

# Field Calibration Technology of DC Current Transformer in Extra and Ultra HVDC Converter Station

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**Abstract.** With further development of the state extra and ultra HVDC transmission engineering and technology, the demand of DC current transmission system for key measuring equipment like direct current transformer is higher and higher, and its application will be increasingly widespread. The DC current transformer is one of the key measuring equipments which are related to stable, safe and reliable operation of DC transmission system, but it mainly depends on import, and we also lack independent test method and equipment for product performance. Therefore, at present, whether before commissioning of converter station, or during operation maintenance, it is difficult to make performance investigation for it. Or the cost is high. These have all resulted in the fact that it is hard to accurately control and grasp the real operation conditions of this type of DC measurement equipment. The DC transformer field test equipment and technology mentioned in this paper have proved to be effective and practical by actual application in DC engineering field, and good effect has been achieved in practical application.

**Keywords:** DC transmission; DC current transformer; High-precision DC current comparator; High-stability DC current source; Wireless synchronous acquisition device

## 1. Introduction

Development of ultra HVDC transmission technology originates in the 1960s. Chalmers University of Technology in Sweden started to research extra and ultra high voltage ( $\pm 750\text{kV}$ ) power transmission line in the mid 1960s. Since then, countries like former Soviet Union in Europe and Brazil in South America have also contributed themselves to research of extra and ultra HVDC transmission engineering and engineering practice work<sup>[1]</sup>. Both IEEE (Institute of Electrical and Electronic Engineers of the US) and Cigre (International Council on Large Electric Systems) pointed out in the 1980s that<sup>[2]</sup>: according to the existing technology and operating experience,  $\pm 800\text{kV}$  is the suitable DC transmission voltage class<sup>[3]</sup>. For several years, our country has done researches on voltage class of HVDC transmission in every way and strived to make technological breakthrough. At the same time, in consideration of the research and development level of DC transmission technology as well as study and production capacity of DC equipment, our country has been determined to set an ultra HVDC transmission class as a direction, and finally decided that  $\pm 800\text{ kV}$  is the nominal voltage of ultra HVDC transmission in China<sup>[4]</sup>.

DC Transformer is the important primary equipment of DC transmission system<sup>[5]</sup>, which provides accurate and reliable measurement information for control and protection of the system, and its operational reliability and measurement accuracy are directly related to safe and stable operation of DC transmission system<sup>[6]</sup>. In order to launch field calibration of DC Transformer in DC converter station, we have to study technical requirements of field calibration current source, type and structure of standard equipment which can be applied to field calibration, measuring circuit and error processing method, and calibration technology of standard equipment for measuring large current<sup>[7]</sup>. Most DC transformers adopted by converter station which has been put into operation are imported, and the nationalization level is quite low<sup>[8]</sup>. In practical

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operation, failure has occurred to DC transformers adopted by some convertor stations for several times, and some failure directly resulted in monopole blocking of DC system. At present, calibration test is done for DC transformer adopted by convertor station only when it leaves the factory. Owing to lack of corresponding test method and test equipment, as well as relevant DC transformer standard and technical supervision regulations, conditions for field calibration test and regular calibration of DC transformer in our country are quite deficient.

## 2. General situation of DC current transformer used in extra and ultra HVDC convertor station

The DC current transformer adopted by convertor station which has been put into operation at present can be divided into optic current transformer (OCT) and zero magnetic flux DC current transformer (zero magnetic flux CT). They have different characteristics: OCT can solve insulation problems easily, and zero magnetic flux CT has high accuracy, so they are applied to different places of convertor station. OCT is mainly applied to current measurement of polar line in DC valve hall, polar line in DC field and return circuit of DC-filter high-pressure side. Zero magnetic flux CT is used for current measurement of DC neutral conductor in valve hall, neutral conductor in DC field and NBGS switch in DC field<sup>[9]</sup>. Figure 1 is the wiring diagram of the DC part in a certain convertor station, and it can be seen that application of DC current transformer in convertor station is quite widespread.

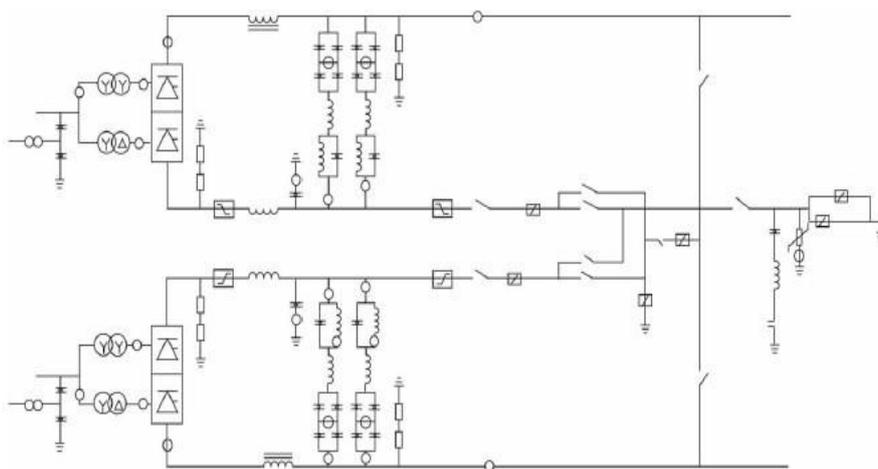


Fig.1. Wiring diagram of the DC part in convertor station

## 3. Field calibration principle and calibration equipment

The equipment used for field test of DC current transformer in extra and ultra HVDC convertor station can be divided into two classes: one is the standard equipment used in field, which is mainly direct current proportion standard equipment---DC current comparator; the other type is the key auxiliary equipment, including field high-stability DC current source<sup>[10]</sup> and wireless synchronous data acquisition device.

### 3.1 High-stability DC current source

With successive commissioning of extra and ultra HVDC transmission engineering in the country, the demand for DC current source which is suitable for field current transformer test is higher and higher. It not only requires the current output of this power source to remain continuous and adjustable from 0 to the rated range, but also requires the current output to keep high stability and high accuracy. At the same time, in order to meet the actual demand of field test, the power source shall be small in size, light in weight and reliable to the greatest extent.

### 3.2 DC current proportion standard

Calibration of 0.2-magnitude zero magnetic flux CT requires the accuracy degree of standard equipment

to reach at least 0.05 magnitudes. Therefore, 5kA DC current comparator is trial-produced as the standard equipment in calibration test<sup>[11]</sup>. Magnetically modulated DC comparator<sup>[12]</sup> was first developed by Kusters of Canada in the 1960s, its accuracy has reached over  $1 \times 10^{-6}$ , and various countries in the world have already adopted such DC current comparator as DC current proportion standard<sup>[13]</sup>.

### 3.3 Synchronous data acquisition device

In DC transformer field calibration test, standard output and output of the calibrated transformer are placed at DC field and control room respectively. When the secondary output of the calibrated transformer is analog signal, in order to measure standard output and calibrated output synchronously, GPS wireless synchronous triggering measurement technology is required.

### 3.4 DC current transformer test technology

#### 3.4.1 Remote synchronous measurement method

When output of the calibrated DC current transformer is far from output of standard equipment owing to field restriction, this method can be adopted. Refer to Figure 2 for the schematic diagram.

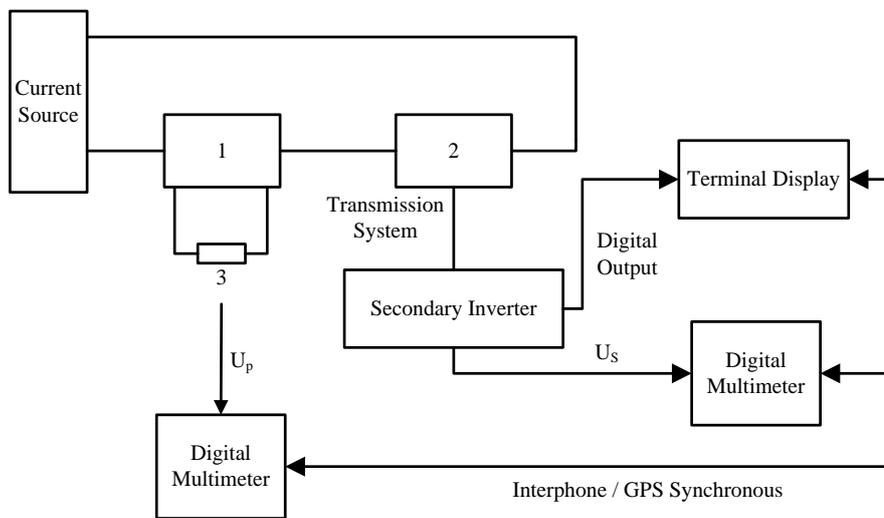


Fig. 2. Schematic diagram of DC current transformer calibration via remote synchronous measurement method

In the figure:

- 1---Standard DC current comparator;
- 2---calibrated DC current transformer;
- 3---Standard resistance (DC current comparator load).

Expression of current ratio error can be calculated as Formula (1):

$$\varepsilon = \frac{U_s - U_p}{U_p} \times 100\% \quad (1)$$

When there is only digital output on the calibrated DC transformer,  $U_s$  can be read artificially on the terminal display, and the output data of standard equipment and output data of the calibrated DC current transformer can be synchronized via interphone. When the calibrated DC transformer is equipped with analog output, output of standard equipment and output of the calibrated transformer can be read synchronously via GPS equipment.

## 4. Field calibration of DC current transformer

OCT is placed at polar line, and the major loop length of injection current is 50m. 3 rated large current wires of 1000A are adopted in parallel for major loop connecting wire.

There is only digital signal for the secondary output of polar line OCT, and the real-time current data are displayed on the host computer in master-control room. Interphone is adopted for manual synchronization, digital multi-meter 34401A is adopted for automatic acquisition of standard equipment output, and camera is

used to take photos for the calibrated OCT screen display output. The data acquisition rate is 1 time/1s, data acquisition time is 10s, and the average value shall be taken for the measurement result. The measurement points are 0, 10%, 20%, 50%, 80% and 100% of the rated current. Refer to Table 1 for the test result.

Table. 1  $\pm 500$ kV D convertor station polar line OCT test data

| Measurement point | Standard indicating value (A) | The test object channel 1 indicating value (A) | Channel 1 error (%) | The test object channel 2 indicating value (A) | Channel 2 error (%) |
|-------------------|-------------------------------|--|---------------------|--|---------------------|
| 0A                | 0.00                          | -0.92  |                     | 4.69   |                     |
| 300A              | 296.30                        | 294.88   | -0.48               | 207.74   | -29.89              |
| 600A              | 597.43                        | 595.34   | -0.35               | 600.93   | 0.59                |
| 1500A             | 1496.35                       | 1492.35  | -0.27               | 1497.76  | 0.09                |
| 2400A             | 2391.89                       | 2386.46  | -0.23               | 2392.24  | 0.01                |
| 3000A             | 2993.12                       | 2984.83  | -0.28               | 2990.67  | -0.08               |

## 5. Conclusion

(1) When DC current transformer error is measured, the error variation of current increase and decrease is small, which shows that the error property of current transformers of these types in convertor station is relatively stable, and at the same time, this also proves reliability of error calibration method and calibration equipment adopted by us.

(2) By study on working principle and performance of DC measurement equipment of all types like DC transformer, we form a set of complete field test method and calibration equipment of extra and ultra HVDC transformer measurement system aimed at the practical operating condition in DC convertor station.

## 6. References

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