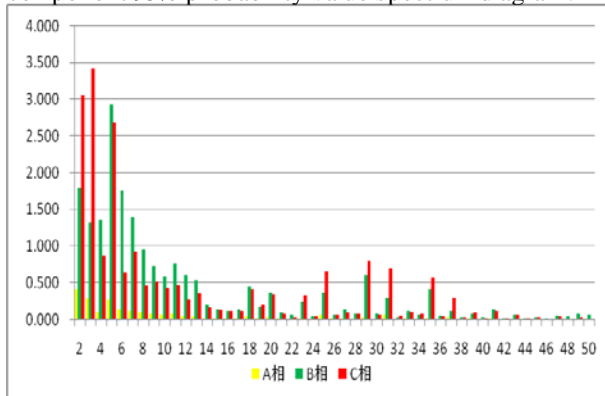


Figure \* 35 kV into line harmonic current 95% probability value spectrum(A)

According to the test results indicate that the flexible HVDC system inverter 35 kV into line current harmonic distribution mainly concentrates in low harmonic, among them, 2, 3, 5 times harmonic content is the highest.

### Three-phase unbalance

Through the long time observation of 35 kV bus voltage waveform, and analyzing the collection of the data to sorting out the test voltage we know that during the test the negative sequence unbalanced three-phase degree maximum is 1.0093%, and the minimum of 0.0377%, 95% probability value is 0.5168%.

Figure × show the curve of the 35kV bus voltage negative sequence imbalance



Figure \* Negative sequence unbalanced three-phase curve

Through the long time observation of 35 kV into

line current waveform, and analyzing the collection of the data to sorting out the test current we know that during the test the maximum negative-sequence current of 71.70A, and the minimum value is 31.67A, 95% probability value of 70.15A.

### Voltage flicker

With longer observation of the 35kV bus voltage in a short time flicker and long time flicker, and by finishing the test data can draw the 35kV bus voltage of the short time flicker and long time flicker trend. Figure × shows the trend of the short time flicker map, and table × statistics of bus voltage for a long time flicker.

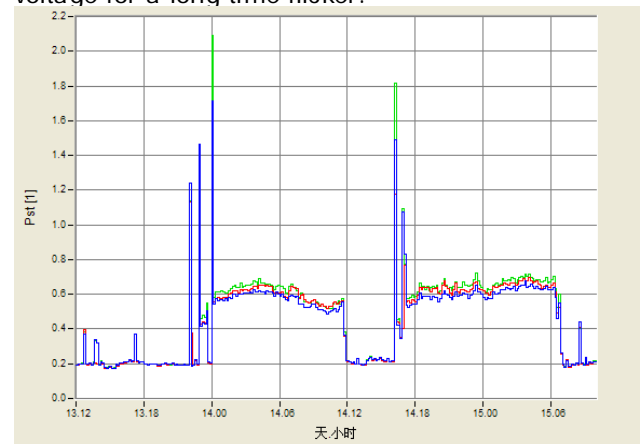


Figure \* Voltage of short-term flicker trend

Table × Voltage long flicker statistics(A)

Operation mode	Statistical methods	Phase A	Phase B	Phase C
During the service	95% probability value	0.252	0.237	0.254
	Maximum value	0.443	0.455	0.482
During operation	95% probability value	0.799	0.670	0.909
	Maximum value	0.839	0.672	0.993

### Comprehensive contrast

Relatively flexible HVDC system of power quality characteristics in the operation and decommissioning of two operation modes, we know that the HVDC flexible than the traditional AC transmission in terms of harmonic voltage and harmonic current and three-phase voltage unbalance more obvious decrease in the same time increase the voltage for a long time flicker. Combined with the actual situation analysis should be out the rectifier frequency controller of HVDC

system operation with the ideal situation.

## **CONCLUSION**

Flexible HVDC transmission technology to send electricity power quality optimize the role, not only enhance the ability of the transmission of electricity to urban load centers also ease the pressure of the growing urban non-resistive load to the city grid power quality. Modulation control, and the ideal situation of a certain gap, but with the constant application of the flexible HVDC transmission technology, the power quality of the urban grid will continue to improve.

## **REFERENCES**

- [1] Guangfu Tang., 2010, HVDC technology based on voltage source converter , China Electric Power Press, Beijing, China, 13-36