FIBER OPTIC CURRENT SENSOR

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Energy efficiency is one of the main directions of engineering development. This produced the great interest to the precision methods and instruments to measure the basic parameters of electrical generating, transmission and distribution devices.

One such parameter is the value of the electric current flowing through the device. The main drawback of the currently used measurement systems is the current characteristics of the primary transmitters (high voltage transformers). They require time-consuming routine maintenance, their accuracy depends on the burden and has a tendency to additional error accumulation. Also for the analysis of signals from primary converters we use meters, indications of which are strongly dependent on the quality of electricity. As a replacement for the primary device, you can consider sensors based on the Hall's effect, which allows to measure DC and have greater accuracy than current transformers. But the general drawback of instrument transformers and Hall sensors is the presence of saturation effect, greatly limiting the range of measured currents.

Today, thanks to the development of fiber optic technology optic current meters appeared recently. They unite many of the advantages of measuring transformers and sensors based on the Hall's effect without drawbacks so characteristic of them.

FOCS is the optimal solution to the most problems that arise when measuring a current. They provide precise measurements over a wide range of measured currents, allow signal processing in real time, ensuring accuracy, repeatability and high accuracy regardless of the signal being analyzed. FOCS provides electromagnetic compatibility with high voltage equipment, and do not require the use of signal analyzers for measuring sensor, as it directly provides information on the measured current. Moreover, they have no problems with the installation and subsequent operation of the sensors which are so typical for Russia.

Structurally FOCS consists of two parts: a sensor and a processing unit. The sensing element is a fiber cable not thicker than 10 mm, which is controlled by a locking ring surrounding the conductor. At the same time for some modifications of the sensor there is no need to break up and shut - controlled conductor, which is a significant advantage FOCS. Sensors measure the current in the conductor, which covers the ring, wherein the measurement results do not depend on the other current-carrying conductors and external magnetic fields. Also, the sensor does not depend on the relative position of the ring and conductor. Processing unit and the sensing element are connected by optical cable. Sensor and optic communication line does not contain conductive parts, and also provides explosion and radiation resistance. It should also be noted that the sensor requires no regular maintenance.

Fiber Optic Sensors have lately found more applications due to their high precision, large dynamic range, electrical insulation, miniature, immunity to electromagnetic interference, high-speed operation, the possibility to transmit information over long distances [1, 2]. Gradually, fiber-optic sensors are replacing sensors with mechanical and electrical conversion of the measured parameter to the information signal. They are used for measuring the current magnetic field, displacement, temperature, pressure, acoustic vibration, etc.

Fiber-optic current sensors designing are designed based on the Faraday's effect. Faraday's effect is a magneto-optical effect, when a linearly polarized light going through an optically inactive substance in a magnetic field, produces a rotation of the plane of the polarized light (Fig. 1).

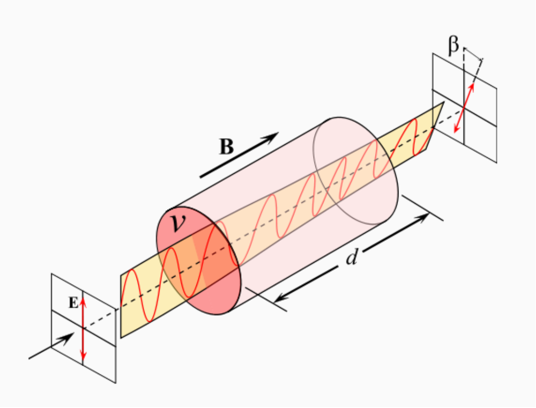

Fig. 1. Rotation of the light polarization plane due to the Faraday's effect

The Faraday's effect is used in a fiber-optic current sensors [3], because there is a large number of glass optical fibers in which it is sufficiently pronounced [4]. These optical elements have a large Verde constant V (physical quantity that characterizes the magnetic rotation of the plane of polarization in the material), which connects the value of the integral of the magnetic field H, taken across the length of the optical path L, and the angle of the plane of linearly polarized light $\Delta\Phi$, transmitted through the optical circuit:

$$\Delta\Phi = V\int_0^L H \times dl$$

This angle ΔΦ is also equivalent to nonreciprocal phase shift of a circularly polarized wave transmitted through a fiber loop. For the right circular wave ΔΦ is positive, for the left circular wave it is negative. The simplest FOCS using the Faraday's effect is a polarimetric sensor (Fig. 2). It the current in a conductor is associated with rotation of the plane of polarization of light passing a closed loop through which current-carrying conductor is passed.

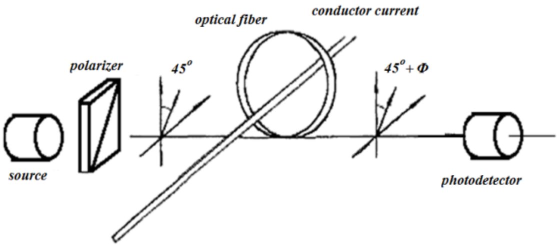

Fig. 2. Simplest configuration of polarimetric FOSC

Linearly polarized source light wave after the polarizer is directed into the optical fiber, covering a conductor carrying an electric current with the power I. The sensor can use as a standard singlemode optical high quality fiber and special types of fibers. The number of optical fiber revolutions around the conductor *N* depends on the range of measured currents. Passing through the contour wave of polarization rotates on the ΔΦ angle, which is a consequence of the induced magnetic field of circular birefringence. Linear polarization can thus be regarded as a superposition of waves with circular polarization in opposite directions of rotation. Each of them is directed to a separate photodetector. Thus, the measured light intensity Int_1 and Int_2 with relatively small losses in the system depends on ΔΦ as (Int_0 - intensity of the input light):

$$Int_1 = Int_0 cos^2(45^0 + \Delta\Phi)$$

$$Int_2 = Int_0 sin^2(45^0 + \Delta\Phi)$$

Due to the fact that the fiber loop is closed, the angle ΔΦ is equal to:

$$\Delta\Phi = VNI$$

This equation is true for single-mode optical fiber with the approximation that the Verde constants for core and cladding differ slightly, otherwise the angle ΔΦ depends on these constants and refractive indices of the core and cladding [5].

For signal ΔΦ irrespective Int_0 intensity is not stable in time, the output signal S is calculated as the ratio:

$$S = \frac{Int_1 - Int_2}{Int_1 + Int_2} = \sin(2 \cdot \Delta\Phi)$$

During the measurement the current, created in the installation, had step-in changing available for the power supply range, and layout information from the current meter and ammeter (±0,01% ±7 е.м.р) was recorded on a personal computer at 50 Hz. The test results of the current meter layout are shown in Fig. 3.

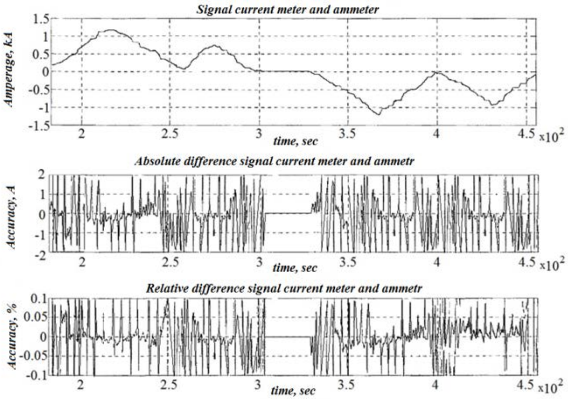

Fig. 3. Test results of a brassboard current meter

For a rough estimation of the error we considered layout, in which current was constant, and it was shown that in the studied range (from -1.2 to +1.2 kA), the absolute accuracy did not exceed 2 A, and the relative accuracy was less than 0.1%.

Thus, the created brassboard allows to demonstrate the meter, built by the author proposed configuration and using created and investigated components. The proposed method minimize the impact of magnetic fields on the measurement.

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