

УДК 681.2.08.

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OPTICAL CURRENT AND VOLTAGE SENSORS

At the current stage of development of the electric power industry, with the widespread usage of current transformers (CTs) and voltage transformers (VTs), the most actual is reliable measurement of current and voltage to ensure high reliability and safety of industrial systems and networks. These measurements take an important part of the substation's working and protective functions [1].

The unflagging interest in optic current and voltage sensors, over the years, is associated with the high potential capabilities of these devices and also significant operational advantages compared to traditional current and voltage measurement technologies. They provide a natural galvanic denouement of the high-voltage and measuring parts while reducing the overall dimensions, increasing the safety of their operation and decreasing the installation costs. Various types of current and voltage sensors are used for monitoring and diagnosing of circuits, launching of protection schemes, detecting failures of electrical equipment and emergency conditions of various types of loads [2].

Advantages of digital current and voltage sensors [3]:

- wide dynamic range of measurements (currents up to hundreds of kA, voltages up to hundreds of kV);
- the sensing element is naturally disconnected from the voltage line;
- high resistance of fiber optic information channels to external electromagnetic interference;
- extremely fast response time with high measurement accuracy;
- smaller overall dimensions compared to existing technologies;
- they do not explode in catastrophic destruction, unlike oil-filled electrical insulating supports.

In addition, they are inherently non-magnetic saturated and, as a rule, have a measurement bandwidth in the kHz range. Bands in the range of tens or hundreds of kHz are also possible. As a result, fiber-optic current transformers produce within their measurement range a true image of the primary current, including in the case of fast transient currents, short-circuit currents and alternating current with DC bias [1].

The operation of the optical current sensor is based on the Faraday's effect, which consists in changing the polarization of the light flux under the influence of a magnetic field. The specific implementation of sensors using this effect can be different and is patented by manufacturers.

The optical circuit of the current sensor contains an optical signal source. This signal is converted, with the help of a splitter, into two right- and left-polarized signals with opposite directions of rotation, which enter the optical loop made of turns (N) of optical fiber. The magnetic field created by the current (I) flowing through the wire, in accordance with the Faraday effect slows down one signal and accelerates another. Both signals reach the next circular polarizer, which converts them into linearly polarized light fluxes with polarized planes shifted by an angle, (1):

$$\Delta\varphi = 4V \cdot N \cdot I, \quad (1)$$

where V is the Verdet constant.

Verdet constant is a quantity characterizing the magnetic rotation of the plane of polarization in a substance. Its value depends on the properties of the substance, wavelength and monochromatic radiation [4].

The operation of the optical voltage sensor is based on the Pockels' effect, which consists in the appearance of birefringence in optical media when a direct or alternating electric field is applied, which is observed in crystalline piezoelectric, (2):

$$\Delta\varphi = \pi \cdot L \cdot K \cdot \frac{E}{\lambda}, \quad (2)$$

where E is the electric field strength; L is the plate thickness; λ is the wavelength; K is electro-optical coefficients.

As follows from the proposed review, optical current and voltage sensors occupy a significant place in monitoring, controlling and management systems in the energy sector, as well as in other engineering branches. New generation sensors significantly increase production efficiency and give a good economic effect.

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