United States Patent Application Publication	20250264365
Kind Code	A1
Publication Date	August 21, 2025
Inventor(s)	GUFFOND; Raphaël

System for non-invasively determining a temperature of a conductor of an electric cable

Abstract

A determination system (**100**) for non-invasively determining a temperature of a conductor of an electric cable includes an electric cable (**10**) with at least one electrical conductor (**12**) and at least one layer of material (**14, 16**) surrounding the at least one conductor. The at least one layer having a layer thermal resistance T.sub.1. At least one temperature sensor (**20**) is placed on an outer surface (**18**) of the at least one layer of material for measuring a peripheral temperature Θ.sub.b1 on the outer surface of the at least one layer of material. A determination unit (**22**) is configured to determine a conductor temperature Θ.sub.cond as a function of the measured peripheral temperature Θ.sub.b1, the layer thermal resistance T.sub.1 and the heat flux W.sub.c generated by the flow of an electrical current in the electrical conductor.

Inventors: **GUFFOND; Raphaël (LYON, FR)**

Applicant: **NEXANS** (Courbevoie, FR)

Family ID: **1000008615916**

Appl. No.: **19/039095**

Filed: **January 28, 2025**

Foreign Application Priority Data

FR	2401717	Feb. 21, 2024

Publication Classification

Int. Cl.: **G01K7/42** (20060101); **G01K1/143** (20210101); **G01R15/18** (20060101)

U.S. Cl.:

CPC **G01K7/427** (20130101); **G01K1/143** (20130101); **G01R15/181** (20130101);

Background/Summary

RELATED APPLICATION

[0001] This application claims the benefit of French Patent Application No. 24 01717, filed on Feb. 17, 2024, the entirety of which is incorporated by reference.

TECHNICAL FIELD

[0002] The present invention relates to a system for determining the temperature of an electrical conductor of an electric cable.

[0003] More specifically, the invention relates to a non-invasive determination system.

TECHNOLOGICAL BACKGROUND

[0004] During the testing or use stage of an electric cable, it is important to know the temperature of the conductor of the electric cable so as to be able to monitor the correct operation of this same cable and for sizing it correctly.

[0005] One difficulty is that placing a temperature sensor directly in the vicinity of the conductor means there is a hole or a space within the cable, and this can generate electrical arcs within this space.

[0006] To overcome this difficulty, it is known practice to connect a portion of the electric cable to a test loop formed by a cable of the same type as the electric cable. No voltage is applied in the test loop and a temperature sensor is placed in contact with the conductor. This makes it possible to monitor the variation in temperature of the conductor of the test loop so as to estimate the temperature of the conductor of the portion of electric cable in which a current flows. The drawback of this method is that it can only be performed in a test phase and not on an electric cable installed in situ.

[0007] Another method consists in placing an optical fibre inside an electric cable along the electrical conductor while this electric cable is being manufactured. This optical fibre makes it possible to measure the temperature of the conductor. The drawback of this method is that it is invasive because the presence of the optical fibre requires an adaptation of the electric cable. Moreover, the optical fibre must be inserted over the entire length of the cable, and this entails high costs.

[0008] There is thus a need for a system for non-invasively determining a temperature of a conductor of an electric cable.

SUMMARY OF THE INVENTION

[0009] To this end, the invention provides a system for non-invasively determining a temperature of a conductor of an electric cable, comprising: [0010] an electric cable comprising at least one electrical conductor and at least one layer of material surrounding said at least one conductor, said at least one layer having a layer thermal resistance T.sub.1, [0011] at least one temperature sensor placed on an outer surface of said at least one layer of material for measuring a peripheral temperature Θ.sub.b1 on the outer surface of said at least one layer of material, [0012] a determination unit configured to determine a conductor temperature Θ.sub.cond as a function of the measured peripheral temperature Θb.sub.1 and the layer thermal resistance T.sub.1.
[0013] The conductor temperature Θ.sub.cond is determined here by means of a physical model utilizing the measured peripheral temperature Θb.sub.1 and the layer thermal resistance T.sub.1.
[0014] The utilization of this physical model makes it possible to dispense with the utilization of a temperature inside the electric cable, i.e. measured via a component placed in the vicinity of the conductor, or more generally inside the outer sheath of the electric cable.
[0015] The physical model utilized makes it possible to estimate the conductor temperature Θ.sub.cond by means of the measured peripheral temperature Θb.sub.1 and the layer thermal resistance T.sub.1.
[0016] According to one embodiment of the determination system, it also comprises: [0017] at least one additional layer of material placed around said at least one layer of material and covering said at least one temperature sensor, said additional layer of material having an additional thermal resistance T.sub.b, [0018] at least one additional temperature sensor placed on an outer surface of said additional layer of material for measuring an additional peripheral temperature Θ.sub.b2 on the outer surface of said at least one additional layer of material.
[0019] According to one embodiment of the determination system, said additional layer of material extends around said at least one layer of material only over a portion of the length of the electric cable.
[0020] According to one embodiment of the determination system, said at least one additional layer of material comprises: [0021] a first additional-layer portion having a first additional thermal resistance T.sub.b, and [0022] a second additional-layer portion having a second additional thermal resistance T′.sub.b, the first additional thermal resistance T.sub.b and second additional thermal resistance T′.sub.b being different,
and wherein said at least one additional temperature sensor comprises: [0023] at least one first additional temperature sensor placed on an outer surface of the first additional-layer portion for measuring a first additional peripheral temperature Θ.sub.b2, [0024] at least one second additional temperature sensor placed on an outer surface of the second additional-layer portion for measuring a second additional peripheral temperature Θ′.sub.b2,
the determination unit being configured to determine the conductor temperature Θ.sub.cond also as a function of the first additional thermal resistance T.sub.b and the second additional thermal resistance T′.sub.b and also of the first additional peripheral temperature Θ.sub.b2 and the second additional peripheral temperature Θ′.sub.b2.
[0025] According to one embodiment of the determination system, said at least one first and at least one second additional layer are placed over different angular sectors around the electrical conductor.
[0026] Said at least one first and at least one second additional layer may overlap at least partially.
[0027] According to one embodiment of the determination system, said at least one first and at least one second additional layer together form a layer extending continuously around the electrical conductor in a plane perpendicular to the longitudinal axis of extent of the electrical conductor.
[0028] According to one embodiment of the determination system, said at least one temperature sensor comprises: [0029] at least one first sensor placed on the outer surface of said at least one layer of material, between said outer surface and the first additional-layer portion, for measuring a peripheral temperature Θ.sub.b1 on the outer surface of said at least one layer of material, [0030] at least one second sensor placed on the outer surface of said at least one layer of material, between said outer surface and the second additional-layer portion, for measuring a peripheral temperature Θ′.sub.b1 on the outer surface of said at least one layer of material.
[0031] According to one embodiment of the determination system, the determination unit is configured to determine the conductor temperature Θ.sub.cond on the basis of the following equation:
[00001] ${}_{c\text{onducteur}} = \frac{(\;{}_{b1}T_b - {}'_{b1}T'_b)\times((\;{}_{b1} - \;{}_{b2}))}{T_b(\;{}'_{b1} - \;{}'_{b2}) - T'_b(\;{}_{b1} - \;{}_{b2})}$ [0032] where T.sub.1 is the thermal resistance of said at least one layer of material, [0033] T.sub.b is the first additional thermal resistance of the first additional layer of material, [0034] T′.sub.b is the second additional thermal resistance of the second additional layer of material, [0035] Θ.sub.b1 is the peripheral temperature measured by said at least one first temperature sensor, [0036] Θ.sub.b2 is the additional peripheral temperature measured by said at least one first additional temperature sensor, [0037] Θ′.sub.b1 is the peripheral temperature measured by said at least one second temperature sensor, [0038] Θ′.sub.b2 is the additional peripheral temperature measured by said at least one second additional temperature sensor.
[0039] According to one embodiment of the determination system, the first and second additional-layer portions are made of a different material.
[0040] According to one embodiment of the determination system, the first and second additional-layer portions have a different thickness, considered perpendicularly in relation to a longitudinal axis of extent of the electric cable.
[0041] According to one embodiment of the determination system, said at least one layer of material comprises an outer sheath forming said outer surface, said at least one temperature sensor being placed on said outer sheath.
[0042] According to one embodiment of the determination system, the determination unit is configured to determine a conductor temperature Θ.sub.cond as a function of the measured peripheral temperature Θ.sub.b1 and the layer thermal resistance T.sub.1 and the heat flux W.sub.c generated by the flow of an electrical current in the electrical conductor.
[0043] According to one embodiment of the determination system, the determination unit is configured to determine the conductor temperature Θ.sub.cond as a function of the heat flux W.sub.c generated by the flow of an electrical current in the electrical conductor, on the basis of the following equation:
[00002] ${}_{\text{cond}} = \;{}_{b1}W_c \star T$
[0044] The determination unit may be placed in the vicinity of or at a distance from the electric cable.
[0045] According to one embodiment of the determination system, said at least one layer of material comprises an outer sheath forming said outer surface, said at least one temperature sensor being placed on said outer sheath.
[0046] According to one embodiment of the determination system, it also comprises a device for measuring the electrical intensity I.sub.cond of an electrical current flowing in said at least one electrical conductor, the determination unit being configured to determine said conductor temperature Θ.sub.cond also as a function of this electrical intensity I.sub.cond.
[0047] According to one embodiment of the determination system, the measuring device is a non-invasive device, in particular of the Rogowski coil type.
[0048] According to one embodiment of the determination system, the conductor temperature Θ.sub.cond is determined as follows:
[00003] ${}_{\text{cond}} = \;{}_{b1} + R_c^{\star} I_{\text{cond}}^{\star} T_1$ [0049] where R.sub.c is the electrical resistance of the conductor.
[0050] According to one embodiment of the determination system, it also comprises: [0051] an additional layer of material placed around said at least one layer of material and covering said at least one temperature sensor, said additional layer of material having an additional thermal

resistance T.sub.b, [0052] at least one additional temperature sensor placed on an outer surface of said additional layer of material for measuring an additional peripheral temperature Θ.sub.b2 on the outer surface of said at least one additional layer of material.
[0053] According to one embodiment of the determination system, said additional layer of material extends around said at least one layer of material only over a portion of the length of the electric cable.
[0054] According to one embodiment of the determination system, the determination unit is configured to determine the conductor temperature Θ.sub.cond on the basis of the following equation:
[00004] ${}_{cond} = {}_{b1} + \frac{({}_{b1} - {}_{b2})}{T_b} \times T_1$ [0055] where Θ.sub.b1 is the peripheral temperature measured by said at least one temperature sensor, [0056] Θ.sub.b2 is the additional peripheral temperature measured by said at least one additional temperature sensor, [0057] T.sub.b is the additional thermal resistance of the additional layer of material, [0058] T.sub.1 is the thermal resistance of said at least one layer of material.
[0059] According to one embodiment of the determination system, the determination unit is configured to determine the conductor temperature Θ.sub.cond also as a function of a heating W.sub.d originating from a dielectric loss in said at least one layer of material.
[0060] According to one embodiment of the determination system, the determination unit is configured to determine the conductor temperature Θ.sub.cond on the basis of the following equation:
[00005] ${}_{cond} = {}_{b1} + T_1 \times (W_c - \frac{W_d}{2})$ [0061] where W.sub.d is the heating originating from a dielectric loss in said at least one layer of material.
[0062] According to one embodiment of the determination system, the determination unit is configured to determine the conductor temperature Θ.sub.cond on the basis of the following equation:
[00006] ${}_{cond} = {}_{b1} + T_1 \times (\frac{{}_{b1} - {}_{b2}}{T_b} - \frac{W_d}{2})$ [0063] where W.sub.d is the heating originating from a dielectric loss in said at least one layer of material.
[0064] According to one embodiment of the determination system, it additionally comprises a determination module comprising one or more of the following: said at least one temperature sensor and the determination unit, the module being configured to be removably mounted on the electric cable.
[0065] According to one embodiment of the determination system, said at least one additional layer of material and said at least one additional temperature sensor are supported by the determination module.
[0066] This determination module is for example removable from the electric cable so as to take a localized measurement on the electric cable at certain points. This module is for example a measurement accessory.
[0067] The determination module has a dimension along the longitudinal axis such that it extends only over a portion of the length of the electric cable.

Description

BRIEF DESCRIPTION OF THE FIGURES
[0068] The following description provided with reference to the appended drawings, which are given by way of non-limiting example, will make it easy to understand what the invention consists of and how it may be implemented. In the appended figures:
[0069] FIG. **1** shows a sectional view of an electric cable in a first configuration comprising an electrical conductor and at least one layer of material, the electric cable belonging to a determination system;
[0070] FIG. **2** shows a sectional view of the electric cable in FIG. **1** comprising a plurality of sensors on an outer surface of said at least one layer of material;
[0071] FIG. **3** shows a diagram of a first modelling of the electric cable, according to a first mode of determination comprising a determination of the electrical intensity of the electrical current flowing in the electrical conductor;
[0072] FIG. **4** shows a sectional view of the electric cable in FIG. **1** according to a second mode of determination in which the determination system comprises an additional layer of material around the electric cable and a plurality of additional sensors placed on an outer surface of this additional layer of material;
[0073] FIG. **5** shows a diagram of a second modelling of the electric cable according to the second mode of determination;
[0074] FIG. **6** shows a third modelling of the electric cable in which the dielectric losses in said at least one layer of material are taken into account, according to the first mode of determination;
[0075] FIG. **7** shows a fourth modelling of the electric cable in which the dielectric losses in said at least one layer of material are taken into account, according to the second mode of determination;
[0076] FIG. **8** shows a sectional view of the electric cable in a second configuration comprising an electrical conductor, one or more layers of material surrounding the electrical conductor and a shield surrounding said layers of material;
[0077] FIG. **9** shows a fifth modelling of the electric cable in which the dielectric losses in said at least one layer of material, as well as the dielectric losses in the shield, are taken into account;
[0078] FIG. **10** shows a sixth modelling of the electric cable for determining the conductor temperature Θ.sub.cond independently of the environment;
[0079] FIG. **11** shows a perspective view of one embodiment of the determination system in FIG. **1** comprising a determination module mounted on the electric cable, the determination module comprising a temperature sensor and/or a temperature unit;
[0080] FIG. **12** represents a view in section of the electrical cable from FIG. **4** in a second determination mode in which the determination system comprises an additional layer of material formed of first and second additional layer portions and a plurality of additional sensors disposed on an external surface of each of the first and second additional layer of material portions;
[0081] FIG. **13** represents a diagram of a seventh model of the electrical cable utilising the first additional layer portion from FIG. **12**;
[0082] FIG. **14** represents a diagram of the seventh model of the electrical cable utilising the second additional layer portion from FIG. **12**;
[0083] FIG. **15** represents an equation for determining the conductor temperature using the seventh model;
[0084] FIG. **16** represents a diagram of an eighth model of the electrical cable utilising the first additional layer portion from FIG. **12**;
[0085] FIG. **17** represents a diagram of the eighth model of the electrical cable utilising the second additional layer portion from FIG. **12**;
[0086] FIG. **18** represents an equation for determining the conductor temperature utilising the eighth model.
DESCRIPTION OF EMBODIMENT(S)
[0087] For the sake of clarity, the same references denoting the same elements according to the prior art and according to the invention are used throughout the figures.
[0088] The concept of the invention is described more fully below with reference to the attached drawings, which show embodiments of the concept of the invention. In the drawings, the size and the relative sizes of the elements may be exaggerated for the sake of clarity. Similar numbers refer to similar elements throughout the drawings. However, this concept of the invention can be implemented in many different forms and should not be interpreted as being limited to the embodiments set out here. Instead, these embodiments are provided so that this description

is comprehensive, and communicate the scope of the concept of the invention to those skilled in the art.
[0089] Reference throughout the specification to “an/one embodiment” means that a particular function, structure or feature described in relation to one embodiment is included in at least one embodiment of the present invention. The occurrence of the expression “in an/one embodiment” in various places throughout the specification thus does not necessarily refer to the same embodiment. Furthermore, the particular functions, structures or features can be combined in any suitable manner in one or more embodiments. In addition, the term “comprising/having/including” does not rule out other elements or steps.
[0090] With reference to FIG. **1**, an electric cable **10** comprises an electrical conductor **12**, a first layer of material **14** around the electrical conductor **12** and a second layer of material **16** around the first layer of material **14**.
[0091] The electrical conductor **12** extends along a longitudinal axis A.
[0092] The first layer of material **14** and second layer of material **16** extend along the longitudinal axis A, around the electrical conductor **12**.
[0093] The first layer of material **14** is for example a layer made of an electrically insulating material. The first layer of material **14** can thus be regarded as an insulating layer.
[0094] The second layer of material **16** in this case forms an outer layer of the electric cable **10**. The second layer of material **16** forms an outer surface **18** of the electric cable **10**.
[0095] The second layer of material **16** is for example an outer sheath.
[0096] More generally, the electric cable **10** may have one or more layers of material surrounding the electrical conductor **12**. The electric cable **10** may in particular comprise one or more of the following: a shield, a semi-conducting layer, an insulating layer, an outer sheath.
[0097] In a preferred configuration, the electric cable **10** comprises, placed around the conductor in the following order from the centre to the periphery: a semi-conducting layer, an insulating layer, a shield and an outer sheath. This configuration corresponds for example to an electric cable configured for a medium-voltage (between 1 and 52 kV) network.
[0098] With reference to FIG. **2**, a determination system **100** comprises the electric cable **10**, at least one temperature sensor **20** and a determination unit **22**.
[0099] The determination system **100** may comprise a plurality of temperature sensors **20** distributed around the longitudinal axis A in a single plane transverse to this longitudinal axis A. In the example in FIG. **2**, the determination system **100** comprises nine temperature sensors **20**.
[0100] The one or more temperature sensors **20** are configured to measure a peripheral temperature Θ.sub.b1. In this configuration, in which the temperature sensors **20** are placed on the outer surface **18** of the electric cable, the peripheral temperature Θ.sub.b1 corresponds to the surface temperature of the electric cable **10**.
[0101] The one or more temperature sensors **20** are connected to the determination unit **22** so as to communicate the peripheral temperature Θ.sub.b1 to this determination unit **22**.
[0102] With preference, the temperature sensors **20** are evenly distributed around the longitudinal axis A. The determination system **100** can provide one or more temperature sensors **20** distributed furthermore along the longitudinal axis A so as to measure the peripheral temperature Θ.sub.b1 at various locations along the electric cable **10**.
[0103] This determination unit **22** is configured to determine the conductor temperature Θ.sub.cond, i.e. the temperature of the electrical conductor **12**.
[0104] This determination is made non-invasively and non-destructively. Thus, no component is inserted beneath the layers of material or in the vicinity of the electrical conductor **12** to determine its conductor temperature Θ.sub.cond. Moreover, no layer of material of the electric cable **10** is damaged or pierced to make this determination. No third component is integrated in the manufacture of the electric cable **10**, such as an optical fibre or a sensor in one of the layers of the electric cable **10** or between these layers of material.
[0105] “Non-invasive” or “non-destructive” is understood more generally to mean that the initial structure of the cable is not modified. This initial structure of the cable corresponds to the structure of the cable without a unit for determining the temperature or, more generally, a device for determining the temperature of the electrical conductor.
[0106] This makes it possible to determine the conductor temperature on an existing electric cable, for example one already installed in situ, without needing to damage it or insert any measuring tool therein.
[0107] The addition of measuring components or additional layers of material is considered not to be invasive or destructive in this case.
[0108] The determination unit **22** utilizes a physical model for determining the conductor temperature Θ.sub.cond as a function of the peripheral temperature Θ.sub.e1 measured by the one or more temperature sensors **20**.
[0109] With reference to FIG. **3**, the diffusion of heat through the electric cable **10** is shown in the form of a diagram for illustrating the physical model utilized by the determination unit **22**.
[0110] This physical model is based on the fact that the diffusion of heat through the layers of an electric cable behaves very much like the flow of a current within an electric circuit which has an electrical resistance.
[0111] Thus, the physical model establishes a relationship between the thermal resistance T.sub.1 of said at least one layer of material. The thermal resistance T.sub.1 may correspond to the thermal resistance of one or more of the layers of material. In the example in FIG. **2**, the thermal resistance T.sub.1 represents the thermal resistance of the assembly of the first layer of material **14** and second layer of material **16**. For this physical model, the first layer of material **14** and second layer of material **16** thus form one and the same layer of material having a layer thermal resistance, denoted T.sub.1.
[0112] The flow of the current inside the conductor generates heating which induces a heat flux W.sub.c.
[0113] In this physical model, the voltage difference ΔU across the terminals of an electrical resistance is close to a temperature difference ΔΘ between the inner and outer surfaces of said at least one layer of material (i.e. across the terminals of this layer of material).
[0114] During use of the electric cable **10**, the temperatures across the terminals of the thermal resistance T.sub.1 are the conductor temperature Θ.sub.cond on one side and the peripheral temperature Θ.sub.b1 on the other side. As a result, the temperature difference ΔΘ is expressed as follows: ΔΘ=Θ.sub.cond−Θ.sub.b1.
[0115] According to this physical model, a mathematical relationship is established between the heat flux W.sub.c, the thermal resistance T.sub.1 and the temperature difference ΔΘ across the terminals of this thermal resistance. This relationship is as follows:
[00007]$\Delta\theta = T_1 * W_c$ [0116] where [0117] ΔΘ is the temperature difference ΔΘ between the inner and outer surfaces of said at least one layer of material, [0118] T.sub.1 is the thermal resistance of said at least one layer of material, [0119] W.sub.c is the heat flux generated by the heating of the conductor.
[0120] The conductor temperature Θ.sub.cond can thus be expressed as follows:
[00008] $_{cond} = {}_{b1} + W_c * T_1$ [0121] where [0122] Θ.sub.cond is the conductor temperature, [0123] Θ.sub.b1 is the peripheral temperature.
[0124] The thermal resistance T.sub.1 of said at least one layer of material is determined as follows:
[00009]$T_1 = \frac{T}{2\times}\ln(1 + 2 * \frac{t_1}{d_c})$ [0125] where [0126] β.sub.T IS the thermal conductivity of said at least one layer of material, [0127] d.sub.c is the inside diameter of said at least one layer of material, [0128] t.sub.1 is the thickness of said at least one layer of material.
[0129] The physical model comprises two modes for determining the conductor temperature Θ.sub.cond.

[0130] In the first mode of determination, the determination system **100** comprises a device for measuring the electrical intensity I.sub.cond of an electrical current flowing in said at least one electrical conductor **12**.
[0131] The measuring device is a non-invasive device, in particular of the Rogowski coil type.
[0132] In the second mode of determination, the determination system **100** comprises at least one additional layer of material **24** and at least one additional temperature sensor **26**.
[0133] This second mode of determination makes it possible to do away with utilizing the electrical intensity I.sub.cond of the current flowing in the conductor.
[0134] Said at least one additional layer of material **24** is placed around said at least one layer of material. The one or more additional layers of material **24** cover said at least one temperature sensor **22**, as can be seen in FIG. **4**.
[0135] These two modes of determination can be utilized to determine the conductor temperature Θ.sub.cond according to different modellings of an electric cable **10**. These different modellings can involve different assumptions (e.g. taking into account or not taking into account dielectric losses) or different configurations of the electric cable **10**.
[0136] The determination unit **22** is configured to implement the first mode of determination and/or the second mode of determination. The determination unit **22** is configured to determine the conductor temperature Θ.sub.cond according to one or more modellings, in particular one or more of the modellings set out below.
Electric Cable without Shield, and without Taking into Account Dielectric Losses
[0137] The determination unit **22** is configured to determine the conductor temperature Θ.sub.cond according to a first modelling and a second modelling, which are illustrated in FIGS. **3** and **5**, respectively.
[0138] More specifically, the determination unit **22** is configured to determine the conductor temperature Θ.sub.cond according to the first modelling by means of the first mode of determination. The determination unit **22** is configured to determine the conductor temperature Θ.sub.cond according to the second modelling by means of the second mode of determination.
[0139] In the first and second modellings, the dielectric losses in said at least one layer of material are not taken into account or are regarded as minimal.
[0140] In these first and second modellings, the electric cable **10** does not have a shield.
[0141] The first modelling applies to the electric cable **10** comprising an electrical conductor **12** and one or more layers of material surrounding the electrical conductor **12**. One or more temperature sensors **20** are placed on the outer surface **18** of said at least one layer of material.
[0142] The electric cable **10** according to FIG. **2** is an example compatible with this first modelling.
[0143] As indicated above, the conductor temperature Θ.sub.cond can be expressed as follows:
[00010] $_{\text{cond}} = {}_{b1} + W_c * T_1$ [0144] where [0145] Θ.sub.cond is the conductor temperature, [0146] Θ.sub.b1 is the peripheral temperature, [0147] T.sub.1 is the thermal resistance of said at least one layer of material, [0148] W.sub.c is the heat flux generated by the heating of the conductor.
[0149] According to the first mode of determination, the heat flux W.sub.c owing to the heating of the electrical conductor **12** is expressed as follows:
[00011]$W_c = R_c * I_{\text{cond}}^2$ [0150] where R.sub.c is the electrical resistance of the electrical conductor, [0151] I.sub.cond is the intensity of the current flowing along the electrical conductor.
[0152] The conductor temperature Θ.sub.cond according to the first mode of determination, i.e. as a function of the intensity of the electrical conductor, is thus expressed as follows:
[00012] $_{\text{cond}} = {}_{b1} + R_c * I_{\text{cond}}^2 * T_1$
[0153] The electrical resistance R.sub.c of the electrical conductor is expressed as follows:
[00013]$R_c = R_0 \times (1 + {}_{20} \times ({}_{\text{cond}} - 20)) \times (1 + y_s + y_p)$ [0154] where [0155] R.sub.0 is the DC resistance of the conductor at 20° C., in ohms, [0156] Y.sub.s is the skin effect factor, which is dimensionless, [0157] Y.sub.p is the proximity effect factor, which is dimensionless, [0158] α.sub.20 is the coefficient of electrical resistivity, in K.sup.−1 (i.e. per kelvin).
[0159] The parameters R.sub.0, Y.sub.s, Y.sub.p and α.sub.20 are values linked to the structure and the type of the electrical conductor.
[0160] The conductor temperature Θ.sub.cond can thus be expressed as follows:
[00014] $_{\text{cond}} = \frac{{}_{b1} - R_0^2 \times T_1 \times (1 - 20 \times {}_{20})}{1 - R_0 \times I_{\text{cond}}^2 \times {}_{20} \times T_1}$
[0161] According to the second mode of determination, i.e. without the conductor intensity I.sub.cond, the determination unit **100** comprises an additional structure illustrated in FIG. **4**. Thus, the determination system **100** comprises at least one additional layer of material **24** and at least one additional temperature sensor **26**.
[0162] Said at least one additional layer of material **24** has an additional thermal resistance T.sub.b.
[0163] Said at least one additional layer of material **24** is for example at least one electrically insulating layer.
[0164] The material of said at least one additional layer of material **24** preferably has a thermal resistance between 0.001 m.sup.2.Math.K/W and 0.1 m.sup.2.Math.K/W. Within this thermal resistance range, said at least one layer of material **24** makes it possible to avoid the overheating of the conductor while permitting a temperature difference that is large enough to be measured.
[0165] Said at least one additional temperature sensor **26** makes it possible to measure an additional peripheral temperature Θ.sub.b2 on the outer surface **28** of said at least one additional layer of material **24**.
[0166] The determination system **100** may comprise a plurality of additional temperature sensors **26** distributed around the longitudinal axis A in a single plane transverse to the longitudinal axis A. In the example in FIG. **4**, the determination system **100** comprises nine additional temperature sensors **26**.
[0167] The one or more additional temperature sensors **26** are connected to the determination unit **22** so as to communicate the additional peripheral temperature Θ.sub.b2 to this determination unit **22**.
[0168] With preference, the additional temperature sensors **26** are evenly distributed around the longitudinal axis A. The determination system **100** can provide one or more additional temperature sensors **26** distributed furthermore along the longitudinal axis A so as to measure the additional peripheral temperature Θ.sub.b2 at various locations along the electric cable **10**.
[0169] With preference, the number and/or the angular position and/or the longitudinal position of the temperature sensors **20** are respectively identical to the number and/or the angular position and/or the longitudinal position of the additional temperature sensors **26**.
[0170] The electric cable **10** equipped with said at least one additional layer of material **24** and said at least one additional temperature sensor **26** is modelled by a second modelling in FIG. **5**. Said at least one additional layer of material **24** is regarded as a resistance of value T.sub.b connected in series with the resistance of value T.sub.1 corresponding to said at least one layer of material.
[0171] According to this second mode of determination, the heat flux Wo is expressed as follows:
[00015]$W_c = \frac{({}_{b1} - {}_{b2})}{T_b}$
[0172] The conductor temperature can thus be expressed as follows:

[00016] ${}_{cond} = {}_{b1} + \frac{({}_{b1} - {}_{b2})}{T_b} \times T_1$

[0173] The conductor temperature Θ.sub.cond can thus be determined without requiring the value for the intensity of the current flowing in the electrical conductor **12**. This determination is made possible by the addition of an additional layer and an additional sensor.

Electric Cable without Shield, and Taking into Account Dielectric Losses

[0174] The determination unit **22** is configured to determine the conductor temperature Θ.sub.cond according to a third and a fourth modelling which are illustrated in FIGS. **6** and **7**, respectively.

[0175] More specifically, the determination unit **22** is configured to determine the conductor temperature Θ.sub.cond according to the third modelling by means of the first mode of determination. The determination unit **22** is configured to determine the conductor temperature Θ.sub.cond according to the fourth modelling by means of the second mode of determination.

[0176] In the third and fourth modellings, the dielectric losses in said at least one layer of material are taken into account.

[0177] In these third and fourth modellings, the electric cable **10** does not have a shield.

[0178] In these third and fourth modellings, the dielectric losses in said at least one layer of material are regarded as a loss heat flux W.sub.d at the resistance of value T.sub.1 corresponding to said at least one layer of material. This loss heat flux W.sub.d can be seen in FIGS. **6** and **7**.

[0179] The third modelling applies to the electric cable **10** comprising an electrical conductor **12** and one or more layers of material surrounding the electrical conductor **12**. One or more temperature sensors **20** are placed on the outer surface **18** of said at least one layer of material.

[0180] The electric cable **10** according to FIG. **2** is an example compatible with this third modelling.

[0181] According to the first mode of determination, the conductor temperature Θ.sub.cond can be expressed as follows as a function of the electrical intensity I.sub.cond:

[00017] ${}_{cond} = {}_{b1} + T_1 \times (W_c - \frac{W_d}{2})$

[0182] This conductor temperature Θ.sub.cond may also be expressed as follows by deconstructing R.sub.c as described above:

[00018] ${}_{cond} = \frac{{}_{b1} - (R_0 I_{cond}^2) T_1 (1 - 20 \times {}_{20}) + \frac{1}{2} T_1 W_d}{1 - R_0 I_{cond}^2 {}_{20} T_1}$

[0183] According to the second mode of determination, i.e. without the conductor intensity I.sub.cond, the determination unit **100** comprises an additional structure as illustrated in FIG. **4**. Thus, the determination system **100** comprises at least one additional layer of material **24** and at least one additional temperature sensor **26**.

[0184] The electric cable **10** equipped with said at least one additional layer of material **24** and said at least one additional temperature sensor **26** is modelled by a fourth modelling in FIG. **7**.

[0185] Said at least one additional layer of material **24** is regarded as a resistance of value T.sub.b connected in series with the resistance of value T.sub.1 corresponding to said at least one layer of material.

[0186] According to this second mode of determination, the conductor temperature Θ.sub.cond is expressed as follows:

[00019] ${}_{cond} = {}_{b1} + T_1 \times (\frac{({}_{b1} - {}_{b2})}{T_b} - \frac{W_d}{2})$

[0187] The above equation is obtained by considering the following equations:

[00020] ${}_{cond} = {}_{b1} + T_1 \times (W_c + \frac{W_d}{2})$ and ${}_{b1} = {}_{b2} + T_b \times (W_d + W_c)$

[0188] The loss heat flux W.sub.d is determined as a function of the voltage applied to the electrical conductor **12**, the frequency of the voltage applied to the electrical conductor **12**, and the dielectric characteristics of said at least one layer of material.

Electric Cable with Shield, and Taking into Account Dielectric Losses

[0189] The determination unit **22** is also configured to determine the conductor temperature Θ.sub.cond in a configuration of the electric cable **10** comprising a shield **17**.

[0190] As illustrated in FIG. **8**, the electric cable **10** comprises an electrical conductor **12**, one or more layers of material surrounding the electrical conductor **12**, and a shield **17** surrounding said layers of material.

[0191] Said layers of material are for example a dielectric layer **30** surrounding the electrical conductor **12** and an insulating layer **32** placed between the dielectric layer **30** and the shield **17**.

[0192] The electric cable **10** also comprises an outer layer **34**, for example an outer sheath, defining an outer surface **38** of the outer layer **34**. The outer layer **34** may comprise a plurality of layers of material.

[0193] The outer layer **34** has a thermal resistance T.sub.3.

[0194] One or more temperature sensors **20** are placed on the outer surface **38** of the outer layer **34**.

[0195] Losses in the shield **17** are modelled by a shield heat flux W.sub.s. These losses are caused by Joule heating in the shield **17**.

[0196] The determination of the shield heat flux W.sub.s requires an invasive measurement on the electric cable **10**. To make expressing the conductor temperature Θ.sub.cond as a function of the heat flux W.sub.s redundant, it is proposed in this case to combine the first and second modes of determination seen above. In other words, it is provided in this case to express the conductor temperature Θ.sub.cond as a function of the intensity I.sub.cond of the voltage flowing in the electrical conductor **12** and to use an additional structure comprising at least one additional layer of material **24** and at least one additional temperature sensor **26**, as can be seen in FIG. **8**.

[0197] Said at least one additional layer of material **24** has a thermal resistance T.sub.b.

[0198] A fifth modelling is illustrated in FIG. **9**, taking into account the shield losses (heat flux W.sub.s) and the dielectric losses in said at least one layer (heat flux W.sub.d) and comprising three resistances connected in series for modelling the thermal resistances of said at least one layer of material (T.sub.1), of the outer sheath **34** (T.sub.3) and of said at least one additional layer of material **24** (T.sub.b).

[0199] In this fifth modelling, the conductor temperature Θ.sub.cond is expressed as follows:

[00021] ${}_{cond} = \frac{{}_{b1} + T_3 \frac{\Delta\theta_b}{T_b} + \frac{1}{2} T_1 W_d - (R_0 I^2) T_1 (1 - 20 \times {}_{20})}{1 - R_0 I_{cond}^2 {}_{20} T_1}$ [0200] where Θ.sub.b1 is the peripheral temperature measured by said at least one temperature sensor **20**, [0201] Θ.sub.b2 is the additional peripheral temperature measured by said at least one additional temperature sensor **26**, [0202] ΔΘ is the temperature difference Θ.sub.b1−Θ.sub.b2, [0203] T.sub.1 is the thermal resistance of said at least one layer of material, [0204] T.sub.b is the thermal resistance of said at least one additional layer of material **24**, [0205] T.sub.3 is the thermal resistance of the outer layer **34**, [0206] R.sub.0 is the DC resistance of the conductor at 20° C., in ohms, [0207] Y.sub.s is the skin effect factor, which is dimensionless, [0208] Y.sub.p is the proximity effect factor, which is dimensionless, [0209] α.sub.20 is the coefficient of electrical resistivity, in K.sup.−1 (i.e. per kelvin).

[0210] The determination unit **22** is thus capable of determining the conductor temperature Θ.sub.cond independently of the shield heat flux W.sub.s.

[0211] This expression of the conductor temperature Θ.sub.cond is obtained by considering that:

[00022] ${}_{cond} = {}_{surf} + n(W_c + W_s + W_d) T_3 + (W_c + \frac{W_d}{2}) T_1 \, n(W_c + W_s + W_d) = \frac{\Delta\theta_b}{T_b} \; {}_{conducteur} = {}_{b1} + T_3 \frac{\Delta\theta_b}{T_b} + (W_c + \frac{W_d}{2}) T_1$ [0212] where Θ.sub.surf is the peripheral temperature on the outer surface of the electric cable **10**, and [0213] n is the number of electrical conductors **12**.

[0214] As set out in detail above, the thermal resistance T.sub.1 is determined as follows:

[00023]$T_1 = \frac{T}{2\times}\ln(1 + 2 * \frac{t_1}{d_c})$
[0215] The thermal resistance T.sub.3 of the outer layer **34** is determined as follows:
[00024]$T_3 = \frac{T}{2\times}\ln(1 + 2 * \frac{t_3}{D_a})$ [0216] where [0217] t.sub.3 is the thickness of the outer layer **34**, [0218] D.sub.a is the inside diameter of the outer layer **34**.
[0219] According to a sixth modelling illustrated in FIG. **10**, the determination unit is also configured to determine the conductor temperature Θ.sub.cond independently of the environment, in particular of the temperature of this environment.
[0220] This sixth modelling applies to the same configuration of electric cable **10** as the fifth modelling. In other words, the sixth modelling applies to an electric cable of the type in FIG. **8** with an additional structure and a shield **17**.
[0221] Depending on the environment, the heat will be discharged from the electric cable **10** to a greater or lesser extent. The environment is modelled by a layer of material which has a certain thermal resistance T.sub.5 and a temperature Θ.sub.a corresponding to the ambient temperature of the environment.
[0222] The conductor temperature Θ.sub.cond can be expressed in this way:
[00025] $_{\text{cond}} = {}_a + (W_c + \frac{W_d}{2})T_1 + n(W_c + W_d + W_s)T_3 + n(W_c + W_d + W_s)T_b + n(W_c + W_d + W_s)T_5$
[0223] The temperature difference Θ.sub.b1−Θ.sub.b2 in the temperature on either side of the additional layer of material **24** makes it possible to express the conductor temperature Θ.sub.cond as follows:
[00026] $_{\text{cond}} = {}_{b1} + (W_c + \frac{W_d}{2})T_1 + n(W_c + W_d + W_s)T_b$ and ${}_{b1} - {}_{b2} = n(W_c + W_d + W_s)T_b$
[0224] The conductor temperature Θ.sub.cond can thus be determined by the determination unit **22** independently of the environment.
[0225] With reference to FIG. **11**, the determination system **100** may comprise a determination module **50** which accommodates one or more of the following: said at least one temperature sensor **20**.
[0226] The determination unit **22** is preferably supported by the determination module **50**. If the determination unit is offset from the determination module **50**, the determination module **50** is configured to communicate information, in particular sensor measurements, to the determination unit **22**.
[0227] This determination module **50** is for example removable from the electric cable **10** so as to take a localized measurement on the electric cable **10** at certain points. This module is for example a portable measurement accessory.
[0228] The determination module **50** has a dimension along the longitudinal axis A such that it extends only over a portion of the length of the electric cable **10**.
[0229] The determination module **50** may also comprise the additional structure. In other words, the determination module **50** may also comprise said at least one additional layer of material **24** and said at least one additional temperature sensor **26**.
[0230] In connection with FIGS. **12** to **18**, the determination unit **22** is also configured to determine the conductor temperature Θ.sub.cond according to a seventh and an eighth modelling.
[0231] In seventh and eighth modellings, the determination unit **22** is configured to determine the conductor temperature Θ.sub.cond without needing to determine the heat flux W.sub.c generated by the flow of an electrical current in the electrical conductor.
[0232] For these seventh and eighth modellings, the determination system **100** is similar to that in FIG. **4**, the difference being that said at least one additional layer **24** comprises a first additional-layer portion **60** and a second additional-layer portion **62**, as illustrated in FIG. **12**.
[0233] The first additional-layer portion **60** has a first additional thermal resistance T.sub.b. The second additional-layer portion **62** has a second additional thermal resistance T′.sub.b. The first additional thermal resistance T.sub.b and second additional thermal resistance T′.sub.b are different.
[0234] This difference between the first additional thermal resistance T.sub.b and second additional thermal resistance T′.sub.b can be obtained by utilizing a different material and/or one or more different geometric characteristics between the first additional-layer portion **60** and the second additional-layer portion **62**. One example of a different geometric characteristic is a different thickness, considered along an axis perpendicular to the longitudinal axis of extent A of the electrical conductor.
[0235] This difference between the first additional thermal resistance T.sub.b and the second additional thermal resistance T′.sub.b makes it possible to construct two different equations with the conductor temperature Θ.sub.cond as the unknown. It is thus no longer necessary to know the heat flux W.sub.c.
[0236] A plurality of first temperature sensors **64** are placed on the outer surface **18** of said at least one layer of material, between said outer surface **18** and the first additional-layer portion **60**. The plurality of first temperature sensors **64** makes it possible to measure a first peripheral temperature Θ.sub.b1 on the outer surface **18** of said at least one layer of material.
[0237] A plurality of second temperature sensors **66** is placed on the outer surface **18** of said at least one layer of material, between said outer surface **18** and the second additional-layer portion **62**. The plurality of second temperature sensors **66** makes it possible to measure a second peripheral temperature Θ′.sub.b1 on the outer surface **18** of said at least one layer of material.
[0238] A plurality of first additional temperature sensors **68** are placed on an outer surface of the first additional-layer portion **60** for measuring a first additional peripheral temperature Θ.sub.b2.
[0239] A plurality of second additional temperature sensors are placed on an outer surface of the second additional-layer portion for measuring a second additional peripheral temperature Θ′.sub.b2.
[0240] The determination unit **22** is configured to determine the conductor temperature Θ.sub.cond also as a function of the first additional thermal resistance T.sub.b and of the second additional thermal resistance T′.sub.b, as well as of the first additional peripheral temperature Θ.sub.b2 and the second additional peripheral temperature Θ′.sub.b2.
Electric Cable without Shield, without Taking into Account Dielectric Losses
[0241] The seventh modelling is illustrated in FIGS. **13** to **15**.
[0242] In this seventh modelling, the conductor temperature Θ.sub.cond is expressed as follows:
[00027] $_{\text{conducteur}} = \frac{({}_{b1}T_b - {}'_{b1}T'_b)\times(({}_{b1} - {}_{b2}))}{T_b({}'_{b1} - {}'_{b2}) - T'_b({}_{b1} - {}_{b2})}$
[0243] This equation is obtained via the following developments:
[00028]
$\frac{({}_{\text{conducteur}} - {}_{b1})}{T_1} = \frac{({}_{b1} - {}_{b2})}{T_b}\frac{({}_{\text{conducteur}} - {}'_{b1})}{T_1} = \frac{({}'''_{b1} - {}'_{b2})}{T'_b}({}_{\text{conducteur}} - {}_{b1})\frac{T_b}{({}_{b1} - {}_{b2})} = ({}_{\text{conducteur}} - {}'_{b1})\frac{T'_b}{({}'''_{b1} - {}'_{b2})}\ {}_{\text{conducteur}} = \frac{{}_{b1}T_b - {}'_{b1}T'_b}{({}'_{b1} - {}'_{b2})} / (\frac{T_b}{({}_{b1} - {}_{b2})} - \frac{T'_b}{({}'_{b1} - b}$
Electric Cable without Shield, Taking into Account Dielectric Losses
[0244] The eighth modelling is illustrated in FIGS. **16** to **18**.
[0245] In this eighth modelling, the conductor temperature Θ.sub.cond is expressed as follows:
[00029] $_{\text{conducteur}} = \frac{{}'_{b1} - \frac{B}{A}\ {}_{b1}}{1 - \frac{B}{A}}$
[0246] This equation is obtained via the following developments:
[00030] $_{\text{conducteur}} = {}_{b1} + T_1 \times (\frac{({}_{b1} - {}_{b2})}{T_b} - \frac{W_d}{2})\ {}_{\text{conducteur}} = {}'_{b1} + T_1 \times (\frac{({}'_{b1} - {}'_{b2})}{T'_b} - \frac{W_d}{2}) A = (\frac{({}_{b1} - {}_{b2})}{T_b} - \frac{W_d}{2}) B = (\frac{({}'_{b1} - {}'_{b2})}{T'_b} - \frac{W_d}{2})$ [0247] where

θ.sub.b1′ is the first peripheral temperature on the outer surface **18** of said at least one layer of material, [0248] Θ.sub.b2′ is the second additional peripheral temperature, [0249] T.sub.b′ is the second additional thermal resistance.

Claims

1. A determination system for non-invasively determining a temperature of a conductor of an electric cable, comprising: an electric cable comprising at least one electrical conductor and at least one layer of material surrounding said at least one conductor, said at least one layer having a layer thermal resistance T.sub.1, at least one temperature sensor placed on an outer surface of said at least one layer of material for measuring a peripheral temperature Θ.sub.b1 on the outer surface of said at least one layer of material, a determination unit configured to determine a conductor temperature Θ.sub.cond as a function of the measured peripheral temperature Θ.sub.b1 and the layer thermal resistance T.sub.1.
2. The determination system according to claim 1, further comprising: at least one additional layer of material placed around said at least one layer of material and covering said at least one temperature sensor, said additional layer of material having an additional thermal resistance T.sub.b, at least one additional temperature sensor placed on an outer surface of said additional layer of material for measuring an additional peripheral temperature Θ.sub.b2 on the outer surface of said at least one additional layer of material.
3. The determination system according to claim 2, wherein said additional layer of material extends around said at least one layer of material only over a portion of the length of the electric cable.
4. The determination system according to claim 2, wherein said at least one additional layer of material comprises: a first additional-layer portion having a first additional thermal resistance T.sub.b, and a second additional-layer portion having a second additional thermal resistance T′.sub.b, the first additional thermal resistance T.sub.b and second additional thermal resistance T′.sub.b being different, and wherein said at least one additional temperature sensor comprises: at least one first additional temperature sensor placed on an outer surface of the first additional-layer portion for measuring a first additional peripheral temperature Θ.sub.b2, at least one second additional temperature sensor placed on an outer surface of the second additional-layer portion for measuring a second additional peripheral temperature Θ′.sub.b2, the determination unit being configured to determine the conductor temperature Θ.sub.cond also as a function of the first additional thermal resistance T.sub.b and the second additional thermal resistance T′.sub.b and also of the first additional peripheral temperature Θ.sub.b2 and the second additional peripheral temperature Θ′.sub.b2.
5. The determination system according to claim 4, wherein said at least one first and at least one second additional layer are placed over different angular sectors around the electrical conductor.
6. The determination system according to claim 5, wherein said at least one temperature sensor comprises: at least one first sensor placed on the outer surface of said at least one layer of material, between said outer surface and the first additional-layer portion, for measuring a peripheral temperature Θ.sub.b1 on the outer surface of said at least one layer of material, at least one second sensor placed on the outer surface of said at least one layer of material, between said outer surface and the second additional-layer portion, for measuring a peripheral temperature Θ′.sub.b1 on the outer surface of said at least one layer of material.
7. The determination system according to claim 6, wherein the determination unit is configured to determine the conductor temperature Θ.sub.cond on the basis of the following equation: ${}_{\text{conducteur}} = \frac{({}_{b1}T_b - {}'_{b1}T'_b)\times(({}_{b1} - {}_{b2}))}{T_b({}'_{b1} - {}'_{b2}) - T'_b({}_{b1} - {}_{b2})}$ where T.sub.1 is the thermal resistance of said at least one layer of material, T.sub.b is the first additional thermal resistance of the first additional layer of material, T′.sub.b is the second additional thermal resistance of the second additional layer of material, Θ.sub.b1 is the peripheral temperature measured by said at least one first temperature sensor, Θ.sub.b2 is the additional peripheral temperature measured by said at least one first additional temperature sensor, Θ′.sub.b1 is the peripheral temperature measured by said at least one second temperature sensor, Θ′.sub.b2 is the additional peripheral temperature measured by said at least one second additional temperature sensor.
8. The determination system according to claim 4, wherein the first and second additional-layer portions are made of a different material.
9. The determination system according to claim 4, wherein the first and second additional-layer portions have a different thickness, considered perpendicularly in relation to a longitudinal axis of extent of the electric cable.
10. The determination system according to claim 1, wherein said at least one layer of material comprises an outer sheath forming said outer surface, said at least one temperature sensor being placed on said outer sheath.
11. The determination system according to claim 1, wherein the determination unit is configured to determine the conductor temperature Θ.sub.cond as a function of the heat flux W.sub.c generated by the flow of an electrical current in the electrical conductor, on the basis of the following equation: ${}_{\text{cond}} = {}_{b1} + W_c * T_1$
12. The determination system according to claim 1, further comprising a device for measuring the electrical intensity I.sub.cond of an electrical current flowing in said at least one electrical conductor, the determination unit being configured to determine said conductor temperature Θ.sub.cond also as a function of this electrical intensity I.sub.cond.
13. The determination system according to claim 12, wherein the measuring device is a non-invasive device, in particular of the Rogowski coil type.
14. The determination system according to claim 12, wherein the conductor temperature Θ.sub.cond is determined as follows: ${}_{\text{cond}} = {}_{b1} + R_c * I^2_{\text{cond}} * T_1$ where R.sub.c is the electrical resistance of the conductor, I.sub.cond is the electrical current flowing in said at least one electrical conductor.
15. The determination system according to claim 2, wherein said additional layer of material extends around said at least one layer of material only over a portion of the length of the electric cable.
16. The determination system according to claim 2, wherein the determination unit is configured to determine the conductor temperature Θ.sub.cond on the basis of the following equation: ${}_{\text{cond}} = {}_{b1} + \frac{({}_{b1} - {}_{b2})}{T_b} \times T_1$ where Θ.sub.b1 is the peripheral temperature measured by said at least one temperature sensor, Θ.sub.b2 is the additional peripheral temperature measured by said at least one additional temperature sensor, T.sub.b is the additional thermal resistance of the additional layer of material, T.sub.1 is the thermal resistance of said at least one layer of material.
17. The determination system according to claim 1, wherein the determination unit is configured to determine the conductor temperature Θ.sub.cond also as a function of a heating W.sub.d originating from a dielectric loss in said at least one layer of material.
18. The determination system according to claim 12, wherein the determination unit is configured to determine the conductor temperature Θ.sub.cond also as a function of a heating W.sub.d originating from a dielectric loss in said at least one layer of material, and wherein the determination unit is configured to determine the conductor temperature Θ.sub.cond on the basis of the following equation: ${}_{\text{cond}} = {}_{b1} + T_1 \times (W_c + \frac{W_d}{2})$ where W.sub.d is the heating originating from a dielectric loss in said at least one layer of material.
19. The determination system according to claim 2, wherein the determination unit is configured to determine the conductor temperature Θ.sub.cond also as a function of a heating W.sub.d originating from a dielectric loss in said at least one layer of material, and wherein the determination unit is configured to determine the conductor temperature Θ.sub.cond on the basis of the following equation:

${}_{cond} = {}_{b1} + T_1 \times (\frac{{}_{b1} - {}_{b2}}{T_b} - \frac{W_d}{2})$ where W.sub.d is the heating originating from a dielectric loss in said at least one layer of material.

20. The determination system according to claim 1, further comprising a determination module comprising one or more of the following: said at least one temperature sensor and the determination unit, the module being configured to be removably mounted on the electric cable.

21. The determination system according to 20, the determination system further comprising: at least one additional layer of material placed around said at least one layer of material and covering said at least one temperature sensor, said additional layer of material having an additional thermal resistance T.sub.b, at least one additional temperature sensor placed on an outer surface of said additional layer of material for measuring an additional peripheral temperature Θ.sub.b2 on the outer surface of said at least one additional layer of material, and wherein said at least one additional layer of material and said at least one additional temperature sensor are supported by the determination module.