Technical Note

AC/DC Clamp Meter CM4375/CM4376

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***Abstract*—The AC/DC Clamp Meter CM4375/CM4376, which can measure both AC and DC currents, was developed with the concept of delivering a clamp meter with slim jaws that let users easily get into narrow gaps between cables. This paper describes the product's functionality, features, and architecture.**

I. Introduction

Clamp meters, which can measure current without the need for disconnection of circuits, have been offering user convenience and are increasingly being used at various worksites. In addition to current measurement, clamp meters provide functionality for measuring voltage and resistance and checking continuity to meet diversifying market needs. However, a common complaint heard with increasing frequency these days is that users cannot get the jaws of a clamp meter into gaps between cables that have become narrower because of downsizing of electric facilities and high-density wiring. To resolve this problem, Hioki redesigned the shape of the jaws and developed new clamp meters with the concept of delivering a clamp meter with slim jaws that let users easily get into narrow gaps between cables.

II. Overview

Hioki included the CM4375 and the CM4376 in the lineup of the AC/DC Clamp Meter CM4370 series. In addition to the CM4375's features, the CM4376 is equipped with the Bluetooth wireless communication, enabling data transfer with smartphones and tablet computers. The CM4375/CM4376 is a clamp meter that inherits the advantages of the CM4370 series: high measuring speed, high usability, and high environmental resistance, with a jaw structure that improves ease-of-use.

III. Current Sensor and Characteristics Examples

The advantages and features of the CM4375/CM4376 can be reviewed in the Hioki Technical Note "AC/DC Clamp Meter CM4370 Series" [1]. This paper describes the newly developed current sensor (clamp sensor). Fig. 1 illustrates the construction of the sensor. The core material consists of a split-type magnetic circuit using a directional silicon steel plate with good magnetic saturation characteristics. The Hall element located at the break detects the magnetic flux in the gap. Since the magnetic flux density varies with a change in the gap distance, high-strength glass-fiber-reinforced polycarbonate is used for the sensor covers,

Appearance of the CM4375 and the CM4376.

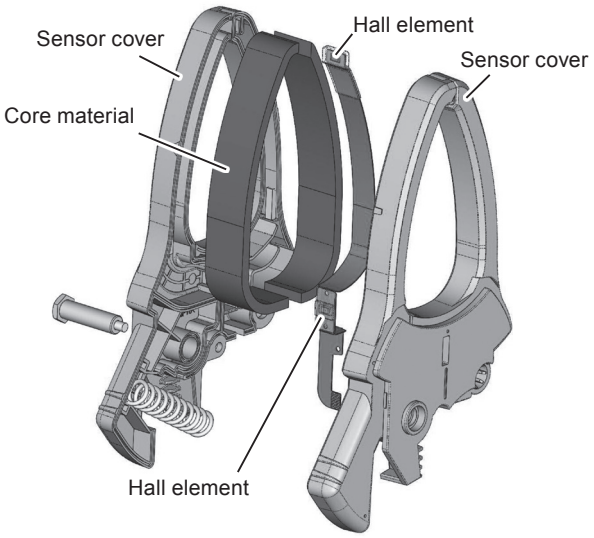

Fig. 1. Construction of the sensor.

which form the tips where the jaws contact each other. This contributes to a reduction in variation in the gap distance.

A. Clamp Shape

Considering the clearance between cables and between cables and the wall based on the combination of cable diameters and circuit breakers that are actually used, Hioki designed the sensor with a shape that meets the following conditions:

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- Can be clamped around a 600 V cross-linked polyethylene insulated vinyl sheath cable (CV) with a cross-section area of up to 250 mm^2 (cables in excess of 250 mm^2 in cross-section area are hardly used because of their hardness and weight).
- Can be clamped around a pair of CV 200 mm^2 cables, which is used as a substitute for a cable in excess of 200 mm^2 in cross-section area.
- Can be clamped around one of the CV 150 mm^2 cables that connect to terminals of a 250-ampere-frame circuit breaker (250AF terminals) and are adjacent to each other. Current sensors with a rating of 600 A to 1000 A are often used under this condition.

Fig. 2 illustrates that the sensor is clamped around one of three CV 150 mm^2 cables, which connect to 250AF terminals and are adjacent to each other. The sensor can be clamped around the cable without coming into contact with the wall.

B. Current Rating

The CM4375/CM4376 has a current rating of 1000 A, which reflects demands for current sensors with a mid-rating between 600 A and 2000 A, both of which have been available from the legacy CM4370 series.

The rating of the current sensor is mainly determined by the shape of the core material and the core volume (core cross-sectional area). Although it is difficult to achieve both a sensor shape that can be easily clamped around the cable and a core volume rated at 1000 A, by increasing the volume in terms of the sensor thickness, we can achieve both a jaw that can easily clamp around cables and a large current rating (Fig. 3).

Fig. 4 illustrates the linearity characteristics during measurement of AC current having a frequency of 55 Hz. The linearity can be maintained up to 1000 A of input current without magnetic saturation of the core material. Inputting a current in excess of 1000 A caused the core material to be magnetically saturated, failing to maintain the linearity characteristics.

C. Effect of Conductor Position

Effect of conductor position means that measured values vary based on where the conductor is placed within the core. It was expected that since the sensor shape was designed to allow users to clamp the sensor around a conductor easily, the leakage flux would increase between the gap, worsening the effect of conductor position. Legacy Hioki clamp meters have a Hall element positioned near the surface of the core, whereas these new models are designed with the Hall element positioned at the center of the gap (Fig. 5). By moving the position of the Hall element, we were able to decrease the effect of conductor position despite the sensor shape.

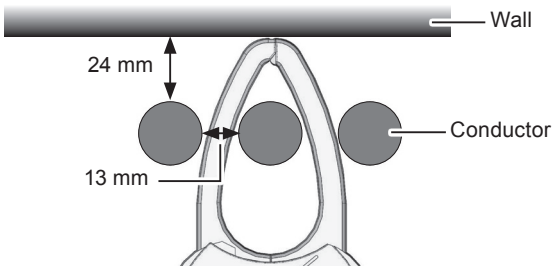

Fig. 2. Sensor clamped around one of three cables all adjacent to one another.

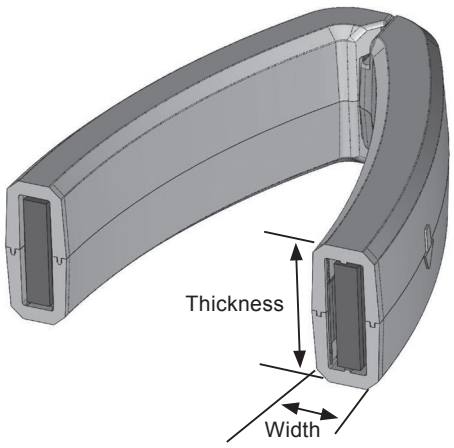

Fig. 3. Cross-sectional view of the sensor.

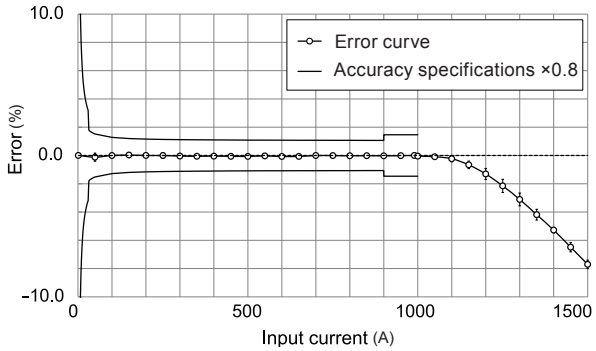

Fig. 4. Linearity.

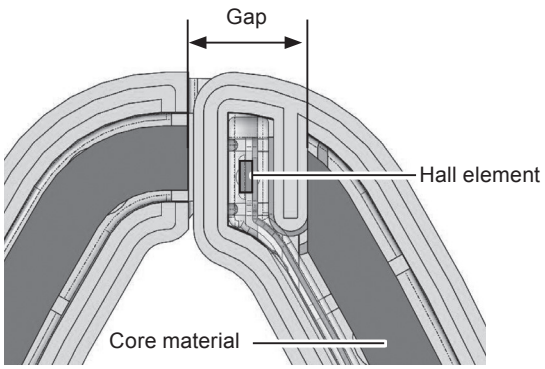

Fig. 5. Position of the Hall element.

Figs. 6 and 7 illustrate the conductor position and its effect during measurement of 100 A of current, respectively. The effect was limited to a range of 0.5% in either direction.

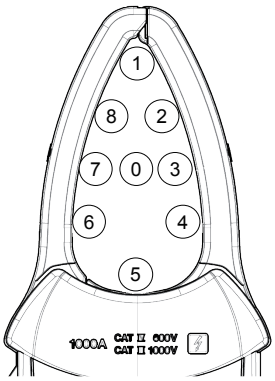

Fig. 6. Positions of the conductor.

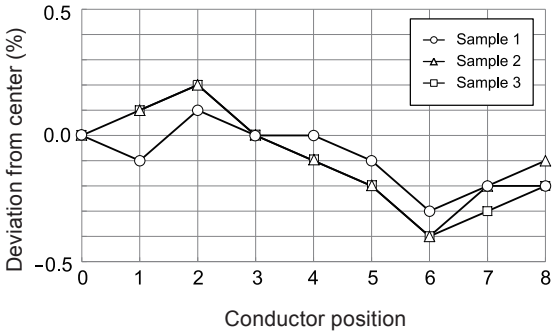

Fig. 7. Effect of conductor position.

D. Temperature Characteristics

Fig. 8 illustrates the temperature characteristics during measurement of an AC (55 Hz) current of 100 A. Although the temperature characteristics are susceptible to the Hall element characteristics, the instrument provided an adequate margin for their accuracy specifications.

E. Durability of the Sensor Against Open/Close Action

When the jaw is closed and opened, the mating surface of the jaw tip compressively deforms and recovers, respectively. The deformation causes the distance between the mating surface and the Hall element to vary, resulting in measurement errors because the magnetic flux density detected by the Hall element varies.

In order to ensure jaw durability and the ability to sustain a sufficient number of openings and closings, the clamp sensor has been designed with a larger mating surface than that on legacy products so as to extend the possible number of opening/closing cycles (Fig. 9).

Fig. 10 illustrates the variation in the measurement accuracy with respect to the number of sensor opening/closing cycles. Measurement accuracy was maintained even after the sensor was opened and closed 30 000 times, as defined in the product specifications.

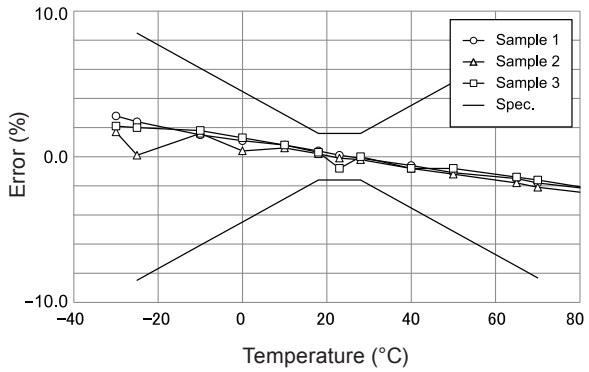

Fig. 8. Temperature characteristics.

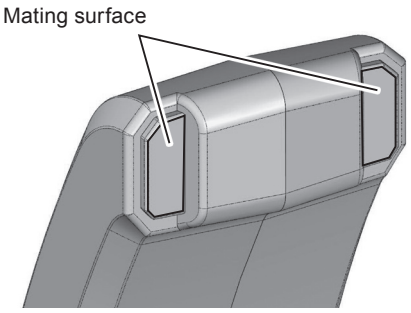

Fig. 9. Mating surface.

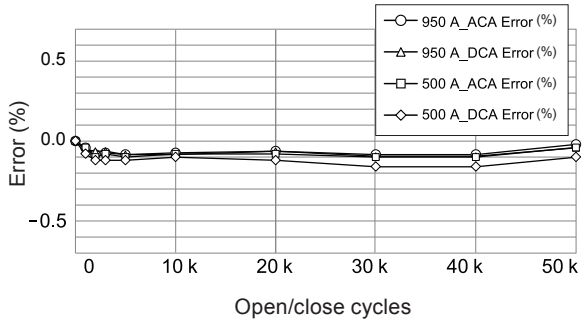

Fig. 10. Measurement errors due to opening/closing of the jaw.

IV. Conclusion

Hioki developed the CM4375/CM4376 to resolve user issues. With these new products enhancing the CM4370 series lineup, we hope to contribute to improving the work efficiency of our customers.

Reference

[1] T. Nakamura, “AC/DC Clamp Meter CM4370 Series,” *Hioki Giho (Hioki Technical Notes)*, vol. 37, no. 1, pp. 73-78, 2016. (Japanese, also available in English).

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