



A CURRENT LOOP OF THE 4 mA - 20 mA TYPE OR OF THE 0 - 20 mA TYPE AND INCLUDING A PARALLEL TEST CIRCUIT

The invention relates to a current loop of the 4 mA - 20 mA or of the 0 - 20 mA type, connecting an analog
5 sensor to an acquisition system respectively carrying a sensor current and an acquisition current.

Such current loops are in widespread use. The 4 mA - 20 mA type loop, e.g. made of "2 μ Is" technology enables the sensor to operate using the energy supplied by a 4 mA
10 sensor current. The advantages of a current loop are well known: firstly the power supply for the sensor is carried by the same wires as the signal, thereby reducing the cost of cabling compared with other types of signal that would require additional wires in the cable, and
15 secondly the signal is disturbed to a very small extent by electromagnetic radiation, thereby enabling it to be conveyed over long distances or through surroundings having high radiation density.

In known manner, proper operation of the acquisition
20 system is monitored by means of test devices designed to simulate the operation of the sensor. Simulation is performed by connecting the test device so that it takes the place of the analog sensor. Nevertheless, there are drawbacks in disconnecting the sensor: there is a risk of
25 it being wrongly reconnected, e.g. by reversing its polarity, or even that reconnection will be forgotten, or perhaps that the connections will be left too loose. Under such conditions, maintenance of the acquisition system turns out to be counterproductive.

30 Also in known manner, the operation of the analog sensor is monitored by disconnecting the current loop. This is done, in particular, when the sensor is removed from its installation site. In that case also, disconnection is not without its drawbacks: as a general
35 rule, the acquisition system interprets the open loop as being anomalous and generates an alarm. It is therefore necessary to take action to prevent the anomaly being



treated as such by a unit that controls the acquisition system.

The object of the invention is to remedy the problem of monitoring the operation of an acquisition system or
5 of a sensor by disconnection and reconnection in a current loop of the 4 mA – 20 mA type or of the 0 – 20 mA type.

The invention is based on the idea of inspecting the current loop without opening it.

10 To this end, the invention provides a current loop of the 4 mA – 20 mA type or of the 0 – 20 mA type, connecting an analog sensor to an acquisition system respectively carrying a sensor current and an acquisition current, the loop being characterized in that a test
15 circuit is connected in parallel with the current loop to inject a superposition current into said loop, which current is superposed on the sensor current or the acquisition current.

The superposition current injected into the current
20 loop by the test circuit is superposed on the current carried by the sensor to simulate its operation relative to the acquisition system, or it is superposed on the current passing through the acquisition system to simulate its operation relative to the analog sensor.

25 The test circuit connected in parallel with the current loop thus serves to inject a superposition current without opening the current loop connecting the acquisition system to the analog sensor. This remedies the drawbacks mentioned above: firstly the risk of the
30 sensor being reconnected with reverse polarity is eliminated, and secondly no open loop anomaly is detected by the acquisition while the analog sensor is being tested.

According to a first advantage of the invention, the
35 test circuit comprises a variable voltage generator connected in parallel with the acquisition system to inject the superposition current by adding it to the

acquisition current, thereby making it possible to monitor a low-current threshold of the acquisition system.

5 In a preferred embodiment, the test circuit includes an ammeter connected in series with the variable DC voltage generator to determine the magnitude of the superposition current.

10 In another preferred embodiment, the test circuit includes a diode connected in series with the variable voltage generator to protect the current loop when the variable voltage is zero.

15 In another preferred embodiment, the test circuit includes a diode connected in series with the acquisition system to preserve operating independence of a plurality of current loops connecting a plurality of sensors to a common acquisition system.

20 According to a second advantage of the invention, the test circuit includes a variable current regulator connected in parallel with the analog sensor to inject the superposition current by being added to the sensor current, thereby making it possible to monitor a high-current threshold of the acquisition system.

25 According to a third advantage of the invention, the test current includes a variable current regulator connected in parallel with the analog sensor to inject the superposition current by adding it to the sensor current, the superposition current being servo-controlled to said sensor current, thereby making it possible to maintain the acquisition current in the current loop.

30 In a preferred embodiment, the test circuit includes an ammeter connected in series with the variable current regulator to determine the magnitude of the simulation current.

35 Other characteristics and advantages of the invention will appear on reading the following description of embodiments as illustrated by the drawings.

Figure 1 is an electrical circuit diagram of a current loop with an analog sensor and an acquisition system, together with a test circuit connected in parallel to test the low-current threshold of the acquisition system.

Figure 2 is an electrical circuit diagram of a current loop with an analog sensor and an acquisition system, together with a test circuit connected in parallel to test the high-current threshold of the acquisition system.

Figure 3 is an electrical circuit diagram of a current loop with an analog sensor and an acquisition system, together with a test circuit connected in parallel to keep an acquisition current constant regardless of a sensor current.

A 4 mA – 20 mA type current loop as shown in Figure 1 comprises an analog sensor 1 and an acquisition system 3. By way of example, the analog sensor is a pressure sensor mounted on the outside of the casing of a high voltage electrical apparatus such as a circuit breaker. Nevertheless, it is clear that the invention is not limited to such a pressure sensor, and it applies to other analog sensors operating in a 0 – 20 mA or a 4 mA – 20 mA current loop. By way of example, such sensors include temperature sensors, flow rate sensors, pH sensors, and indeed viscosity sensors.

The pressure sensor 1 has a sensor current I_c flowing therethrough, which current is determined by the pressure present inside the casing of a circuit breaker that is filled with an arc-distinguishing dielectric gas.

The acquisition system 3 comprises a DC voltage source 5, e.g. at 24 volts (V1). The voltage source delivers acquisition current I_a into a series resistor R_1 , e.g. having a resistance of 100 ohms (Ω). An ammeter A_1 is temporarily connected in parallel with a diode D_1 in series with the acquisition system 3 to determine the magnitude of the acquisition current I_a .

According to the invention, a test circuit is connected in parallel with the current loop to inject a superposition current into said loop, which current is superposed on the sensor current or on the acquisition current.

In a first embodiment of the invention, as shown in Figure 1, the test circuit comprises a DC generator 7 generating a voltage V_4 that can be varied over the range 0 to 24 V and that is connected in parallel with the acquisition system 3. The generator 7 delivers a superposition current I_s into a series resistor R_4 of resistance equal to 100 Ω , for example.

The superposition current I_s is injected via the voltage generator 7 upstream from the pressure sensor 1 relative to the flow direction of the acquisition current I_a so as to be added thereto, with the sum $I_a + I_s$ being equal to the sensor current I_c . An ammeter A_2 is connected in series with the variable DC voltage generator 7 to determine the magnitude of the superposition current I_s .

In this way, the variable voltage V_4 is increased progressively so as to increase the superposition current I_s and so as to decrease the acquisition current I_a , given that, while the test is taking place, the sensor current I_c as imposed by the constant pressure inside the casing, itself remains constant. This thus causes the acquisition current I_a to be lowered to a low threshold so as to verify that the acquisition system is operating properly without opening the current loop.

The test circuit as shown in Figure 1 preferably comprises a diode D_2 connected in series with the variable voltage generator to prevent part of the acquisition current I_a being diverted into the test circuit when the variable voltage V_4 is small.

Provision is also made to connect a diode D_3 in series with the DC voltage source 5 of the acquisition system 3 so as to deal with an increase in said voltage

V1, since the current I_a must not become negative. In this way, the possibility of feeding a plurality of pressure sensors in a plurality of current loops from the same DC source is maintained and it continues to be possible to maintain the low acquisition current threshold of a current loop without disturbing feed to other pressure sensors in other current loops.

In a second embodiment, as shown in Figure 2, the test circuit comprises a variable DC current regulator 9 connected in parallel with the analog sensor 1.

The superposition current I_s is injected via the variable DC regulator 9 downstream from the pressure sensor 1 relative to the direction of the acquisition current I_a so as to be added to the sensor current I_c , with the sum $I_c + I_s$ being equal to the acquisition current I_a . An ammeter A2 is connected in series with the variable DC regulator 9 to determine the magnitude of the superposition current I_s .

In this way, the superposition current I_s is varied progressively so as to increase the acquisition current I_a given that the sensor current I_c as imposed by the constant pressure inside the casing throughout the duration of the test remains constant. This causes the acquisition current I_a to increase to a high threshold to verify proper operation of the acquisition system 3 without opening the current loop.

It should be observed, advantageously, that while testing the low and high-current thresholds of the acquisition system, the sensor current I_c can be determined from the magnitudes of the acquisition current I_a and of the superposition current I_s as determined by the ammeters A1 and A2 connected in the test circuit. As a result, the pressure of the dielectric gas contained in the casing is monitored throughout the entire duration of the test being applied to the thresholds of the acquisition system by means of a test circuit connected in parallel with the current loop. A leak of dielectric

gas from the casing would give rise to a drop in the sensor current I_c and consequently to a drop in the superposition current I_s which can easily be determined by the ammeter A2.

5 In a third embodiment of the invention, as shown in Figure 3, the test circuit comprises a variable current regulator 11 connected in parallel with the pressure sensor 1 to inject a superposition current I_s by being added to the sensor current I_c , the superposition current
10 I_s being servo-controlled to the acquisition current I_a .

 The magnitude of the acquisition current I_a as acquired by the acquisition system at the beginning of the test is given as a reference to the variable DC regulator 11 by a servo-control system 13 connected to
15 the ammeter A1 connected in parallel with the series diode D1 of the acquisition system 3.

 Throughout the duration of the test, any variation in the sensor current I_c gives rise to a variation in the acquisition current I_a which is immediately compensated
20 by the superposition current I_s injected by the regulator 11 to keep the acquisition current I_a constant. If the sensor current I_c drops, the superposition current I_s increases to keep it constant.

 In this way, the sensor current I_c is progressively
25 decreased and replaced by the superposition current I_s without opening said current loop. When I_c is zero, the pressure sensor 1 can be disconnected from the current loop to inspect it while avoiding any open loop anomaly being detected by the acquisition current. No alarm is
30 generated by the acquisition system.

 In a fourth embodiment of the invention, the test circuit is installed in a portable and removable box which has connection terminals for connection to test points permanently mounted on the current loop.

35 One of the connection terminals 13 is connected downstream from the diode D1 connected in series with the acquisition system at a point common with the ammeter A1

that measures the magnitude of the acquisition current
Ia. The other connection terminal 15 is connected
downstream from the pressure sensor 1. The ammeter A1 is
preferably integrated in the test box, which in this case
5 has a third terminal 17 connected upstream from the diode
D1 in a connection that is common with the ammeter.

CLAIMS

- 1/ A current loop, in particular of the 4 mA - 20 mA type or of the 0 - 20 mA type connecting an analog sensor (1) to an acquisition system (3) respectively carrying a
5 sensor current (I_c) and an acquisition current (I_a), the loop being characterized in that it comprises a circuit for testing proper operation that is connected in parallel with the current loop to enable a superposition current (I_s) to be injected therein, which current is
10 superposed on the sensor current (I_c) or on the acquisition current (I_a), and is increased progressively to verify the opposition of the acquisition system to a low-current threshold and to a high-current threshold, respectively.
- 15 2/ A current loop according to claim 1, in which the test circuit includes a variable voltage generator (7) connected in parallel with the acquisition system (3) and which makes it possible, while the superposition current is being increased, for the superposition current (I_s) to
20 be injected while keeping constant the sum of the acquisition current (I_a) plus the superposition current, which sum corresponds to the sensor current (I_c), so as to verify the acquisition system down to a low-current
25 threshold.
- 30 3/ A current loop according to claim 2, in which the test circuit includes a diode (D2) connected in series with the variable voltage generator (7).
- 4/ A current loop according to claim 2, in which the test circuit includes a diode (D3) connected in series with the acquisition system.
- 35 5/ A current loop according to claim 2, in which the test circuit includes an ammeter (A2) connected in series with the variable voltage generator (7).

6/ A current loop according to claim 1, in which the test circuit includes a variable current regulator (9) which is connected in parallel with the analog sensor (1) and which makes it possible while the superposition current is being increased, for the superposition current (I_s) to be injected while keeping constant the sum of the sensor current (I_c) plus the superposition current constant, which sum corresponds to the acquisition current, so as to verify the operation of the acquisition system up to a high-current threshold.

7/ A current loop according to claim 6, in which the test circuit includes an ammeter (A2) connected in series with the variable current regulator (9).

8/ A current loop according to claim 6, in which the current regulator (9) is servo-controlled to the acquisition current (I_a).

9/ A current loop according to any one of claims 1 to 8, in which the analog sensor is a pressure sensor for sensing the pressure in the casing of an electrical apparatus.

10/ A removable box comprising a test circuit for testing a current loop according to any one of claims 1 to 9, the box including connection terminals (13, 15, 17) designed to be connected to test points permanently mounted in the current loop.