IEEE P2869 Synchronous Monitoring of Direct Current (DC) Bias Magnetic current Distribution in Power Grid(PE/AMPS/SMBMCD)

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10 April, 2020
<table>
<thead>
<tr>
<th></th>
<th>Table of Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Background to Standard-setting</td>
</tr>
<tr>
<td>II</td>
<td>Exploration and Experience in China</td>
</tr>
<tr>
<td>III</td>
<td>Research on the Relevant Standards</td>
</tr>
<tr>
<td>IV</td>
<td>Duties and Recommendations of the Working Group</td>
</tr>
<tr>
<td>V</td>
<td>Implementation Plan</td>
</tr>
</tbody>
</table>
In recent years, the global direct current transmission technology has developed rapidly, with more than 100 direct current projects in operation. Especially in large grid regions such as the United States, Canada, Brazil, India and European grids, DC transmission engineering plays an important role in long-distance, high-capacity transmission and interregional networking.

China is the country with the largest number of HVDC projects in the world, with 36 HVDC projects in operation, nearly 80 converter stations. The pattern of AC-DC hybrid large grid has been formed.
I. Background to Standard-setting

Hazards of DC Magnetic Bias

- High-voltage DC transmission systems typically operate in a bipolar balanced power fashion. When the main equipment or poles of the exchange station fails, the DC transmission system will operate in a single-pole earth return line, or single-pole independent operation makes the bipolar power imbalance, the grounding pole of the exchange station huge grounding DC current will cause the surrounding transformer DC magnetic bias.

- Voltage waveform distortion, resulting in misalignment of the transformer protection.

- Increased temperature and vibration in transformers, resulting in damage to components such as transformers, capacitors, etc.

- Increased reactive power losses in transformers, resulting in a reduction in transformer busbar voltage.

- Electrochemical corrosion of energy transmission pipelines and interference with rail transport communications.
As the degree of mixing of AC and DC systems is getting closer, DC magnetic bias has more and more influence on the safe and stable operation of AC systems and equipment.

With the implementation of China's "One Belt, One Road" initiative, the global energy interconnection and communication is developing rapidly, with power, oil and gas transported over longer distances, greater power, denser distribution, higher coupling, and a wider range and greater degree of DC magnetic bias hazard.

Therefore, the monitoring, early warning and analysis of DC bias magnetic current distribution in power grids, as well as the analysis and field verification of DC bias magnetic current in power system simulation, provide a strong technical support and decision-making basis for the effective implementation of integrated suppression and reduction of DC magnetic bias hazards.
It provides an effective theoretical foundation and standard basis for the closed-loop solution to the DC magnetic bias problem of power grids.
Satellite Time-synchronous Monitoring Technology

Plant and System Technical Requirements

Feature and Distribution Law Analysis Requirements

DC Bias Magnetic Current Synchronization Monitoring

Field verification and engineering applications in Hubei, Shanghai, Zhejiang, Guangdong, Xinjiang, Sichuan, Ningxia, Yunnan and Meng Dong

Formulation of national industry-wide standards for the management of enterprises with DC magnetic bias of power grids, industry promotion and application, guiding standards

Synchronous monitoring of DC bias magnetic current is conducive to comprehensive measurement and analysis, as well as an in-depth understanding of the size and distribution laws of DC bias magnetic current in the grid, which provides an effective quantitative basis for analyzing the correlation between grid operation and DC magnetic bias from a network-wide perspective, formulating correct DC magnetic bias defense measures and evaluating DC magnetic bias defense measures at a later stage.
Conventional DC Bias Magnetic Current Monitoring Methods

The traditional approach is to carry out DC bias magnetic current monitoring of transformers in isolated dispersions at substations, which is achieved by offline measurements by manual means.

- Periodic testing, on demand, with poor timeliness.
- Synchronization of different monitoring points cannot be achieved.
- Only the amplitude of the bias current of a single transformer can be measured.

In the face of the current status of large-scale AC-DC hybrid grids, traditional monitoring methods can no longer meet the current need for effective warning and analysis of DC magnetic bias.
A study of the detection method and data processing method for DC bias magnetic currents was conducted. A DC bias magnetic current monitoring terminal that can be remotely and automatically calibrated has been developed, and the principle of monitoring point arrangement has been summarized by the results of research on relevant influencing factors.
Multi-point Simultaneous Monitoring Methods Used in China

Theoretical and analytical methods for the synchronous triggering and synchronous monitoring of DC bias magnetic current in power grids have been studied, and a satellite based synchronous timing DC bias magnetic current multipoint self-synchronous monitoring network has been constructed in several regions of China. A multi-dimensional DC magnetic bias analysis system has been formed, which achieves self-synchronous monitoring of the grid bias current at multiple terminals.
Our synchronous monitoring system monitored the typical waveforms of multi-point DC bias magnetic currents and analyzed the characteristic distribution patterns in China's Hubei Power Grid and Hubei-Shanghai DC transmission projects.

- The DC bias magnetic current of the substation is linearly related to the load current of the converter station;
- Factors that affect the DC bias magnetic current also include: the electrical distance between the substation and the grounding pole of the converter station, earth soil conditions, grid network structure, etc.
Ⅲ. Research on the Relevant Standards

There is no standard for synchronous monitoring of DC bias magnetic current distribution in the grid in IEC and IEEE.

The IEC 60076 series standard specifies requirements for the ability of current transformers to withstand DC magnetic bias, but lacks provisions for monitoring the DC bias magnetic current of the grid.

IEEE C57-163 analyzes the impact of GICs on the performance of power transformers, but it only addresses the monitoring of GIC currents in a single transformer and does not regulate DC bias magnetic current monitoring for regional grids.

Therefore, it is very important to carry out IEEE DC bias magnetic current synchronous monitoring standard specification.

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<tr>
<td>1</td>
<td>IEC</td>
<td>IEC 60076.8-1997 Power transformer –application guide</td>
</tr>
<tr>
<td>2</td>
<td>IEC</td>
<td>IEC 60076.1-2011 transformer general</td>
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<tr>
<td>3</td>
<td>IEC</td>
<td>IEC 61869-1 ED2 Instrument transformers - Part 1: General requirements</td>
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<td>4</td>
<td>IEC</td>
<td>IEC/IEEE TS 61869-105 ED1 Instrument transformers - Part 105: Uncertainty evaluation in the calibration of Instrument Transformers</td>
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<td>5</td>
<td>IEC</td>
<td>IEC TS 60076-23-2018 Power transformers –Part 23: DC magnetic bias suppression devices</td>
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<td>6</td>
<td>IEC</td>
<td>IEC 60477 Laboratory D.C. Resistor</td>
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<td>7</td>
<td>IEC</td>
<td>IEC 60477-2 Laboratory A.C. Resistor</td>
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<tr>
<td>8</td>
<td>IEEE</td>
<td>C57.163 IEEE guide for establishing power transformer capability while under geomagnetic disturbances</td>
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### Status of Relevant Chinese Standards

China's three standards, DL/T 1786-2017, DL/T 1957-2018 and Q/GDW 11465-2015, were compiled under our leadership, which regulate the method of synchronous monitoring of DC bias magnetic current distribution, principles of monitoring point selection, technical requirements of monitoring devices and monitoring systems, analysis of monitoring results, risk assessment methods and defense measures, etc., and play a great role in the early warning and defense of DC magnetic bias risk in China's power grid.

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<tr>
<td>1</td>
<td>National</td>
<td>GB/T 13499-2002 电力变压器应用导则</td>
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<tr>
<td>2</td>
<td>National</td>
<td>GB/T 1094-2013.1 电力变压器 总则</td>
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<tr>
<td>3</td>
<td>National</td>
<td>JB/T 7490-2007 霍尔电流传感器</td>
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<td>4</td>
<td>National</td>
<td>GB/T 35703-2017 柔性直流输电系统成套设计规范</td>
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<tr>
<td>5</td>
<td>Industrial</td>
<td>DL/T 5224-2014 高压直流输电大接地网设计技术规程</td>
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<td>6</td>
<td>Industrial</td>
<td>DL/T 1541-2016 电力变压器中性点直流限流装置技术规范</td>
</tr>
<tr>
<td>7</td>
<td>Industrial</td>
<td>DL/T1799-2018 电力变压器直流偏置耐受能力试验方法</td>
</tr>
<tr>
<td>8</td>
<td>Industrial</td>
<td>DL/T 437-2012 高压直流接地极技术导则</td>
</tr>
<tr>
<td>9</td>
<td>Industrial</td>
<td>DL/T 1786-2017 直流偏置电流分布同步监测技术导则</td>
</tr>
<tr>
<td>10</td>
<td>Industrial</td>
<td>DL/T 1957-2018 电网直流偏置风险评估与防御导则</td>
</tr>
<tr>
<td>11</td>
<td>Enterprise</td>
<td>Q/GDW 11465-2015 电网直流偏置电流分布同步监测技术导则</td>
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Duties of the Working Group

- Templates for editing documents using IEEE SA standards.
- Timely submission of materials and documents to the IEEE SA Committee.
- Inform the IEEE SA Committee of progress in standards development.
- Submission of draft standards to the IEEE SA Committee on a timely basis.
- Regular network or face-to-face working meetings.
Duties and Recommendations of the Working Group

Duties of Members

- Members of the Working Group must attend the meetings of the Working Group on time.

- Members of the working group should provide active feedback on the comments made in the development of the criteria, which should be returned within one month of the solicitation. In exceptional cases, such as test validation, the Working Group would need to discuss and agree. The Working Group will correct any errors and answer any questions and ensure a fair and open process of preparation.

- Provide support for relevant research and information gathering as required by the members of the working group, and complete relevant tasks on time.

- Working group members should be responsive and available to questions and communication needs.
V. Implementation Plan

Standard-setting Master Plan

- **April 2020**: Convene kick-off meetings, form working groups, and promote standards setting.
- **Mar. 2021**: Complete the draft standard and submit it to the AMPS Committee for review.
- **Sept. 2021**: Reviewed by the AMPS Select Committee and submitted to IEEE SA.
- **Sept. 2022**: Approved by IEEE SA for official release.
V. Implementation Plan

2020 Implementation Plan

- **10 April**
  - Recruit working group members, convene a working group kick-off meeting to discuss the standards development framework and assign standards writing tasks

- **June**
  - Complete the standard framework research, improve the framework and clarify the content of the standard

- **Sept.**
  - Assemble the standard writing tasks to form the first draft of the standard

- **Dec.**
  - Discussion and revision of the first draft of the standard within the working group

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**Various Different DC Bias Suppression Measures Comparison**

**3. Key Technological Innovation and Application**
Report completed

Thanks!