



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
09.09.2015 Bulletin 2015/37

(51) Int Cl.:
G08B 25/04 (2006.01) **G08B 29/12 (2006.01)**
G08B 29/06 (2006.01)

(21) Application number: **15157420.9**

(22) Date of filing: **03.03.2015**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

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(30) Priority: **04.03.2014 CN 201410076722**

(54) **FIELD WIRE DETECTION DEVICE AND METHOD FOR FIRE ALARM SYSTEM**

(57) The present invention proposes a control device and control method for a fire alarm system, the control device and control method being capable of monitoring an on-line impedance or inter-wire impedance of field wires. The device is connected to a line, with a capacitive element being terminally connected at a far end of the line. The method comprises: sampling at least three output voltages (V_1 , V_2 , V_3) of the monitoring power supply

at at least three different time points (t_1 , t_2 , t_3), respectively, wherein the at least three time points are all before the capacitive element reaches saturation, and the time points include at least three time points which satisfy: $t_2 = nt_1$, $t_3 = (2n-1)t_1$, where n is an integer greater than 1; and based on the at least three output voltages (V_1 , V_2 , V_3), calculating an on-line impedance (R_c) or inter-wire impedance (R_s) of the line.

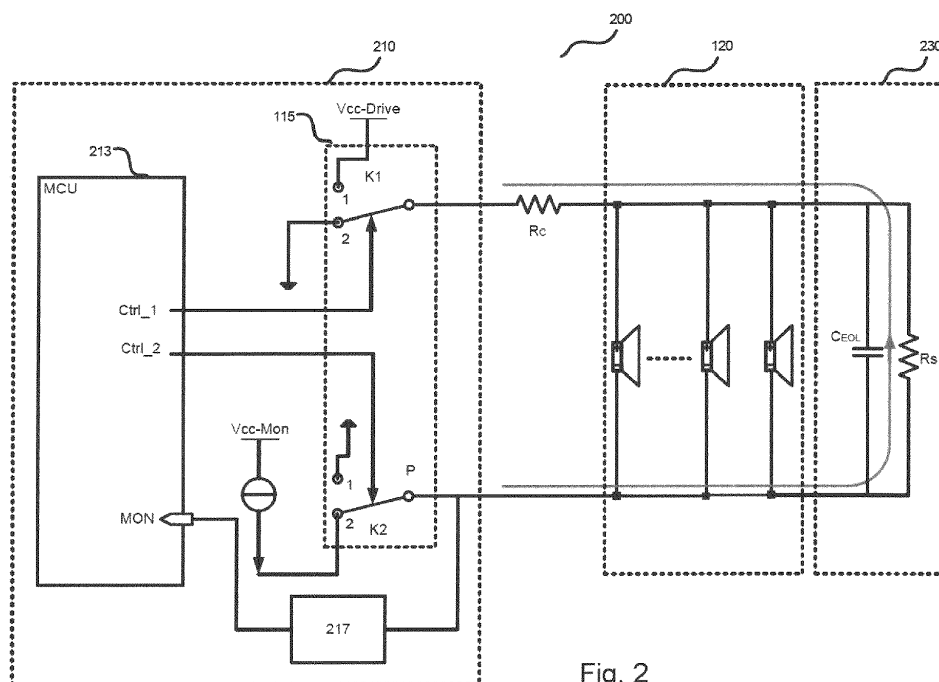


Fig. 2

Description**Technical field**

5 **[0001]** The present invention generally relates to testing of field wires of notification equipment (e.g. a fire alarm device), in particular to detection of line impedance and inter-wire impedance of field wires.

Background art

10 **[0002]** In a fire alarm system, a field device of, for example, an alarm sounder or alarm beacon is connected to a controller (control panel) of the fire alarm system via field wires, also called a line. The controller (control panel) can supply a drive current to each field device via the line, to make it emit a sound and/or flashing alarm. However, field wires may develop line open circuits or inter-wire short circuits as a result of wear caused by a long period of use or careless installation. Current safety standards generally all require that a line open circuit fault or an inter-wire short circuit fault be determined relatively accurately, i.e. they require that a fault be reported as soon as it is detected.

15 **[0003]** Fig. 1 shows by way of example a schematic diagram of an existing fire alarm system 100. As Fig. 1 shows, the fire alarm system 100 comprises a controller 110, one or more field devices 120 connected to the controller 110 via a line (L+, L-), and an End of Line element (EOL) 130 terminally connected to a far end of the line (L+, L-). In Fig. 1, for the sake of simplicity and convenience, the field devices 120 are merely shown as loudspeakers by way of example, with diodes for suppressing reverse current being incorporated in the loudspeakers. Depending on requirements, the field devices could also be alarm beacons (strobes), and could also be field devices that do not incorporate diodes. In the latter case, it is necessary to separately provide a diode outside the field device to suppress reverse current. The EOL in Fig. 1 is generally any resistive element such as a resistor. In the example shown in Fig. 1, the controller 110 specifically comprises a driving power supply Vcc-Drive, a monitoring power supply Vcc-Mon, a switching unit 115, a sampling circuit 117, and a control unit (MCU) 113 connected to the switching unit 115 and the sampling circuit 117. The switching unit 115 in Fig. 1 is for example two linked switches K1 and K2. The MCU controls the action of the two switches K1 and K2 in the switching unit 115 through output terminals Ctrl_1 and Ctrl_2 of the MCU. The sampling circuit 117 for example comprises a sampling resistor R1 which can be connected in series on the line. A voltage MON on the sampling resistor R1 can be read by the MCU.

20 **[0004]** In the system shown in Fig. 1, the controller 110 can operate in two modes, namely a driving mode and a monitoring mode. In the driving mode, the MCU 113 controls K1 and K2 to switch to a position 1 as shown in Fig. 1, i.e. connects the driving power supply Vcc-Drive onto the line, to deliver a forward driving current I_f . At this time, each field device acquires energy from the line L+, L- and operates (e.g. emits sound or light). The number of field devices on the line is related to the driving capacity of the controller and the line loss of the line. In the monitoring mode, the MCU 113 controls K1 and K2 to switch to a position 2 which is opposite to position 1 as shown in Fig. 1. At this time, the monitoring power supply Vcc-Mon (e.g. constant voltage supply) in the controller 110 is connected to the line, to feed a reverse monitoring current I_b onto the line, while the sampling circuit 117 is also connected to the line. At this time, none of the field devices operate, and the monitoring current I_b flows through the entire line, returning to the controller 110 side via the EOL. The sampling circuit 117 samples the size of the monitoring current on the line. If no valid monitoring current can be read by the MCU 113, this indicates that a line open circuit fault has occurred. If the MCU 113 detects that the current on the line exceeds a predetermined value, this indicates that an inter-wire short circuit fault has occurred.

30 **[0005]** The fire alarm system shown in Fig. 1 determines whether an open circuit or inter-wire short circuit has occurred on the line merely according to the size of current detected on the line. However, in practical applications, since the field line length and the number of field devices vary, there is a need for a method and device for determining line open circuits or inter-wire short circuits more accurately or flexibly.

Content of the invention

35 **[0006]** An object of the present invention is to provide a line impedance detection device for a fire alarm system, which device can detect an on-line impedance or inter-wire impedance of a line more accurately, in order to enable a user to distinguish between open circuit and short circuit faults flexibly.

40 **[0007]** According to one aspect of the present invention, a control device for a fire alarm system is proposed, the control device being capable of driving one or more field devices via a line, and a far end of the line being suitable for connecting to a capacitive element serving as an EOL, characterized in that the control device comprises: a driving power supply, which supplies a driving current to the line for the purpose of driving the one or more field devices, the driving current flowing on the line in a first direction; a monitoring power supply, which can supply a constant monitoring current to the line, the monitoring current flowing on the line in a second direction opposite to the first direction; a sampling circuit, for sampling an output voltage of the monitoring power supply; a controlled switching unit, which can selectively

establish an electrical connection from one of the driving power supply and the monitoring power supply to the line; a control unit, which is connected to and controls the switching unit and sampling circuit, the control unit being capable, when the monitoring power supply is connected to the line, of calculating an on-line impedance or inter-wire impedance of the line based on at least three output voltages obtained by sampling at at least three different time points, wherein the at least three time points are all before the capacitive element reaches saturation, and the at least three time points include three time points which satisfy: $t_2 = nt_1$, $t_3 = (2n-1)t_1$, where n is an integer greater than 1. Preferably, the control unit comprises: an acquisition unit, which acquires three output voltages sampled at the at least three different time points; a calculating unit, which uses the at least three output voltages obtained by sampling to calculate the on-line impedance or inter-wire impedance of the line, based on Ohm's law for a circuit and a relation between the voltage across a capacitor and a current.

[0008] Preferably, the calculating unit calculates the inter-wire impedance (R_s) of the line based on the following formula:

$$R_s = \frac{V_1 - V_2}{I \times \frac{n-1}{\sqrt{\frac{V_3 - V_2}{V_2 - V_1}} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1 \right)}};$$

or the calculating unit calculates the on-line impedance (R_c) of the line based on the following formula:

$$R_c = \frac{V_1}{I} - \frac{V_1 - V_2}{I \times \frac{n-1}{\sqrt{\frac{V_3 - V_2}{V_2 - V_1}} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1 \right)}} \times \left(1 - \frac{n-1}{\sqrt{\frac{V_3 - V_2}{V_2 - V_1}}} \right)$$

where R_s is the inter-wire impedance and R_c is the on-line impedance;

I is a constant current supplied to the line by the monitoring power supply;

V_1 , V_2 and V_3 are the three output voltages sampled at the three different time points.

[0009] More preferably, n is 2, and the calculating unit calculates the inter-wire impedance (R_s) of the line based on the following formula:

$$R_s = \frac{(V_1 - V_2)^3}{I \times (V_3 - V_2)(V_3 - 2V_2 + V_1)};$$

or the calculating unit calculates the on-line impedance (R_c) of the line based on the following formula:

$$R_c = \frac{V_1}{I} - \frac{(V_2 - V_1)^2}{I \times (V_3 - V_2)};$$

wherein R_c is the on-line impedance and R_s is the inter-wire impedance;

I is a constant current supplied to the line by the monitoring power supply;

V_1 , V_2 and V_3 are the three output voltages sampled at the three different time points.

[0010] Preferably, the control unit also comprises: a determining unit, which determines that an open circuit fault has occurred on the line if the calculated on-line impedance is greater than a predetermined open circuit threshold, or determines that a short circuit fault has occurred on the line if the calculated inter-wire impedance is less than a predetermined short circuit threshold.

[0011] According to another aspect of the present invention, also proposed is a line detection method for a fire alarm system, the fire alarm system comprising: a control device, and a line connecting the control device to one or more field devices, a far end of the line being suitable for connecting to a capacitive element serving as an EOL, the method comprising: supplying a constant monitoring current from a monitoring power supply to the line ($L+$, $L-$), the direction of the monitoring current being opposite to the direction of a driving current capable of driving the field device; sampling at least three output voltages (V_1 , V_2 , V_3) of the monitoring power supply at at least three different time points (t_1 , t_2 , t_3), respectively, wherein the at least three time points are all before the capacitive element reaches saturation, and the time points include at least three time points which satisfy: $t_2 = nt_1$, $t_3 = (2n-1)t_1$, where n is an integer greater than 1; using the at least three output voltages (V_1 , V_2 , V_3) to calculate an on-line impedance (R_c) or inter-wire impedance (R_s) of the line, based on Ohm's law for a circuit and a relation between the voltage across a capacitor and a current.

[0012] Preferably, the inter-wire impedance (Rs) of the line is calculated based on the following formula:

$$Rs = \frac{V_1 - V_2}{I \times \frac{n-1}{\sqrt{\frac{V_3 - V_2}{V_2 - V_1} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1\right)}}};$$

or the on-line impedance (Rc) of the line is calculated based on the following formula:

$$Rc = \frac{V_1}{I} - \frac{V_1 - V_2}{I \times \frac{n-1}{\sqrt{\frac{V_3 - V_2}{V_2 - V_1} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1\right)}}} \times \left(1 - \frac{n-1}{\sqrt{\frac{V_3 - V_2}{V_2 - V_1}}}\right);$$

where Rs is the inter-wire impedance and Rc is the on-line impedance;
I is a constant current supplied to the line by the monitoring power supply;
V₁, V₂ and V₃ are the three output voltages sampled at the three different time points.

[0013] More preferably, n is 2, and the inter-wire impedance (Rs) of the line is calculated based on the following formula:

$$Rs = \frac{(V_1 - V_2)^3}{I \times (V_3 - V_2)(V_3 - 2V_2 + V_1)};$$

or the on-line impedance (Rc) of the line is calculated based on the following formula:

$$Rc = \frac{V_1}{I} - \frac{(V_2 - V_1)^2}{I \times (V_3 - V_2)};$$

where Rs is the inter-wire impedance and Rc is the on-line impedance;
I is a constant current supplied to the line by the monitoring power supply;
V₁, V₂ and V₃ are the three output voltages sampled at the three different time points.

[0014] Using the method and device proposed in the present invention enables the on-line impedance on a line or inter-wire impedance at the present time to be calculated more accurately and promptly, thereby enabling a judgment to be made more promptly and accurately about whether a short circuit or open circuit fault has occurred. At the same time, the method and device proposed in the present invention do not need an EOL with a complex structure, and the calculation of on-line impedance or inter-wire impedance is independent of the terminally connected capacitive element. Thus, when a fire alarm system is being set up, the user can select a suitable capacitive element as an EOL as required, without having a negative impact on the accuracy of line impedance calculation. Therefore the method and device proposed in the present invention are simpler, more convenient and cheaper. Furthermore, as the EOL, the capacitive element is a balanced element, and has a definite advantage with regard to electromagnetic compatibility. Moreover, in the special case where n is 2, the formulas for calculating on-line impedance and inter-wire impedance are simple, particularly suited to being achieved by the MCU, and place lower demands on the operating capability of the MCU. In other words, precise monitoring of line impedance is possible at a lower cost.

[0015] Preferred embodiments are explained below in conjunction with the accompanying drawings in a clear and easy to understand fashion, to further illustrate the above characteristics, technical features and advantages of the switching device as well as embodiments thereof.

Description of the accompanying drawings

[0016] The accompanying drawings below merely illustrate and explain the present invention schematically, without defining the scope thereof.

Fig. 1 shows a structural block diagram of a schematic embodiment of an existing fire alarm system.

Fig. 2 shows a structural block diagram of a control device according to an embodiment of the present invention.

Fig. 3 shows a method according to an embodiment of the present invention, performed in the control device shown

in Fig. 2.

Fig. 4 shows a structural block diagram of a control device according to another embodiment of the present invention.

Particular embodiments

[0017] Particular embodiments of the present invention are now explained with reference to the accompanying drawings, to furnish a clearer understanding of the technical features, objects and effects of the present invention. Identical labels in the drawings indicate components with the same structure, or similar structures but the same function.

[0018] In this text, "schematic" means "serving as a real instance, example or illustration". No drawing or embodiment described herein as "schematic" should be interpreted as being a more preferred or more advantageous technical solution.

[0019] To make the drawings uncluttered, only those parts relevant to the present invention are shown schematically therein, and these do not represent the actual structure thereof as a product. Moreover, to make the drawings uncluttered and easy to understand, in some drawings, when there are components with the same structure or function, only one of these is drawn schematically, or only one is labeled.

[0020] In this text, "a" does not just mean "only this one", but may also mean "more than one". Moreover, in this text, "first" and "second", etc. merely serve to differentiate two parts, rather than indicating the order or degree of importance, etc., thereof.

[0021] Fig. 2 shows the specific structure of a controller 210 according to an embodiment of the present invention. In Fig. 2, the same labels are used for elements which are the same as in Fig. 1, and the functions thereof are also similar to those of the elements in Fig. 1, so will not be repeated here. As Fig. 2 shows, apart from the elements which are the same as in Fig. 1, the EOL in Fig. 2 is a capacitor, not a conventional resistor. A capacitive element 230 may be a commercially available capacitive element, with a range of capacitance of preferably a few hundred μF , and more preferably between 100 μF and 470 μF . Of course, the range of capacitance of the capacitive element is not limited to this. Those skilled in the art may select a capacitive element sensibly according to parameters of the MCU. In Fig. 2, R_c denotes the line resistance of the line, while R_s denotes the inter-wire resistance.

[0022] Fig. 2 merely shows the manner of connection in the monitoring mode. In Fig. 2, K1 and K2 are set so that the monitoring power supply $V_{cc}\text{-Mon}$ (not the driving power supply) in the controller 210 supplies power to the line. The monitoring power supply in the controller 210 is a constant current supply, capable of continuously outputting a constant monitoring current I to the line. A monitoring point P is also provided on the output path of the constant monitoring current I . The monitoring point P is disposed inside the controller, and is also called the on-board monitoring point of the controller 210. The voltage of the monitoring point P is then the output voltage V of the monitoring power supply, and the size of the output voltage V is related to the on-line impedance and inter-wire impedance. The output voltage V at the monitoring point P can be sampled by a sampling circuit 217 and fed back to a monitoring terminal MON of the MCU 213. The monitoring terminal MON may be a port including A/D voltage sampling. Based on at least three sample output voltages V_1 , V_2 and V_3 obtained, the MCU 213 can calculate an inter-wire impedance R_s and on-line impedance R_c on the line. In Fig. 2, the sampling circuit 217 is preferably an emitter follower circuit, and may also comprise a level conversion circuit or an A/D voltage conversion circuit (when the MCU port does not include A/D conversion), so that the output voltage V obtained by sampling suits the input range of the MCU 213.

[0023] In the case of the circuit structure shown in Fig. 2, before the capacitor C_{EOL} reaches saturation, the charge on the capacitor C_{EOL} satisfies the following relation:

$$C \times V_c(t) = \int_0^t I - \frac{V_c(x)}{R_s} dx \quad (1)$$

[0024] By taking the derivative of both sides of the equation in formula (1), the following formula can be obtained:

$$C \times \frac{dV_c(t)}{dt} = I - \frac{V_c(t)}{R_s} \quad (2)$$

[0025] Solving the differential equation in formula (2) above then gives:

$$V_c(t) = IR_s(1 - e^{-\frac{t}{CR_s}}) \quad (3)$$

where C denotes the capacitance of the terminally connected capacitive element C_{EOL} ; $V_c(t)$ is the voltage across the capacitive element C_{EOL} as a function of time.

[0026] Based on formula (3), the relation between the on-board voltage (i.e. the output voltage V) and the constant monitoring current I can be obtained:

$$V = I \times R_c + V_c(t). \quad (4)$$

[0027] Thus, if output voltages V_1 , V_2 and V_3 are obtained by sampling at three different time points t_1 , t_2 and t_3 , the output voltages V_1 , V_2 and V_3 will satisfy the following set of equations:

$$V_1 = I \times R_c + V_c(t_1) \quad (5)$$

$$V_2 = I \times R_c + V_c(t_2) \quad (6)$$

$$V_3 = I \times R_c + V_c(t_3) \quad (7)$$

[0028] Formulas (5 - 7) can be transformed to obtain relations between V_1 - and t_1 - t_3 . For example, by subtracting formula (6) and formula (7), subtracting formula (5) and formula (6), and then substituting formula (3) into the subtraction results, the following can be obtained:

$$V_3 - V_2 = V_c(t_3) - V_c(t_2) = I \times R_s \left(e^{-\frac{t_2}{CR_s}} - e^{-\frac{t_3}{CR_s}} \right) \quad (8)$$

$$V_2 - V_1 = V_c(t_2) - V_c(t_1) = I \times R_s \left(e^{-\frac{t_1}{CR_s}} - e^{-\frac{t_2}{CR_s}} \right). \quad (9)$$

[0029] At this time, if t_1 - t_3 satisfy the following relations,

$$t_2 = n \times t_1; \quad (10)$$

$$t_3 = (2n - 1) \times t_1, \quad (11)$$

where n is an integer greater than or equal to 1, then the following is possible:

$$\begin{aligned} \frac{V_3 - V_2}{V_2 - V_1} &= \frac{I \times R_s \times \left(e^{-\frac{t_2}{CR_s}} - e^{-\frac{t_3}{CR_s}} \right)}{I \times R_s \times \left(e^{-\frac{t_1}{CR_s}} - e^{-\frac{t_2}{CR_s}} \right)} \\ \frac{V_3 - V_2}{V_2 - V_1} &= \frac{I \times R_s \times e^{-\frac{t_2}{CR_s}} \left(e^{\frac{t_3 - t_2}{CR_s}} - 1 \right)}{I \times R_s \times e^{-\frac{t_1}{CR_s}} \left(e^{\frac{t_2 - t_1}{CR_s}} - 1 \right)} = e^{-\frac{(n-1)t_1}{CR_s}}. \end{aligned} \quad (12)$$

[0030] Formula (12) is substituted into formula (9) below, allowing the size of R_s to be calculated:

$$\begin{aligned}
 R_s &= \frac{V_1 - V_2}{I \times \left(e^{-\frac{t_2}{CR_s}} - e^{-\frac{t_1}{CR_s}} \right)} = \frac{V_1 - V_2}{I \times e^{-\frac{t_1}{CR_s}} \times \left(e^{\frac{(n-1)t_1}{CR_s}} - 1 \right)} \\
 &= \frac{V_1 - V_2}{I \times \frac{n-1}{\sqrt{\frac{V_3 - V_2}{V_2 - V_1}} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1 \right)}}. \quad (13)
 \end{aligned}$$

[0031] Correspondingly, substituting formula (13) into formula (3) gives:

$$\begin{aligned}
 V_c(t_1) &= I \times R_s \times \left(1 - e^{-\frac{t_1}{CR_s}} \right) \\
 &= I \times \frac{V_1 - V_2}{I \times \frac{n-1}{\sqrt{\frac{V_3 - V_2}{V_2 - V_1}} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1 \right)}} \times \left(1 - \frac{n-1}{\sqrt{\frac{V_3 - V_2}{V_2 - V_1}}} \right). \quad (14)
 \end{aligned}$$

[0032] Substituting formula (14) into formula (5) allows the size of R_c to be obtained:

$$R_c = \frac{V_1 - V_c(t_1)}{I} = \frac{V_1}{I} - \frac{V_1 - V_2}{I \times \frac{n-1}{\sqrt{\frac{V_3 - V_2}{V_2 - V_1}} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1 \right)}} \times \left(1 - \frac{n-1}{\sqrt{\frac{V_3 - V_2}{V_2 - V_1}}} \right). \quad (15)$$

[0033] It can be seen from formulas (13) and (15) that if sample output voltages $V_1 - V_3$ at three time points $t_1 - t_3$ are obtained, and these three time points are all before the capacitor C_{EOL} reaches saturation and satisfy the conditions of formulas (10) and (11), then the inter-wire impedance R_s and on-line impedance R_c on the line can be calculated according to the sample output voltages $V_1 - V_3$.

[0034] Preferably, n in formulas (10) and (11) may be chosen to be 2, i.e.

$$t_2 = 2 \times t_1; \quad t_3 = 3 \times t_1 \quad (16)$$

[0035] At this time, formulas (13) and (15) can be simplified to:

$$\begin{aligned}
 R_s &= \frac{V_1 - V_2}{I \times \frac{V_3 - V_2}{V_2 - V_1} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1 \right)} = \frac{(V_1 - V_2)^3}{I \times (V_3 - V_2)(V_3 - 2V_2 + V_1)} \quad (17) \\
 R_c &= \frac{V_1}{I} - \frac{(V_2 - V_1)^2}{I \times (V_3 - V_2)} \quad (18)
 \end{aligned}$$

[0036] The two simplified formulas (17) and (18) are easy to calculate, and do not place high demands on the computing capability of the MCU 213. Therefore if formulas (17) and (18) are used to calculate R_s and R_c , the cost of calculation is lower, and the calculating speed is faster.

[0037] Fig. 3 shows by way of example a flow chart of a method for using the abovementioned method of calculating R_c and R_s to determine whether a short circuit or open circuit fault has occurred on the line. As Fig. 3 shows, in step S310, the MCU 213 acquires sample output voltages (on-board voltages) $V_1 - V_3$ at three time points $t_1 - t_3$, wherein the time points $t_1 - t_3$ satisfy the conditions defined by formulas (10 - 11) or formula (16). In step S320, the MCU 213 uses formulas (13, 15) or formulas (17, 18) to calculate the inter-wire impedance R_s and on-line impedance R_c of the line, respectively. In step S330, the MCU 213 compares the calculated R_s with a predetermined short circuit threshold, and if R_s is lower than the short circuit threshold, this indicates that a short circuit fault has occurred on the line. The MCU 213 can also compare the calculated R_c with a predetermined open circuit threshold, and if R_c is larger than the open circuit threshold, this indicates that an open circuit fault has occurred on the line. If it is determined in step S330 that an open circuit or short circuit fault has occurred, the MCU 213 further triggers a line fault alert.

[0038] Fig. 4 shows by way of example a structural block diagram of the MCU 213 in Fig. 2. As Fig. 4 shows, the MCU 213 may comprise a sampling unit 410, a calculating unit 420 and a determining unit 430. Specifically, the sampling unit

410 acquires sample output voltages (on-board voltages) $V_1 - V_3$ at three time points $t_1 - t_3$, wherein the time points $t_1 - t_3$ satisfy the conditions defined by formulas (10 - 11) or formula (16). The calculating unit 420 uses formulas (13, 15) or formulas (17, 18) to calculate the inter-wire impedance R_s and on-line impedance R_c of the line, respectively. The determining unit 430 compares the calculated R_s with a predetermined short circuit threshold, and if R_s is lower than the short circuit threshold, this indicates that a short circuit fault has occurred on the line. The determining unit 430 can also compare the calculated R_c with a predetermined open circuit threshold, and if R_c is larger than the open circuit threshold, this indicates that an open circuit fault has occurred on the line. Optionally, the MCU may also comprise an alert unit 440. Upon receiving a short circuit or open circuit fault signal from the determining unit 430, the alert unit 440 triggers a line fault alert, e.g. an audible and/or optical alert.

[0039] Using the device and method proposed in the present invention, if the monitoring current I is 100 mA, and the A/D voltage acquisition port of the MCU 213 can distinguish a change of 10 mV, then each 0.1 Ohm change in the on-line impedance can be detected. Clearly, the method and device proposed in the present invention can calculate more precisely the on-line and inter-wire impedances, and thereby accurately determine whether a fault has occurred on the line.

[0040] It should be understood that although this description is based on various embodiments, it is by no means the case that each embodiment comprises just one independent technical solution. The description employs this method of presentation purely for the sake of clarity. Those skilled in the art should consider the description in its entirety. The technical solutions in the various embodiments may also be suitably combined to form other embodiments capable of being understood by those skilled in the art.

[0041] The series of detailed explanations set out above are merely specific explanations of feasible embodiments of the present invention, which are not intended to limit the scope of protection of the present invention. All equivalent embodiments or changes made without deviating from the artistic spirit of the present invention, such as combinations, divisions or repetitions of features, should be included in the scope of protection of the present invention.

Claims

1. A control device for a fire alarm system, the control device being capable of driving one or more field devices (120) via a line (L+, L-), and a far end of the line (L+, L-) being suitable for connecting to a capacitive element (C_{EOL}) serving as an End of Line element, **characterized in that** the control device comprises:

a driving power supply ($V_{cc-Drive}$), which supplies a driving current (I_f) to the line (L+, L-) for the purpose of driving the one or more field devices (120), the driving current flowing on the line (L+, L-) in a first direction;
 a monitoring power supply (V_{cc-Mon}), which can supply a constant monitoring current (I) to the line (L+, L-), the monitoring current (I) flowing on the line in a second direction opposite to the first direction;
 a sampling circuit (217), for sampling an output voltage (V) of the monitoring power supply;
 a controlled switching unit (115), which can selectively establish an electrical connection from one of the driving power supply ($V_{cc-Drive}$) and the monitoring power supply (V_{CC-Mon}) to the line (L+, L-);
 a control unit (213), which is connected to the switching unit (115) and sampling circuit (217), the control unit calculating, when the monitoring power supply is connected to the line, an on-line impedance (R_c) or inter-wire impedance (R_s) of the line using at least three output voltages (V_1, V_2, V_3) obtained by sampling at at least three different time points (t_1, t_2, t_3), wherein the at least three time points are all before the capacitive element reaches saturation, and the at least three time points include three time points which satisfy: $t_2 = nt_1$, $t_3 = (2n-1)t_1$, where n is an integer greater than 1.

2. The control device as claimed in claim 1, the control unit (213) comprising:

an acquisition unit (410), which acquires the at least three output voltages (V_1, V_2, V_3) at the at least three different time points (t_1, t_2, t_3);
 a calculating unit (420), which uses the at least three output voltages (V_1, V_2 and V_3) obtained by sampling to calculate the on-line impedance (R_c) or inter-wire impedance (R_s) of the line, based on Ohm's law for a circuit and a relation between the voltage across a capacitor and a current.

3. The control device as claimed in claim 1 or 2, the control unit (213) being configured to calculate the inter-wire impedance (R_s) of the line based on the following formula:

$$R_s = \frac{V_1 - V_2}{I \times \frac{n-1}{\sqrt{V_2 - V_1}} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1 \right)}$$

where R_s is the inter-wire impedance;

I is a constant current supplied to the line by the monitoring power supply;

V_1 , V_2 and V_3 are the three output voltages sampled at the three different time points.

4. The control device as claimed in any one of claims 1 - 3, the control unit (213) being configured to calculate the on-line impedance (R_c) of the line based on the following formula:

$$R_c = \frac{V_1}{I} - \frac{V_1 - V_2}{I \times \frac{n-1}{\sqrt{V_2 - V_1}} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1 \right)} \times \left(1 - \frac{n-1}{\sqrt{V_2 - V_1}} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1 \right) \right)$$

where R_c is the on-line impedance;

I is a constant current supplied to the line by the monitoring power supply;

V_1 , V_2 and V_3 are the three output voltages sampled at the three different time points.

5. The control device as claimed in any one of claims 1 - 4, wherein n is 2, so the three time points satisfy: $t_2 = 2t_1$, $t_3 = 3t_1$, and the control unit (213) is configured to calculate the inter-wire impedance (R_s) of the line based on the following formula:

$$R_s = \frac{(V_1 - V_2)^3}{I \times (V_3 - V_2)(V_3 - 2V_2 + V_1)}$$

where R_s is the inter-wire impedance;

I is a constant current supplied to the line by the monitoring power supply;

V_1 , V_2 and V_3 are the three output voltages sampled at the three different time points.

6. The control device as claimed in any one of claims 1 - 5, wherein n is 2, so the three time points satisfy: $t_2 = 2t_1$, $t_3 = 3t_1$, and the control unit (213) is configured to calculate the on-line impedance (R_c) of the line based on the following formula:

$$R_c = \frac{V_1}{I} - \frac{(V_2 - V_1)^2}{I \times (V_3 - V_2)}$$

where R_c is the on-line impedance;

I is a constant current supplied to the line by the monitoring power supply;

V_1 , V_2 and V_3 are the three output voltages sampled at the three different time points.

7. The control device as claimed in any one of claims 1 - 6, the control unit (213) being configured to determine that an open circuit fault has occurred on the line if the calculated on-line impedance is greater than a predetermined open circuit threshold, or to determine that a short circuit fault has occurred on the line if the calculated inter-wire impedance is less than a predetermined short circuit threshold.

8. A line impedance detection method for a fire alarm system, the fire alarm system comprising:

a control device, and a line (L+, L-) connecting the control device to one or more field devices (120), a far end of the line (L+, L-) being suitable for connecting to a capacitive element (C_{ECL}) serving as an End of Line element, the method comprising:

supplying a constant monitoring current (I) from a monitoring power supply (V_{cc-Mon}) to the line (L+, L-), the direction of the monitoring current (I) being opposite to the direction of a driving current capable of driving the field device;
sampling at least three output voltages (V₁, V₂, V₃) of the monitoring power supply at at least three different time points (t₁, t₂, t₃), respectively, wherein the at least three time points are all before the capacitive element reaches saturation, and the time points include at least three time points which satisfy: t₂ = nt₁, t₃ = (2n-1)t₁, where n is an integer greater than 1;
using the at least three output voltages (V₁, V₂, V₃) to calculate an on-line impedance (R_c) or inter-wire impedance (R_s) of the line.

9. The method as claimed in claim 8, wherein the inter-wire impedance (R_s) of the line is calculated based on the following formula in the calculation step:

$$R_s = \frac{V_1 - V_2}{I \times \sqrt[n-1]{\frac{V_3 - V_2}{V_2 - V_1}} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1 \right)}$$

or the on-line impedance (R_c) of the line is calculated based on the following formula:

$$R_c = \frac{V_1}{I} - \frac{V_1 - V_2}{I \times \sqrt[n-1]{\frac{V_3 - V_2}{V_2 - V_1}} \times \left(\frac{V_3 - V_2}{V_2 - V_1} - 1 \right)} \times \left(1 - \sqrt[n-1]{\frac{V_3 - V_2}{V_2 - V_1}} \right)$$

where R_s is the inter-wire impedance and R_c is the on-line impedance;

I is a constant current supplied to the line by the monitoring power supply;

V₁, V₂ and V₃ are the three output voltages sampled at the three different time points.

10. The method as claimed in claim 8 or 9, wherein n is 2, so the three time points satisfy: t₂ = 2t₁, t₃ = 3t₁, and the inter-wire impedance (R_s) of the line is calculated based on the following formula in the calculation step:

$$R_s = \frac{(V_1 - V_2)^3}{I \times (V_3 - V_2)(V_3 - 2V_2 + V_1)}$$

or the on-line impedance (R_c) of the line is calculated based on the following formula:

$$R_c = \frac{V_1}{I} - \frac{(V_2 - V_1)^2}{I \times (V_3 - V_2)}$$

where R_s is the inter-wire impedance and R_c is the on-line impedance;

I is a constant current supplied to the line by the monitoring power supply;

V₁, V₂ and V₃ are the three output voltages sampled at the three different time points.

11. The method as claimed in any one of claims 8 - 10, further comprising:

determining that an open circuit fault has occurred on the line if the calculated on-line impedance (R_c) is greater

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than a predetermined open circuit threshold, or determining that a short circuit fault has occurred on the line if the calculated inter-wire impedance (R_s) is less than a predetermined short circuit threshold.

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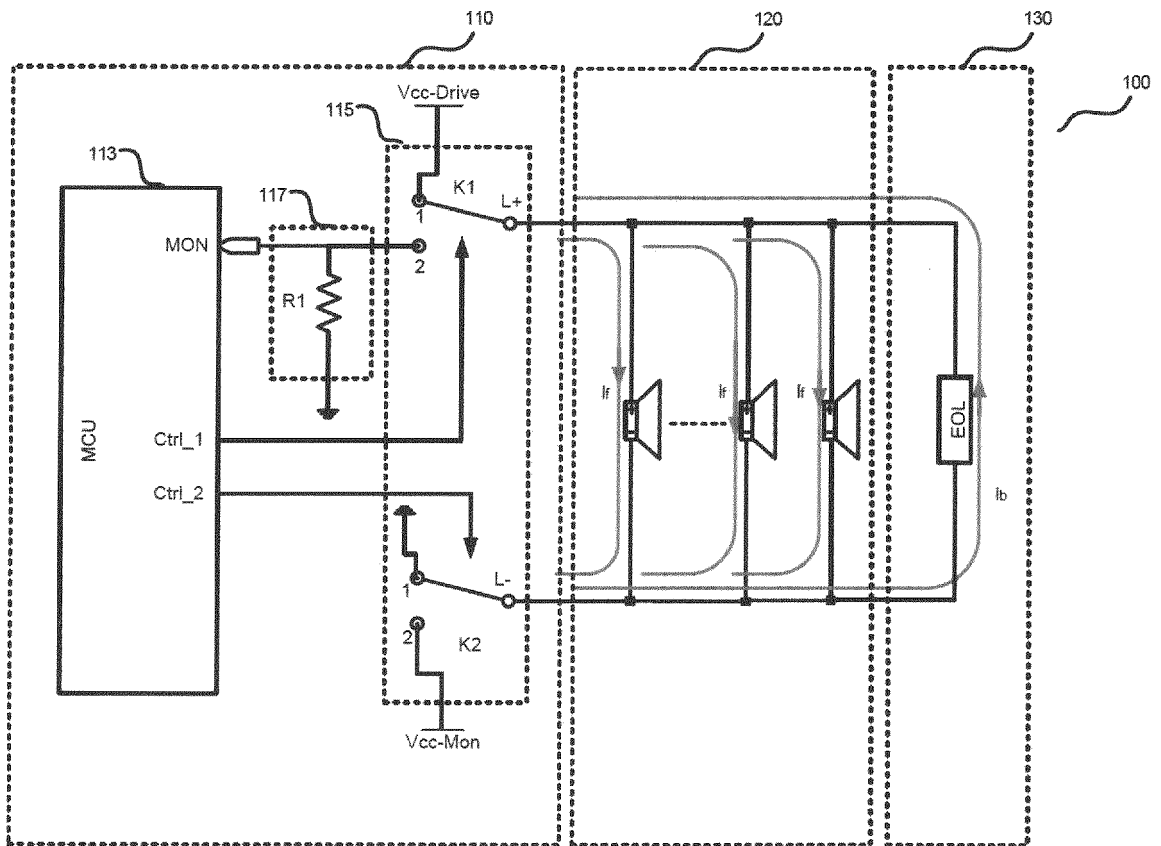


Fig. 1

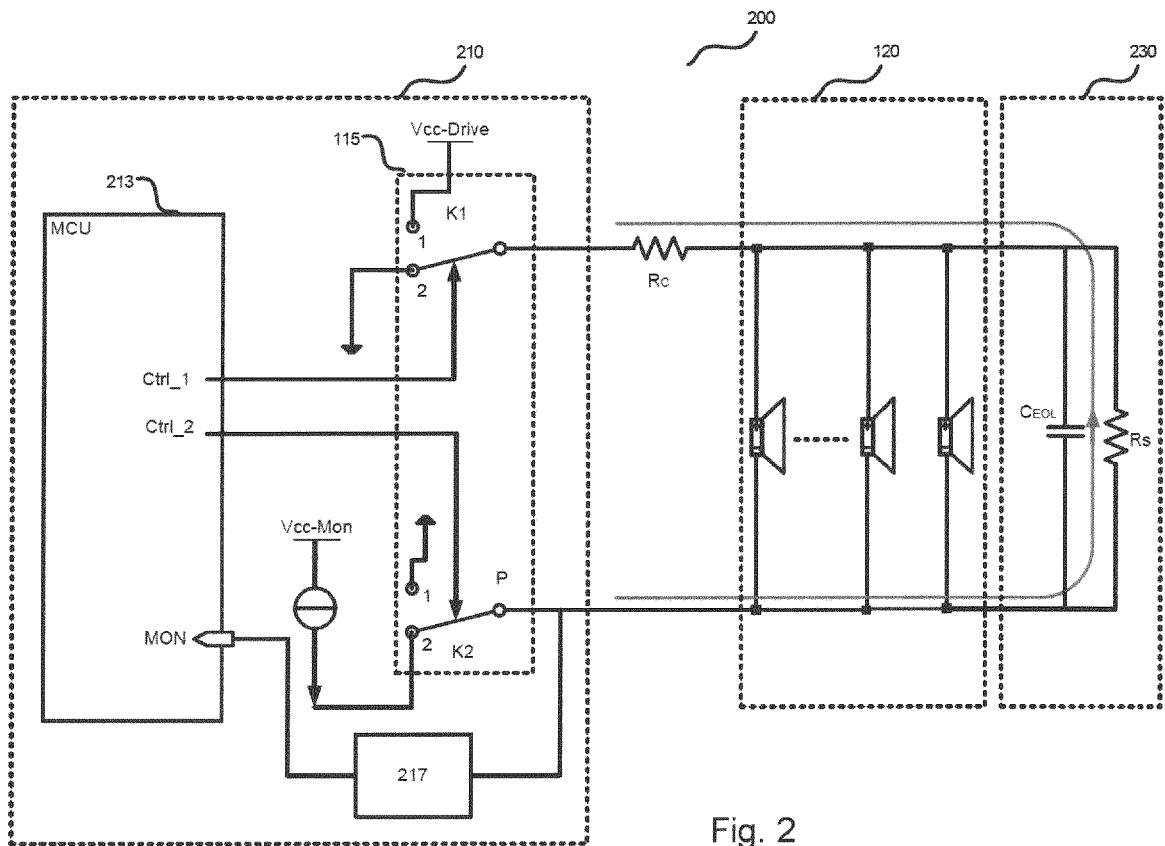


Fig. 2

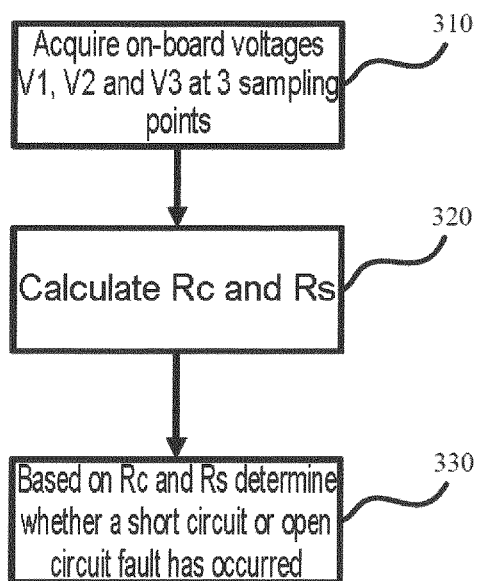


Fig. 3

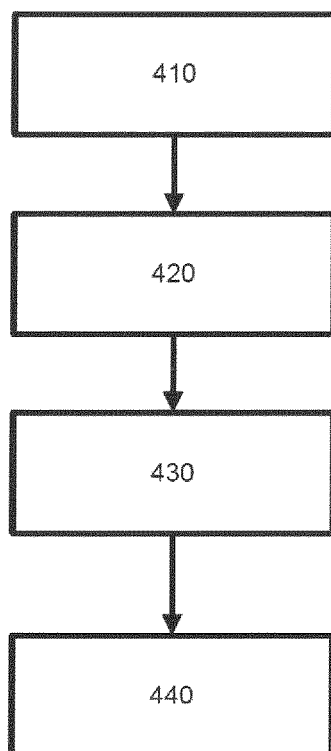


Fig. 4



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X,P	EP 2 804 163 A1 (MINIMAX GMBH & CO KG [DE]) 19 November 2014 (2014-11-19) * paragraph [0020] * * paragraph [0022] * * paragraph [0033] * * paragraph [0037] * * paragraph [0047] * * paragraph [0061] * * paragraph [0083] - paragraph [0089] * * paragraph [0093] * * paragraph [0081] *	1-11	
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Place of search The Hague		Date of completion of the search 5 June 2015	Examiner de la Cruz Valera, D
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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