METROLOGICAL SUPPORT OF HIGH CURRENT MEASUREMENTS IN THE RUSSIAN FEDERATION

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Abstract: The paper considers various types of DC and AC measurement transducers and the effects on which they are based. The current state of the metrological support of DC and AC measurement transducers is specified. The results of improvements introduced into the State Primary Standard of units for electric current intensity conversion coefficients are presented. The paper considers measurement transducers of high current that are used in the Russian Federation and included in the Federal Information Fund for Ensuring the Uniformity of Measurements. Intended activities to expand the measurement capabilities of the State Primary Standard are specified.

Keywords: standard, DC and AC measurement transducers, ratio coefficient

Introduction

The measurements of high currents (more than 100 A) are performed using measurement transducers. During such measurements, high currents are subject to intermediate conversion with the use of special measuring instruments – high current measurement transducers. The main and only purpose of these transducers is the conversion of the high current value into a secondary physical quantity (usually also electrical, e.g. current or voltage), the value of which is proportional to that of high current and is available for direct measurement by standard general-purpose instruments having measurement limits and other technical characteristics, consistent with the output characteristics of the transducers.

1 Types of measurement transducers used for measuring high current

According to the type of current under measurement, high current measurement transducers can be divided into two types that operate based on particular physical effects:

a) Measurement transducers of high direct current:

- Resistive measurement transducers (shunts, Ohm's law);
- Magnetic modulation measurement transducers (the effect of changing the magnetic state of a material with simultaneous magnetization in direct and alternating fields);
- Magnetic galvanic measurement transducers (the Hall and Gaussian effects are used);
- Magnetic resonance measurement transducers (the phenomenon of electron and proton paramagnetic resonance is used);
- Magnetic optical measurement transducers (based on the Faraday and Zeeman effects).

b) Measurement transducers of high alternating current:

- Current measurement transducers (based on energy transfer through mutual inductance);
- Current magnetic comparators (the resultant magnetomotive force tends to zero);
- Resistive measurement transducers (shunts, Ohm's law);
- Inductive measurement transducers (Rogowski coil, based on electromagnetic induction);
- Magnetic optical measurement transducers (based on the Faraday effect).

The measurement of the electric current intensity value is necessary, mainly, for the purposes of energy accounting during the implementation of energy supply and energy saving tasks, as well as control of technological processes based on the use of high currents (electric metallurgy, welding, power system protection, electric transport).

Key industrial sectors requiring high current measurements:

- power industry (AC and DC transmission lines);
- metallurgy (measurement of AC and DC currents for the control of technological processes);
- electric transport (measurement of AC and DC currents for energy accounting on rolling stock).

2 Regulatory documents

The fundamental document is the Federal Law "On Ensuring the Uniformity of Measurements" dated June 26, 2008 No. 102-FZ, which regulates the relations that arise when performing measurements, setting and complying with the requirements for measurements, units of quantities, standards of units, measuring instruments, use of measuring instruments, measuring techniques (methods), and

also in the implementation of activities for ensuring the uniformity of measurements provided by the legislation of the Russian Federation on ensuring the uniformity of measurements, including when performing work and providing services on ensuring the uniformity of measurements.

The following GOSTs applicable to current transformers and measurement transducers manufactured and sold in the Russian Federation are valid in the Russian Federation:

- GOST 18685-73 Current and voltage transformers. Terms and definitions;
- GOST 24855-81 Analogue measurement transducers for current, voltage, power, frequency. General technical requirements;
- GOST 30605-98 Digital measurement transducers for current and voltage. General technical requirements;
- GOST 7746-2015 Current transformers. General technical requirements;
- GOST 23624-2001 Current measuring transformers for laboratories. General technical requirements.

Besides, there are GOSTs that apply to current transformers manufactured in the territory of the Russian Federation for further sale to other countries:

- GOST IEC 60044-1-2013 Measuring transformers. Section 1. Current transformers;
- GOST R IEC 61869-2-2015 Measuring transformers. Section 2. Additional requirements for current transformers;
- GOST R IEC 60044-8-2010 Measuring transformers. Section 8. Electronic current transformers;

Enterprises that manufacture transformers and measurement transducers issue and register their technical specifications on the basis of the existing regulatory documents.

3 Standards

The State Primary Standard of units for electric current intensity conversion coefficients GET 152-2018 is responsible for the transfer of units of the electric current intensity conversion coefficients to current measurement transducers (metrological assurance of measurement transducers) in the Russian Federation.

In 2017, the primary standard was upgraded and now its measurement capabilities allow the unit to be transferred to DC and AC measurement transducers.

GET 152-2018 includes two standard systems:

1 Sinusoidal current standard system (shown in Figure 1);

2 High direct current standard system (shown in Figure 2).

4 Prospects

In 2014, a study of the effect of frequency variation on the characteristics of the primary standard at frequencies of 60 and 400 Hz was carried out. Currently, the following works are carried out:

a) to expand the measurement capabilities of the primary standard to a frequency range from 40 to 2,500 Hz;

b) to expand the range of direct currents up to 10,000 A;

c) to ensure the metrological support of measurement transducers with digital output.

Table 1 – Measurement capabilities of GET 152-2018

Name of the characteristic	Value of the characteristic
1	2
Primary current range	from 0.5 to 50,000 A
Secondary current	1 or 5 A
Frequency	50 Hz
Value of the conversion coefficient error	from 0 to 0.02 A/A
Value of the phase shift angle	from 0 to 20,000 μrad
Extended uncertainty of the conversion coefficient error	from 5 to 15 μA/A
Extended uncertainty of the phase shift angle	from 5 to 15 μrad
Range of direct currents	from 3.75 to 1,000 A
DC conversion coefficients	1,000/1; 500/1; 300/1 A/A
Extended uncertainty of the DC conversion coefficient	from 15 to 60 μA/A

Figure 1. Sinusoidal current standard system

5 Conclusions

Currently, the development of metrological support of high current measurement transducers in the Russian Federation has received a new impulse, since it has become clear that the existing measurement accuracy fails to satisfy the current needs of manufacturers. Industrial enterprises have started purchasing optical measurement transducers based on the Faraday effect. By 2020, the State Primary Standard of units for electric current intensity conversion coefficients will transmit a unit to DC and AC measurement transducers for frequencies up to 2,500 Hz.

Figure 2. High direct current standard system

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