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(54) **METHOD FOR LOCATING A FAULT POINT ON A HIGH-VOLTAGE THREE-PHASE AC CABLE, AND SYSTEM FOR LOCATING A FAULT POINT**

(71) Applicant: **LUMIKER APLICACIONES TECNOLOGICAS S.L.**, DERIO (ES)

(72) Inventor: **Francisco Javier BENGOECHEA DE LA LLERA**, DERIO (ES)

Publication Classification

(57)   **ABSTRACT**

Method for locating a fault point (F) on a high-voltage three-phase AC cable with single point connection system. The method includes the following steps: (a) determining the conductor (R, S, T) in fault based on previously measured conductor currents (I_{R1}, I_{1S}, I_{T1}, I_{R2}, I_{S2}, I_{T2}). In the event the cable includes more than one section (P_1, P_2), determining section (P_1, P_2) in fault based on previously measured shield currents (I_{SR1}, I_{SS1}, I_{ST1}, I_{SR2}, I_{SS2}, I_{ST2}). The fault point (F) being located by means of a model of section (P_1, P_2) in fault of the earth continuity conductor (ECC), the only unknown being the distance (x) to the fault point (F) from an end of said section (P_1, P_2) in fault.

FIG. 1

FIG. 2

FIG. 3

FIG. 4
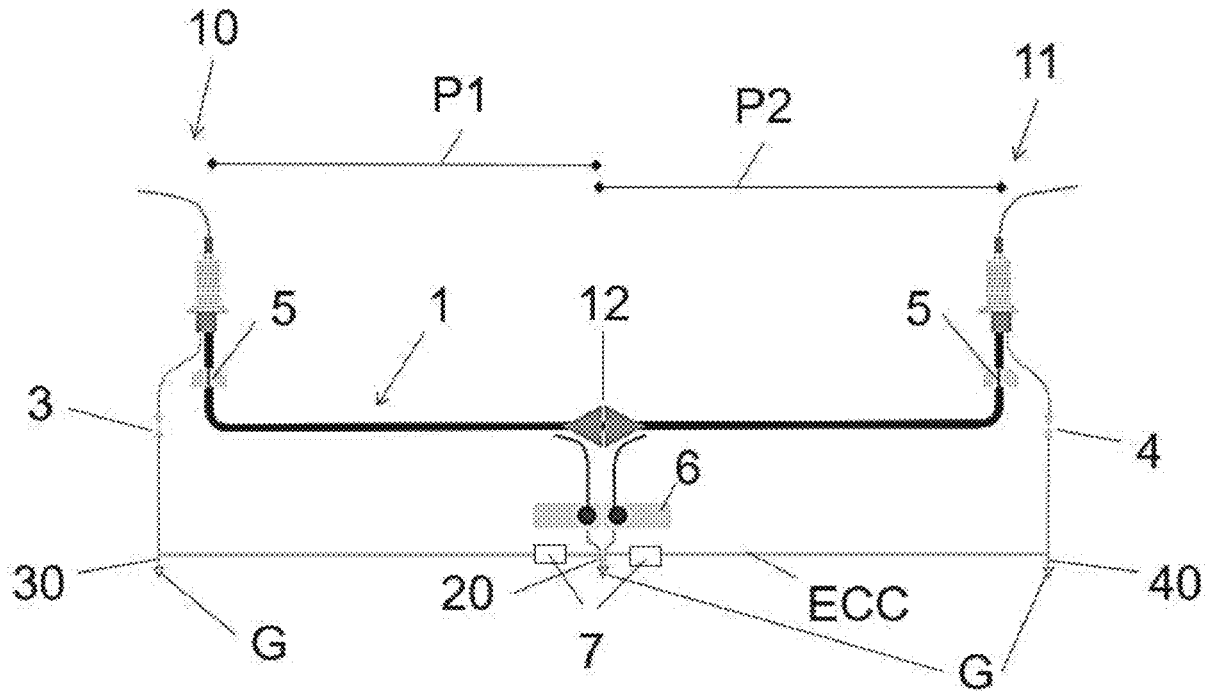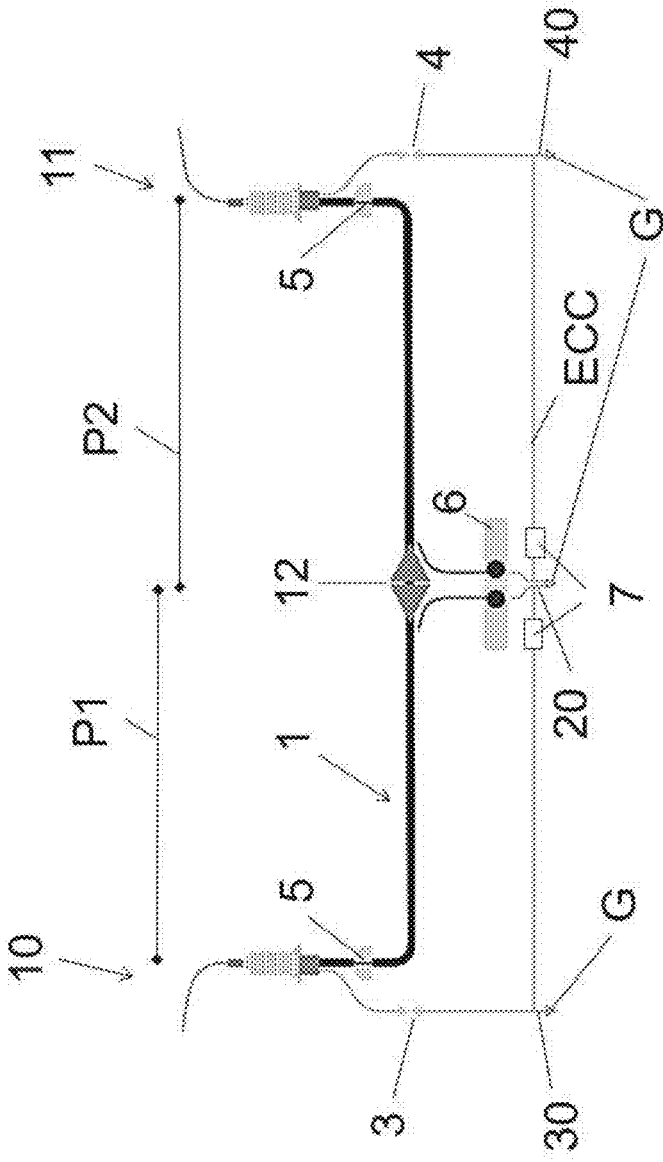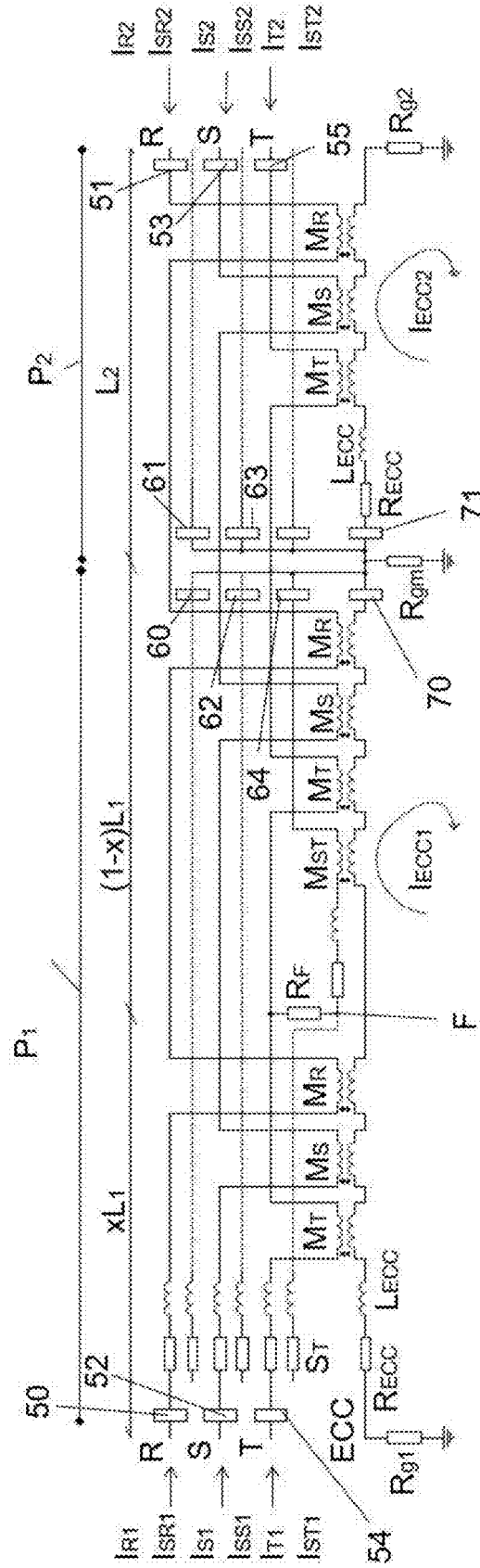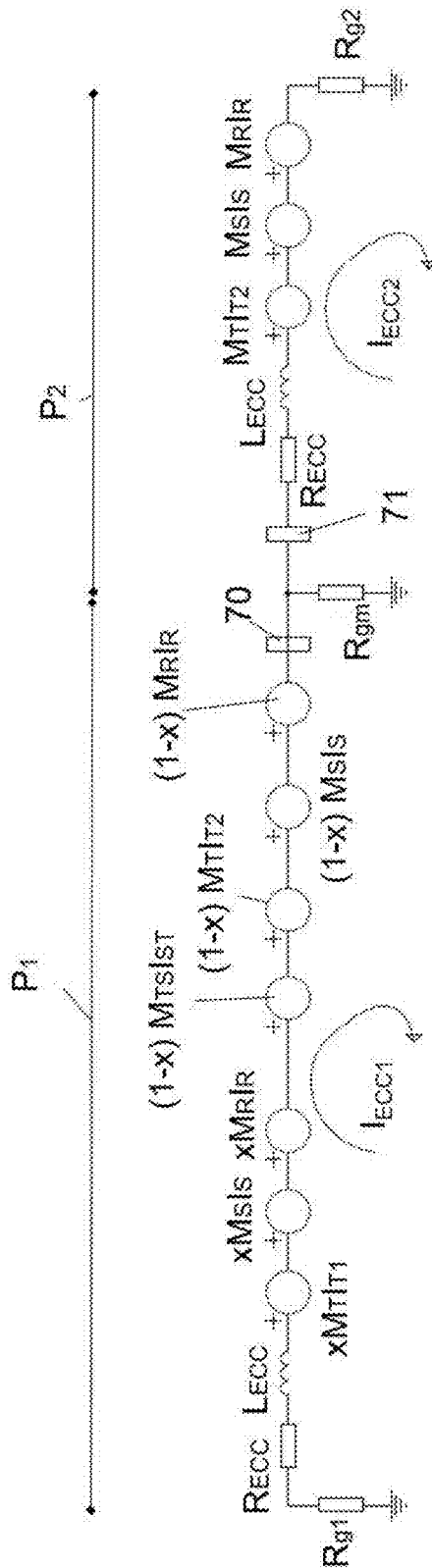
METHOD FOR LOCATING A FAULT POINT ON A HIGH-VOLTAGE THREE-PHASE AC CABLE, AND SYSTEM FOR LOCATING A FAULT POINT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application relates to and claims the benefit and priority to European Application No. EP223822331.1, filed Apr. 6, 2022.

TECHNICAL FIELD

[0002] The present invention relates to a method for locating a fault point on a high-voltage three-phase AC cable and to a system for locating a fault point.

BACKGROUND

[0003] Methods for detecting a fault on high-voltage three-phase AC cables, i.e., that a short circuit has occurred between a conductor and a shield of said cable, are known.

[0004] Methods which, in addition to detecting a fault, locate the point where said fault has occurred, are also known.

[0005] For example, U.S. Publication No. 20210072302A1 relates to a method for locating a fault point on a high-voltage cable based on providing at least two current measuring apparatuses arranged at the cable at a given distance and having timers synchronized with one another, and a measuring device for detecting an electric current flowing in the shield and/or an earthing line connecting the shield and earth. The measuring apparatus transmits pairs of current measurement values and associated values of the timer to an analysis unit which, upon the occurrence of a current exceeding a threshold value and/or of a current profile over time that satisfies specific stipulations, feeds to a calculation unit the associated values of the timers and also an indication about the location of the measurement, for which first effects of the short circuit occurred. The calculation unit calculates the location of the fault from the known distance between the measuring apparatuses and a difference between the values of the synchronized timers.

SUMMARY

[0006] An object of the invention is to provide a method for locating a fault point on a high-voltage three-phase AC cable, and a system for locating a fault point on a high-voltage three-phase AC cable.

[0007] A first aspect of the invention relates to a method for locating a fault point on a high-voltage three-phase AC cable.

[0008] The cable in which the method of the invention is applied comprises a first end, a second end, and at least one section extending between said ends, the cable comprising a conductor and a respective shield per phase. The cable comprises a single point connection system, i.e., the shields are connected to a surge arrester device grounded at one end of said at least one section, and the shields are connected to a grounding element at the other end of said at least one section. The cable comprises an earth continuity conductor establishing a common ground connecting the ground connections of the grounding element(s) and the surge arrester device(s).

[0009] The method comprises the following steps:
[0010] measuring the conductor current circulating through each conductor both at the first end and at the second end of the cable,
[0011] measuring the shield current circulating through each shield in each section at a point close to the grounding element,
[0012] measuring the earth continuity conductor current circulating through each section at a point close to the grounding element,
[0013] determining the conductor in fault based on the previously measured conductor currents,
[0014] in the event that the cable comprises more than one section, determining the section in fault based on the previously measured shield currents, and
[0015] locating the fault point by means of a model, also referred to as digital twin, of the section in fault of the earth continuity conductor, the only unknown being the distance to the fault point from an end of said section in fault.

[0016] A second aspect of the invention relates to a system for locating a fault point on a cable such as the one described in the first aspect of the invention, the system comprising:
[0017] a first current measuring equipment configured for measuring the conductor current circulating through each conductor both at the first end and at the second end of the cable,
[0018] a second current measuring equipment configured for measuring the shield current of each shield in each section at a point close to the grounding element,
[0019] a third current measuring equipment configured for measuring the earth continuity conductor current of the earth continuity conductor in each section at a point close to the grounding element, and
[0020] a computer configured for executing the method described in the first aspect of the invention based on the current measurements performed by said current measuring equipment.

[0021] The points at which the shields are connected to a surge arrester device are free for the purpose of conductivity, i.e., as if they were in an open circuit, such that it complicates the possibility of using a model of the shields to be able to calculate the fault point, since the voltage is unknown at said points. The voltage would have to be measured at said points to be able to use a model of the shields, and this may generate many problems. This problem is avoided by using the model of the earth continuity conductor since it is a model the ends of which are grounded.

[0022] The method for locating and the system for locating of the invention offer a rapid solution for locating a fault point on a high-voltage three-phase AC cable, with the result virtually being obtained in real time.

[0023] Even though a model of the earth continuity conductor is required for locating the exact fault point, said model is not very sensitive to the type of the terrain in which the cable is arranged, since it affects the different parameters of the model in a similar manner, and therefore, the influence thereof is virtually cancelled.

[0024] Furthermore, the fault resistance, i.e., the resistance between the conductor in fault and the shield in fault at fault point F, does not need to be known to locate the fault point.

[0025] These and other advantages and features will become apparent in view of the figures and of the detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]   FIG. 1 schematically shows a system for locating a fault point on a cable according to a first embodiment of the invention applied on a cable having a first configuration.

[0027]   FIG. 2 shows the model of the cable of FIG. 1.

[0028]   FIG. 3 shows the model of the earth continuity conductor of the cable of FIG. 1.

[0029]   FIG. 4 schematically shows a system for locating a fault point on a cable according to a second embodiment of the invention applied on a cable having a second configuration.

DETAILED DESCRIPTION

[0030]   A first aspect of the invention relates to a method for locating a fault point F on a high-voltage three-phase AC cable 1.

[0031]   The method of the invention is configured for locating a fault point F on a cable 1 extending between a first end 10 and a second end 11, said cable 1 comprising at least one section P_1, P_2 extending between said ends 10, 11. The cable 1 comprises one conductor R, S, T per phase and a shield S_R, S_S, S_T associated with each conductor R, S, T.

[0032]   As discussed above, fault point F is considered the point where one of the conductor R, S, T, of the cable 1 has electrical contact with the corresponding shield S_R, S_S, S_T, such that a short circuit occurs between said conductor R, S, T and the corresponding shield at said fault point F. Furthermore, in the context of the invention, section in fault will be considered section P_1, P_2 of cable 1 at which the fault point F is arranged.

[0033]   The method of the invention is configured for being applied on cables 1 with single point connection systems, i.e., on cables 1 in which the shields S_R, S_S, S_T are connected to a surge arrester device 3, 4 connected to ground G at one end of each section P_1, P_2, shields S_R, S_S, S_T being connected to a grounding element at the other end of each section P_1, P_2.

[0034]   Cables 1 of this type with single point connection systems comprise an earth continuity conductor ECC establishing a common ground G of the system connecting the ground connection(s) 20 of the grounding element(s) and the ground connection(s) 30, 40 of the surge arrester device(s) 3, 4 of the cable 1.

[0035]   The method of the invention comprises the following steps:

[0036]   measuring the conductor current I_{R1}, I_{S1}, I_{T1}, I_{R2}, I_{S2}, I_{T2} circulating through each conductor R, S, T both at the first end 10 and at the second end 11 of the cable 1,

[0037]   measuring the shield current I_{SR1}, I_{SS1}, I_{ST1}, I_{SR2}, I_{SS2}, I_{ST2} circulating through each shield S_R, S_S, S_T in each section P_1, P_2 at a point close to the grounding element 2,

[0038]   measuring the earth continuity conductor current I_{ECC1}, I_{ECC2} circulating through each section P_1, P_2 at a point close to the grounding element 2,

[0039]   determining the conductor R, S, T in fault based on the previously measured conductor currents I_{R1}, I_{S1}, I_{T1}, I_{R2}, I_{S2}, I_{T2},

[0040]   in the event that the cable 1 comprises more than one section P_1, P_2, determining section P_1, P_2 in fault based on the previously measured shield currents I_{SR1}, I_{SS1}, I_{ST1}, I_{SR2}, I_{SS2}, I_{ST2}, and

[0041]   locating the fault point F by means of a model of section P_1, P_2 in fault of the earth continuity conductor ECC, the only unknown being the distance x to the fault point F from an end of said section P_1, P_2 in fault.

[0042]   Preferably, for determining the conductor R, S, T in fault, the conductor current I_{R1}; Isi; I_{T1} measured at the first end 10 of the cable 1 for each conductor R, S, T is compared with the conductor current I_{R2}; I_{S2}; I_{S2} measured at the second end 11 of the cable 1, determining that the conductor R, S, T in fault will be the conductor in which the conductor current I_{R1}, I_{R2}; I_{S1}, I_{S2}; I_{T1}, I_{T2} at said ends 10, 11 is different.

[0043]   Preferably, for determining section P_1, P_2 in fault, the shield currents I_{SR1}, I_{SS1}, I_{ST1}; I_{SR2}, I_{SS2}, I_{ST2}, of each section P_1, P_2 are analysed, determining that section P_1, P_2 in fault will be the conductor in which one of the shield currents I_{SR1}, I_{SS1}, I_{ST1}; I_{SR2}, I_{SS2}, I_{ST2} has an overcurrent value. The shield current I_{SR1}, I_{SS1}, I_{ST1}; I_{SR2}, I_{SS2}, I_{ST2} circulating through the shields S_R, S_S, S_T when there is no fault is a low-value eddy current, for example a current of up to 10 A. However, when a fault occurs, an overcurrent that is much higher than the eddy current, for example a current higher than 10,000 A, circulates through the corresponding shield S_R, S_S, S_T. Therefore, when a fault occurs, simply looking at the shield currents I_{SR1}, I_{SS1}, I_{ST1}; I_{SR2}, I_{SS2}, I_{ST2} of each section P_1, P_2 is sufficient to determine which of the sections P_1, P_2 is in fault. It should be pointed out that since each section P_1, P_2 is connected at one of its ends to ground G, the overcurrent circulating through the shield S_R, S_S, S_T in fault circulates towards ground G such that the rest of the sections P_1, P_2 are not affected by said fault.

[0044]   Preferably, the model of the earth continuity conductor ECC of section P_1, P_2 in fault takes into account the self-resistance R_{ECC} and the self-inductance L_{ECC} of the earth continuity conductor ECC, the ground resistance R_g of the ground connections 20, 30, 40 of the grounding element and the corresponding surge arrester device 3, 4, the mutual inductance M_R, M_S, M_T between said earth continuity conductor ECC and each of the conductors R, S, T, and the mutual inductance M_{SR}, M_{SS}, M_{ST} between said earth continuity conductor ECC and the shield in fault S_R, S_S, S_T from the fault point F to the point where the shields are connected to ground G.

[0045]   Determining the parameters of the model can be accomplished through the use of an electromagnetic transients simulator (EMT simulator) which estimates parameters based on the features of the cable 1 (i.e., layers, thickness, material, etc.), the arrangement of said cable 1 (i.e., depth, separation, etc.) and the features of the land where it is disposed. For example, the EMT simulator PSCAD™ manufactured by PSCAD can be used. See pscad. com.

[0046]   When defining the model of the earth continuity conductor ECC, values relevant for the purpose of current have been taken into account, and capacitive inputs have been disregarded since they are of little value in fault situations.

[0047]   Furthermore, mutual inductance between the shields S_R, S_S, S_T which are not in fault and earth continuity conductor ECC have been ignored for defining the model since they input scarcely any coupling on the cable ECC and are therefore negligible values, and the same occurs with the shield in fault to fault point F.

[0048] Preferably, the location of the fault point is calculated using the following formula:

$$0 = I_{ECCF}(R_g + R_g + R_{ECC} + jwL_{ECC}) - I_{ECCNFR}R_g - I_{ECCNFR}R_g + jwxl_{CNF1}M_{CNF1} + jwxl_{CNF2}M_{CNF2} + jwxl_{CF1}M_{CF} + jw(1-X)I_{CNF1}M_{CNF1} + jw(1-X)I_{CNF2}M_{CNF2} - jw(1-X)I_{CF2}M_{CF} + jw(1-X)I_{SF}M_{SF}$$

wherein,

[0049] I_{ECCF}=The current circulating through the section that is in fault,

[0050] I_{ECCNFL}=The current circulating through the section which is not in fault to the left of the section in fault; in the event that there is no section to the left of the section in fault its value will be zero,

[0051] I_{ECCNFR}=The current circulating through the section which is not in fault to the right of the section in fault; in the event that there is no section to the right of the section in fault its value will be zero,

[0052] R_g=The ground resistance of the grounding of the shields or of the grounding of the surge arrester device at one of the ends of the section in fault,

[0053] R_{ECC}=The self-resistance of the earth continuity conductor ECC of the section in fault, calculated taking into account the characteristics of the cable **1**,

[0054] L_{ECC}=The self-inductance of the earth continuity conductor ECC of the section in fault, calculated taking into account the characteristics of the cable **1**,

[0055] I_{CNF1}=Current circulating through a first conductor which is not in fault, both at the first end **10** of the cable **1** and at the second end **11** of the cable **1**,

[0056] I_{CNF2}=Current circulating through a second conductor which is not in fault, both at the first end **10** of the cable **1** and at the second end **11** of the cable **1**,

[0057] I_{CF1}=Current circulating through the conductor in fault at the first end **10** of the cable **1**,

[0058] I_{CF2}=Current circulating through the conductor in fault at the second end **11** of the cable **1**,

$$I_{CF1} \neq I_{CF2}$$

[0059] I_{SF}=Current circulating through the shield in fault in the section in fault; if the current flows from the first end to the second end, it will be considered positive; in contrast, if it flows from the second end to the first end, it will be considered negative,

[0060] M_{CNF1}=Mutual inductance between the first conductor which is not in fault and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable **1**,

[0061] M_{CNF2}=Mutual inductance between the second conductor which is not in fault and the earth continuity conductor EC, is calculated taking into account the characteristics of the cable **1**,

[0062] M_{CF}=Mutual inductance between the conductor which is in fault and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable **1**,

[0063] M_{SF}=Mutual inductance between the shield which is in fault and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable **1**, and x=The distance to the fault point from the end of section P_1 in fault at which the surge arrester device is arranged to the fault point F.

[0064] Preferably when the cable **1** comprises more than one section P_1, P_2, ground resistance R_g is determined by means of a model of the earth continuity conductor ECC of a section P_1, P_2 which is not in fault, said model comprising the self-resistance R_{ECC} and the self-inductance L_ECC of the earth continuity conductor ECC, the ground resistance R_g of the ground connections **20**, **30**, **40** of the grounding element and the corresponding surge arrester device **3**, **4**, the mutual inductance M_R, M_S, M_T between said earth continuity conductor ECC and each of the conductors R, S, T, the only unknown being said ground resistance R_g.

[0065] Preferably, ground resistance R_g is calculated by means of the following formula:

$$0 = I_{ECCNF}(R_g + R_g + R_{ECC} + jwL_{ECC}) - I_{ECCL}R_g - I_{ECCR}R_g + jwI_{CNF1}M_{CNF1} + jwI_{CNF2}M_{CNF2} + jwI_{CF}M_{CF}$$

wherein,

[0066] I_{ECCNF}=The current circulating through the section which is not in fault the model of which is used to calculate ground resistance R_g,

[0067] I_{ECCL}=The current circulating through the section to the left of the section the model of which is used to calculate ground resistance R_g; in the event that there is no section to the left its value will be zero,

[0068] I_{ECCR}=The current circulating through the section to the right of the section the model of which is used to calculate ground resistance R_g; in the event that there is no section to the right its value will be zero,

[0069] R_g=The ground resistance of the grounding of the shields or of the grounding of the surge arrester device at one of the ends of the section in fault,

[0070] R_{ECC}=The self-resistance of the earth continuity conductor ECC of the section the model of which is used to calculate ground resistance R_g, calculated taking into account the characteristics of the cable **1**,

[0071] L_{ECC}=The self-inductance of the earth continuity conductor ECC of the section the model of which is used to calculate ground resistance R_g, calculated taking into account the characteristics of the cable **1**,

[0072] I_{CNF1}=Current circulating through a first conductor which is not in fault, both at the first end **10** of the cable **1** and at the second end **11** of the cable **1**,

[0073] I_{CNF2}=Current circulating through a second conductor which is not in fault, both at the first end **10** of the cable **1** and at the second end **11** of the cable **1**,

[0074] I_{CF}=Current circulating through the conductor in fault; if the current flows from the first end to the second end, it will be considered positive; in contrast, if it flows from the second end to the first end, it will be considered negative,

[0075] $M_{CNF}1$=Mutual inductance between the first conductor which is not in fault and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable **1**,

[0076] M_{CNF}=Mutual inductance between the second conductor which is not in fault and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable **1**, and

[0077] M_{CF}=Mutual inductance between the conductor which is in fault and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable **1**.

[0078] Conversely, when the cable **1** comprises a single section P_1, preferably the ground resistance R_g of the ground connections **20**, **30** of the grounding element and the surge arrester device **3** is estimated, for example, taking into account parameters such as: ground humidity, ground temperature, etc.

[0079] A second aspect of the invention relates to a system for locating a fault point F on a high-voltage three-phase AC cable **1**.

[0080] The system of the invention is configured for locating a fault point F on a cable **1** extending between a first end **10** and a second end **11**, comprising said cable **1** at least one section P_1, P_2 extending between said ends **10**, **11**. The cable **1** comprises one conductor R, S, T per phase and a shield S_R, S_S, S_T associated with each conductor R, S, T.

[0081] The system of the invention is configured for being applied on cables **1** with single point connection systems, i.e., on cables **1** in which the shields S_R, S_S, S_T are connected to a surge arrester device **3**, **4** connected to ground G at one end of each section P_1, P_2, being the shields S_R, S_S, S_T connected to a grounding element at the other end of each section P_1, P_2. Cables **1** of this type with single point connection systems comprise an earth continuity conductor ECC establishing a common ground G of the system connecting the ground connection(s) **20** of the grounding element(s) and the ground connection(s) **30**, **40** of the surge arrester device(s) **3**, **4** of the cable **1**.

[0082] The system of the invention comprises a first current measuring equipment **5** configured for measuring the conductor current I_{R1}, I_{S1}, I_{T1}, I_{R2}, I_{S2}, I_{T2} circulating through each conductor R, S, T both at the first end **10** and at the second end **11** of the cable **1**.

[0083] The system of the invention also comprises a second current measuring equipment **6** configured for measuring the shield current I_{SR1}, I_{SS1}, I_{ST1}, I_{SR2}, I_{SS2}, I_{ST2} of each shield S_R, S_S, S_T in each section P_1, P_2 at a point close to the grounding element **2**.

[0084] Furthermore, the system of the invention also comprises a third current measuring equipment **7** configured for measuring the earth continuity conductor current I_{ECC1}, I_{ECC2} of the earth continuity conductor ECC in each section P_1, P_2 at a point close to the grounding element **2**.

[0085] The system of the invention comprises a computer configured for executing the method described in the first aspect of the invention based on the current measurements performed by said current measuring equipment **50**, **51**, **52**, **53**, **54**, **55**, **60**, **61**, **62**, **63**, **64**, **65**, **70**, **71**.

[0086] In at least one embodiment, the computer used to implement the method of the invention may include one or more processors, one or more memory elements, storage, a bus, one or more network processing units interconnected with one or more network input/output (I/O) interfaces, one or more I/O interfaces, and a computer program.

[0087] The computer program comprises a plurality of instructions which, when executed by the processor, cause the processor to execute the steps of the method of the invention. In at least one embodiment, the processor or processors are at least a hardware processor configured to execute various tasks, operations and/or functions for the computer according to the software and/or the instructions configured for the computer, for example, in the computer program.

[0088] In at least one embodiment, the memory element and/or storage are configured to store data, information, software, and/or instructions associated with the computer, and/or the logic configured for the memory element and/or storage. In an embodiment of the computer, the computer program is stored in any combination of memory element(s) and/or storage.

[0089] In at least one embodiment, the bus can be configured as an interface that enables one or more elements of the computer to communicate with each other so as to exchange information and/or data. The bus can be implemented with any architecture designed for exchanging control, data, and/or information between processors, memory elements/storage, peripheral devices, and/or any other hardware and/or software component that may be configured for the computer.

[0090] In several embodiments, the network processor unit(s) may enable communication between the computer and other systems, entities, etc., through the network I/O interface(s) (wired and/or wireless). In several embodiments, the network processor unit(s) can be configured as a combination of hardware and/or software, as one or more Ethernet drivers and/or controllers or interface cards, fibre channel (e.g., optical) driver(s) and/or controller(s), wireless receivers/transmitters/transceivers, baseband processor(s)/modem(s) and/or other similar network interface driver(s) and/or controller(s) that are known now or may be developed hereinafter so as to enable communications between the computer and other systems, entities, etc., to facilitate the operations for the various embodiments of the method described herein. In several embodiments, the network VO interface(s) can be configured as one or more Ethernet ports, fibre channel ports, any other I/O port(s) and/or antennas/antenna array that are known now or may be developed in the future. Therefore, the network processor unit(s) and/or the network VO interface(s) may include suitable interfaces for receiving, transmitting, and/or otherwise communicating data and/or information in a network environment.

[0091] I/O interfaces allow the input and output of data and/or information with other entities which may be connected to the computer. For example, the VO interfaces may provide a connection to external devices such as a keyboard, numerical keypad, a touch screen, and/or any other suitable input and/or output device that is known now or may be developed in the future. In some instances, the external devices can also include (non-transitory) computer-readable storage media such as database systems, USB memories, portable optical or magnetic discs and memory cards. In still some instances, the external devices can be a mechanism for displaying data to a user, such as a computer monitor, a display screen, or the like.

[0092] FIG. **1** schematically show a first embodiment of the system of the invention, said system being applied on a high-voltage three-phase AC cable **1** having a first cable configuration.

[0093] The cable **1** according to the first configuration comprises one conductor R, S, T per phase and a shield S_R, S_S, S_T associated with each conductor R, S, T and it extends between a first end **10** and a second end **11**.

[0094] Furthermore, the cable **1** according to the first configuration has a single point connection system, the connection to ground G of the shields S_R, S_S, S_T being performed at an intermediate point **12** by means of a grounding element, with the cable **1** being divided into two sections P_1, P_2. Furthermore, the shields S_R, S_S, S_T are connected to a surge arrester device **3**, **4** connected to ground G both at the first end **10** and at the second end **11** of the cable **1**.

[0095] The cable **1** according to the first configuration also comprises an earth continuity conductor ECC connecting the ground connection **20** of the grounding element and the

ground connections **30, 40** of the devices surge arrester **3, 4** establishing a common ground G of the system.

[0096] In the first embodiment, the system comprises a first current measuring equipment **5** configured for measuring the conductor current I_{R1}, I_{S1}, I_{T1}, I_{R2}, I_{S2}, I_{T2} circulating through each conductor R, S, T both at the first end **10** and at the second end **11** of the cable **1**. As shown in FIG. **2**, the first current measuring equipment **5** comprises six current sensors **50, 51, 52, 53, 54, 55**, with one current sensor **50, 51, 52, 53, 54, 55** being arranged at each end of each conductor R, S, T.

[0097] In the first embodiment, the system comprises a second current measuring equipment **6** configured for measuring the shield current I_{SR1}, I_{SS1}, I_{ST1}, I_{SR2}, I_{SS2}, I_{ST2} of each shield S_R, S_S, S_T in each section P_1, P_2 at a point close to the grounding element. As shown in FIG. **2**, the second current measuring equipment **5** comprises six current sensors **60, 61, 62, 63, 64, 65**, with one current sensor **60, 61, 62, 63, 64, 65** being arranged in each shield S_R, S_S, S_T in each section P_1, P_2 at a point close to the grounding element.

[0098] Furthermore, in the first embodiment the system comprises a third current measuring equipment **7** configured for measuring the earth continuity conductor current I_{ECC1}, I_{ECC2} of the earth continuity conductor ECC in each section P_1, P_2 at a point close to the grounding element. As shown in FIG. **2**, the third current measuring equipment **7** comprises two current sensors **70, 71**, with one of the current sensors **70** being arranged in section P_1 of the earth continuity conductor ECC at a point close to the grounding element, with the other current sensor **71** being arranged in section P_2 of the earth continuity conductor ECC at a point close to the grounding element.

[0099] The system of the invention comprises a computer, not shown in the figures, configured for executing the method of the invention based on the current measurements performed by said current measuring equipment **50, 51, 52, 53, 54, 55, 60, 61, 62, 63, 64, 65, 70, 71**.

[0100] A fault between the conductor T and its shield S_T in the first section P_1 has been depicted in FIG. **2**. In order to locate said fault point F, the method of the invention would be applied as follows:

[0101] Measuring the conductor current I_{R1}, I_{S1}, I_{T1}, I_{R2}, I_{S2}, I_{T2} circulating through each conductor R, S, T both at the first end **10** and at the second end **11** of the cable **1** by means of the first current measuring equipment **5**.

[0102] Also, measuring the shield current I_{SR1}, I_{SS1}, I_{ST1}, I_{SR2}, I_{SS2}, I_{ST2} circulating through each shield S_R, S_S, S_T in each section P_1, P_2 at a point close to the grounding element by means of the second current measuring equipment **6**. Also, measuring the earth continuity conductor current I_{ECC} circulating through each section P_1, P_2 at a point close to the grounding element by means of the third current measuring equipment.

[0103] Comparing the conductor current I_{R1}; I_{S1}; I_{T1} measured at the first end **10** of the cable **1** for each conductor R, S, T with the conductor current I_{R2}; I_{S2}; T_2 measured at the second end **11** of the cable **1**. In this case, the conductor current I_{R1} of the conductor T at the first end **10** of the cable **1** will be different from the conductor current I_{R2} at the first end **11**, such that it will be determined that conductor T is the conductor which is in fault.

[0104] Also, analysing the shield currents I_{SR1}, I_{SS1}, I_{ST1}; I_{SR2}, I_{SS2}, I_{ST2} of each section P_1, P_2. In this case, the shield

current I_{ST1} will be observed as having an overcurrent value, determining that section P_1 is the section which is in fault.

[0105] Once conductor T in fault and section P_1 in fault have been determined, defining the model of the earth conductor ECC shown in FIGS. **2** and **3**.

[0106] The net representing section P_2 which is not in fault comprises the self-resistance R_{ECC} and the self-inductance L_{ECC} of the earth continuity conductor ECC, the ground resistance R_{gm}, R_{g2} of the ground connections **20, 40** of the grounding element and the surge arrester device **4**, and the mutual inductance M_R, M_S, M_T between said earth continuity conductor ECC and each of the conductors R, S, T. Therefore, all the parameters of the net of section P_2 which is not in fault can be calculated by knowing the characteristics of the cable **1**, the conductor currents I_{R2}, I_{S2}, $1T_2$ circulating through the conductor R, S, T at the second end **11** of the cable **1**, and the earth continuity conductor currents ECC I_{ECC1}, I_{ECC2} circulating through both sections P_1, P_2, the only unknown being the ground resistances R_{gm}, R_{g2}. All the ground resistances R_g, R_{g2}, R_{gm}, R_{g2} of the model of the earth conductor ECC are considered equal.

[0107] Therefore, in this case ground resistance R is calculated using the following formula:

$$0 = I_{ECC2}(R_{g2} + R_{gm} + R_{ECC} + jwL_{ECC}) - I_{ECC1}R_{gm} - jwI_{R2}M_R - jwI_{S2}M_S - jwI_{T2}M_T$$

wherein,

[0108] I_{ECC1}=The current circulating through section P_1 which is in fault,

[0109] I_{ECC2}=The current circulating through section P_2 which is not in fault,

[0110] R_{gm}=The ground resistance of the grounding device **2**,

[0111] R_{g2}=The ground resistance of the surge arrester device **4** arranged at the second end **11** of the cable **1**,

[0112] R_{ECC}=The self-resistance of the earth continuity conductor ECC, calculated taking into account the characteristics of the cable **1**,

[0113] L_{ECC}=The self-inductance of the earth continuity conductor ECC, calculated taking into account the characteristics of the cable **1**,

[0114] I_{R2}=Current circulating through the conductor R which is not in fault at the second end **11** of the cable **1**,

[0115] I_{S2}=Current circulating through the conductor S which is not in fault at the second end **11** of the cable **1**,

[0116] I_{T2}=Current circulating through the conductor T which is in fault at the second end **11** of the cable **1**,

[0117] M_R=Mutual inductance between the conductor R and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable **1**,

[0118] M_S=Mutual inductance between the conductor S and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable **1**, and

[0119] M_T=Mutual inductance between the conductor T and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable **1**.

[0120] The net representing section P_1 in fault comprises the self-resistance R_{ECC} and the self-inductance L_{ECC} of the earth continuity conductor ECC, the ground resistance R_g of the ground connection **20** of the grounding element and of the ground connection **30** of the surge arrester device **3**, the mutual inductance M_R, M_S, M_T between said earth continu-

ity conductor ECC and each of the conductors R, S, T, and the mutual inductance M_{ST} between said earth continuity conductor ECC and the shield S_T in fault from the fault point F to the point where the shields are connected to ground G. Taking into account that the ground resistance R_g is obtained from the net of section P_2 which is not in fault, all the parameters of the net of section P_1 in fault can be calculated by knowing the characteristics of the cable 1, the conductor currents I_{R1}, I_{S1}, I_{T1} circulating through the conductor R, S, T at the first end 1 of the cable 1, the shield current I_{ST1} circulating through the shield S_T in fault in section P_1 in fault and the currents of earth continuity conductor ECC I_{ECC1}, I_{ECC2} circulating through both sections P_1, P_2, the only unknown being the distance x to the fault point F.

[0121] Therefore, the location of the fault point is calculated using the following formula:

$$0 = I_{ECC1}(R_{g1} + R_{gm} + R_{ECC} + jwL_{ECC}) - I_{ECC2}R_{gm} + \\ jwxI_R M_R + jwxI_S M_S + jwxI_{T1} M_T + +jw(1-x)I_R M_R + \\ jw(1-x)I_S M_S - jw(1-x)I_{T2} M_T + jw(1-x)I_{ST} M_{ST}$$

wherein,

[0122] I_{ECC1}=The current circulating through section P_1 which is in fault,

[0123] I_{ECC2}=The current circulating through section P_2 which is not in fault,

[0124] R_{g1}=The ground resistance of the surge arrester device 3 arranged at the first end 10 of the cable 1,

[0125] R_{gm}=The ground resistance of the grounding device 2,

[0126] R_{ECC}=The self-resistance of the earth continuity conductor ECC, calculated taking into account the characteristics of the cable 1,

[0127] L_{ECC}=The self-inductance of the earth continuity conductor ECC, calculated taking into account the characteristics of the cable 1,

[0128] $I_R = I_{R1} = I_{R2}$=Current circulating through the conductor R which is not in fault, both at the first end 10 of the cable 1 and at the second end 11 of the cable 1,

[0129] $I_S = I_{S1} = I_{S2}$=Current circulating through the conductor S which is not in fault, both at the first end 10 of the cable 1 and at the second end 11 of the cable 1,

[0130] I_{T1}=Current circulating through the conductor T which is in fault at the first end 10 of the cable 1,

[0131] I_{T2}=Current circulating through the conductor T which is in fault at the second end 11 of the cable 1,

$$I_{T1} \neq I_{T2}$$

[0132] I_{ST}=Current circulating through the shield S_T in fault in section P_1 in fault; if the current flows from the first end to the second end, it will be considered positive; in contrast, if it flows from the second end to the first end, it will be considered negative,

[0133] M_R=Mutual inductance between the conductor R and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable 1,

[0134] M_S=Mutual inductance between the conductor S and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable 1,

[0135] M_T=Mutual inductance between the conductor T and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable 1,

[0136] M_{ST}=Mutual inductance between the shield S_T in fault and the earth continuity conductor ECC, calculated taking into account the characteristics of the cable 1, and x=The distance to the fault point from the

end of section P_1 in fault at which the surge arrester device is arranged to the fault point F.

[0137] FIG. 4 schematically shows a second embodiment of the system of the invention, said system being applied on a high-voltage three-phase AC cable 1 having a second cable configuration.

[0138] The cable 1 according to the first configuration comprises one conductor R, S, T per phase and a shield S_R, S_S, S_T associated with each conductor R, S, T and extends between a first end 10 and a second end 11.

[0139] Furthermore, the cable 1 according to the first configuration has a single point connection system, the connection to ground G of the shields S_R, S_S, S_T being performed at the first end 10 of the cable 1, with shields S_R, S_S, S_T being connected to a surge arrester device 4 connected to ground G at the second end 11 of the cable 1. The cable 1 thereby comprises a single section P_1.

[0140] The cable 1 according to the first configuration also comprises an earth continuity conductor ECC connecting the ground connection 20 of the grounding element and the connection 40 of the surge arrester device 4 establishing a common ground G of the system.

[0141] In the second embodiment, the system comprises a first current measuring equipment 5 configured for measuring the conductor current I_{R1}, I_{S1}, I_{T1}, I_{R2}, I_{S2}, I_{T2} circulating through each conductor R, S, T both at the first end 10 and at the second end 11 of the cable 1. The first current measuring equipment 5 comprises six current sensors 50, 51, 52, 53, 54, 55, with one current sensor 50, 51, 52, 53, 54, 55 being arranged at each end of each conductor R, S, T.

[0142] In the second embodiment, the system comprises a second current measuring equipment 6 configured for measuring the shield current I_{SR1}, I_{SS1}, I_{ST1} of each shield S_R, 5S, S_T at a point close to the grounding element 2. The second current measuring equipment 5 comprises three current sensors 60, 61, 62, with one current sensor 60, 61, 62 being arranged in each shield S_R, S_S, S_T at a point close to the grounding element 2.

[0143] Furthermore, in the second embodiment the system comprises a third current measuring equipment 7 configured for measuring the earth continuity conductor current I_{ECC1} of the earth continuity conductor ECC at a point close to the grounding element 2. The third current measuring equipment 7 comprises a single current sensor 70 arranged at a point close to the grounding element 2.

[0144] The system of the invention comprises a computer, not shown in the figures, configured for executing the method of the invention based on the current measurements performed by said current measuring equipment 50, 51, 52, 53, 54, 55, 60, 61, 62, 70.

[0145] The method of the invention would be applied in a manner similar to that explained for the first embodiment, with the main difference being the obligation to estimate the value of the ground resistance R_g since the cable 1 of the second embodiment comprises a single section P_1, and therefore, the model of the earth conductor ECC will comprise a single net.

[0146] The clauses that follow disclose additional embodiments or combinations of embodiments:

[0147] Clause 1. A method for locating a fault point (F) on a high-voltage three-phase AC cable (1) comprising a first end (10), a second end (11), and at least one section (P_1, P_2) extending between said ends (10, 11), the cable (1) comprising a conductor (R, S, T) and a respective shield (S_R, S_S,

S_T) per phase, shields (S_R, S_S, S_T) being connected to a surge arrester device (**3**, **4**) connected to ground (G) at one end of said at least one section (P_1, P_2), and shields (S_R, S_S, S_T) being connected to a grounding element (**2**) at the other end of said at least one section (P_1, P_2), the cable (**1**) comprising an earth continuity conductor (ECC) establishing a common ground (G) connecting the ground connections (**20**, **30**, **40**) of the grounding element(s) and the surge arrester device(s) (**3**, **4**), the method comprising the following steps:

[0148] measuring the conductor current (I_{R1}, I_{S1}, I_{T1}, I_{R2}, I_{S2}, I_{T2}) circulating through each conductor (R, S, T) both at the first end (**10**) and at the second end (**11**) of the cable (**1**),

[0149] measuring the shield current (I_{SR1}, I_{SS1}, I_{ST1}, I_{SR2}, I_{SS2}, I_{ST2}) circulating through each shield (S_R, S_S, S_T) in each section (P_1, P_2) at a point close to the grounding element,

[0150] measuring the earth continuity conductor current (I_{ECC1}, I_{ECC2}) circulating through each section (P_1, P_2) at a point close to the grounding element,

[0151] determining the conductor (R, S, T) in fault based on the previously measured conductor currents (I_{R1}, I_{S1}, I_{T1}, I_{R2}, I_{S2}, I_{T2}),

[0152] in the event that the cable (**1**) comprises more than one section (P_1, P_2), determining section (P_1, P_2) in fault based on the previously measured shield currents (I_{SR1}, I_{SS1}, I_{ST1}, I_{SR2}, I_{SS2}, I_{ST2}), and

[0153] locating the fault point (F) by means of a model of section (P_1, P_2) in fault of the earth continuity conductor (ECC), the only unknown being the distance (x) to the fault point (F) from an end of said section (P_1, P_2) in fault.

[0154] Clause 2. The method according to clause 1, wherein for determining the conductor (R, S, T) in fault, the conductor current (I_{R1}; I_{S1}; I_{T1}) measured at the first end (**10**) of the cable (**1**) for each conductor (R, S, T) is compared with the conductor current (I_{R2}; I_{S2}; I_{T2}) measured at the second end (**11**) of the cable (**1**), determining that the conductor (R, S, T) in fault will be the conductor in which the conductor current (I_{R1}, I_{R2}; I_{S1}, I_{S2}; I_{T1}, I_{T2}) at said ends (**10**, **11**) is different.

[0155] Clause 3. The method according to clause 1 or 2, wherein the cable (**1**) comprises at least two sections (P_1, P_2), section (P_1, P_2) in fault being determined taking into account that in said section in fault (P_1, P_2), one of the shield currents (I_{SR1}, I_{SS1}, I_{ST1}; I_{SR2}, I_{SS2}, I_{ST2}) will have an overcurrent value.

[0156] Clause 4. The method according to any of clauses 1 to 3, wherein the model of the earth continuity conductor (ECC) of section (P_1, P_2) in fault takes into account the self-resistance (R_{ECC}) and the self-inductance (L_{ECC}) of the earth continuity conductor (ECC), the ground resistance (R_g) of the ground connections (**20**, **30**, **40**) of the grounding elements and/or the surge arrester device(s) (**3**, **4**), the mutual inductance (M_R, M_S, M_T) between said earth continuity conductor (ECC) and each of the conductors (R, S, T), and the mutual inductance (M_{SR}, M_{SS}, M_{ST}) between said earth continuity conductor (ECC) and the shield in fault (S_R, S_S, S_T) from the fault point (F) to the point where the shields are connected to ground (G).

[0157] Clause 5. The method according to claim **4**, wherein the location of the fault point is calculated using the following formula:

$$0=I_{ECCF}(R_g+R_g+R_{ECC}+jwL_{ECC})-I_{ECCNFR}R_g-I_{ECCN-}$$
$$_{FR}R_g+jwxl_{CNF1}M_{CNF1}+jwxl_{CNF2}M_{CNF2}+$$
$$jwxl_{CF1}M_{CF}+jw(1-X)I_{CNF1}M_{CNF1}+jw(1-X)$$
$$I_{CNF2}M_{CNF2}-jw(1-X)I_{CF2}M_{CF}+jw(1-X)I_{SF}M_{SF}$$

wherein,

[0158] I_{ECCF}=The current circulating through the section of the earth continuity conductor (ECC) which is in fault,

[0159] I_{ECCNFL}=The current circulating through the section of the earth continuity conductor (ECC) to the left of the section in fault; in the event that there is no section to the left of the section in fault its value will be zero,

[0160] I_{ECCNFR}=The current circulating through the section of the earth continuity conductor (ECC) to the right of the section in fault; in the event that there is no section to the right of the section in fault its value will be zero,

[0161] R_g=The ground resistance of the grounding of the shields or of the grounding of the surge arrester device,

[0162] R_{ECC}=The self-resistance of the earth continuity conductor (ECC) of the section in fault, calculated taking into account the characteristics of the cable (**1**),

[0163] L_{ECC}=The self-inductance of the earth continuity conductor (ECC) of the section in fault, calculated taking into account the characteristics of the cable (**1**),

[0164] I_{CNF1}=Current circulating through a first conductor which is not in fault, both at the first end (**10**) of the cable (**1**) and at the second end (**11**) of the cable (**1**),

[0165] I_{CNF2}=Current circulating through a second conductor which is not in fault, both at the first end (**10**) of the cable (**1**) and at the second end (**11**) of the cable (**1**),

[0166] I_{CF1}=Current circulating through the conductor in fault at the first end (**10**) of the cable (**1**),

[0167] I_{CF2}=Current circulating through the conductor in fault at the second end (**11**) of the cable (**1**),

$$I_{CF1}{\neq}I_{CF2}$$

[0168] I_{SF}=Current circulating through the shield in fault in the section in fault; if the current flows from the first end to the second end, it will be considered positive; in contrast, if it flows from the second end to the first end, it will be considered negative,

[0169] M_{CNF1}=Mutual inductance between the first conductor which is not in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**),

[0170] M_{CNF2}=Mutual inductance between the second conductor which is not in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**),

[0171] M_{CF}=Mutual inductance between the conductor which is in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**),

[0172] M_{SF}=Mutual inductance between the shield which is in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**), and x=The distance to the fault point from the end of the section in fault at which the surge arrester device is arranged to the fault point (F).

[0173] Clause 6. The method according to clause 4 or 5, wherein when the cable (**1**) comprises more than one section (P_1, P_2), the ground resistance (R_g) of the ground connec-

tions (**20**, **30**, **40**) of the grounding elements and/or the surge arrester device(s) (**3**, **4**) is determined by means of a model of the earth continuity conductor (ECC) of one of the sections (P_1, P_2) which is not in fault, said model comprising the self-resistance (R_{ECC}) and the self-inductance (L_{ECC}) of the earth continuity conductor (ECC), the ground resistance (R_g) of the ground connections (**20**, **30**, **40**) of the grounding elements and/or the surge arrester device(s) (**3**, **4**), the mutual inductance (M_R, M_S, M_T) between said earth continuity conductor (ECC) and each of the conductors (R, S, T), the only unknown being said ground resistance (R).

[0174] Clause 7. The method according to claim **6**, wherein the ground resistance (R_g) is calculated using the following formula:

$$0 = I_{ECCNF}(R_g + R_g + R_{ECC} + jwL_{ECC}) - I_{ECCL}R_g - I_{ECCR}R_g + jwI_{CNF1}M_{CNF1} + jwI_{CNF2}M_{CNF2} + jwI_{CF}M_{CF}$$

wherein,

[0175] I_{ECCNF}=The current circulating through the section which is not in fault the model of which is used to calculate ground resistance (R_g),

[0176] I_{ECCL}=The current circulating through the section to the left of the section which is not in fault; in the event that there is no section to the left of the section which is not in fault, its value will be zero,

[0177] I_{ECCR}=The current circulating through the section to the right of the section which is not in fault; in the event that there is no section to the right of the section which is not in fault, its value will be zero,

[0178] R_g=The ground resistance of the grounding of the shields or of the grounding of the surge arrester device at one of the ends of the section in fault,

[0179] R_{ECC}=The self-resistance of the earth continuity conductor (ECC) of the section in fault, calculated taking into account the characteristics of the cable (**1**),

[0180] L_{ECC}=The self-inductance of the earth continuity conductor (ECC) of the section in fault, calculated taking into account the characteristics of the cable (**1**),

[0181] I_{CNF1}=Current circulating through a first conductor which is not in fault at the first end (**10**) of the cable (**1**),

[0182] I_{CNF2}=Current circulating through a second conductor which is not in fault at the first end (**10**) of the cable (**1**),

[0183] I_{CF}=Current circulating through the conductor in fault; if the current flows from the first end to the second end, it will be considered positive; in contrast, if it flows from the second end to the first end, it will be considered negative,

[0184] M_{CNF1}=Mutual inductance between the first conductor which is not in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**), M_{CNF2}=Mutual inductance between the second conductor which is not in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**), and M_{CF}=Mutual inductance between the conductor which is in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable **1**.

[0185] Clause 8. The method according to clause 4 or 5, wherein when the cable (**1**) comprises a single section (P_1) the ground resistance (R_g) of the ground connections (**20**, **30**) of the grounding element and the surge arrester device (**3**) is estimated.

[0186] Clause 9. A system for locating a fault point (F) on a high-voltage three-phase AC cable (**1**) comprising a first end (**10**) and a second end (**11**) and at least one section (P_1, P_2) extending between said ends (**10**, **11**), the cable (**1**) comprising a conductor (R, S, T) and a respective shield (S_R, S_S, S_T) per phase, shields (S_R, S_S, S_T) being connected to a surge arrester device (**3**, **4**) connected to ground (G) at one end of said at least one section (P_1, P_2) and shields (S_R, S_S, S_T) being connected to a grounding element at the other end of said at least one section (P_1, P_2), the cable (**1**) comprising an earth continuity conductor (ECC) establishing a common ground (G) connecting the ground connections (**20**, **30**, **40**) of the grounding element(s) (**2**) and the surge arrester device(s) (**3**, **4**), the system comprising:

[0187] a first current measuring equipment (**5**) configured for measuring the conductor current (I_{R1}, I_{S1}, I_{T1}, I_{R2}, I_{S2}, I_{T2}) circulating through each conductor (R, S, T) both at the first end (**10**) and at the second end (**11**) of the cable (**1**),

[0188] a second current measuring equipment (**6**) configured for measuring the shield current (I_{SR1}, I_{SS1}, I_{ST1}, I_{SR2}, I_{SS2}, I_{ST2},) of each shield (S_R, S_S, S_T) in each section (P_1, P_2) at a point close to the grounding element,

[0189] a third current measuring equipment (**7**) configured for measuring the earth continuity conductor current (I_{ECC1}, I_{ECC2}) of the earth continuity conductor (ECC) in each section (P_1, P_2) at a point close to the grounding element (**2**), and

[0190] a computer configured for executing the method according to any of clauses 1 to 8 based on the current measurements performed by said current measuring equipment (**5**, **6**, **7**).

What is claimed is:

1. A method for locating a fault point (F) on a high-voltage three-phase AC cable (**1**) comprising a first end (**10**), a second end (**11**), and at least one section (P_1, P_2) extending between the first and second ends (**10**, **11**), the cable (**1**) comprising first, second and third conductors (R, S, T) and respective first, second and third shields (S_R, S_S, S_T), the first, second and third shields (S_R, S_S, S_T) being connected to a surge arrester device (**3**, **4**) connected to ground (G) at one end of the at least one section (P_1, P_2), the first, second and third shields (S_R, 5S, S_T) being connected to a grounding element (**2**) at the other end of said at least one section (P_1, P_2), the cable (**1**) comprising an earth continuity conductor (ECC) establishing a common ground (G) connecting the ground connections (**20**, **30**, **40**) of the grounding element(s) and the surge arrester device(s) (**3**, **4**), the method comprising:

measuring the conductor current (I_{R1}, I_{S1}, I_{T1}, I_{R2}, I_{S2}, I_{T2}) circulating through each of the first, second and third conductors (R, S, T) both at the first end (**10**) and at the second end (**11**) of the cable (**1**);

measuring the shield current (I_{SR1}, I_{SS1}, I_{ST1}, I_{SR2}, I_{SS2}, I_{ST2}) circulating through each of the first, second and third shields (S_R, S_S, S_T) in each section (P_1, P_2) at a point close to the grounding element;

measuring the earth continuity conductor current (I_{ECC1}, I_{ECC2}) circulating through each section (P_1, P_2) at a point close to the grounding element;

determining a conductor (R, S, T) in fault based on the previously measured conductor currents (I_{R1}, I_{S1}, I_{T1}, I_{R2}, I_{S2}, I_{T2});

in the event that the cable (**1**) comprises more than one section (P$_1$, P$_2$), determining section (P$_1$, P$_2$) in fault based on the previously measured shield currents (I$_{SR1}$, I$_{SS1}$, I$_{ST1}$, I$_{SR2}$, I$_{SS2}$, I$_{ST2}$); and

locating the fault point (F) by means of a model of section (P$_1$, P$_2$) in fault of the earth continuity conductor (ECC), the only unknown being the distance (x) to the fault point (F) from an end of said section (P$_1$, P$_2$) in fault.

2. The method according to claim **1**, wherein for determining the conductor (R, S, T) in fault, the conductor current (I$_{R1}$; I$_{S1}$; I$_{T1}$) measured at the first end (**10**) of the cable (**1**) for each of the first, second and third conductors (R, S, T) is compared with the conductor current (I$_{R2}$; I$_{S2}$; I$_{T2}$) measured at the second end (**11**) of the cable (**1**), determining that the conductor (R, S, T) in fault being the conductor in which the conductor current (I$_R$, I$_{R2}$; I$_{S1}$, I$_{S2}$; I$_{T1}$, I$_{T2}$) at the ends (**10**, **11**) is different.

3. The method according to claim **1**, wherein the cable (**1**) comprises at least two sections (P$_1$, P$_2$), section (P$_1$, P$_2$) in fault being determined taking into account that in said section in fault (P$_1$, P$_2$), one of the shield currents (I$_{SR1}$, I$_{SS1}$, I$_{ST1}$; I$_{SR2}$, I$_{SS2}$, I$_{ST2}$) will have an overcurrent value.

4. The method according to claim **1**, wherein the model of the earth continuity conductor (ECC) of section (P$_1$, P$_2$) in fault takes into account the self-resistance (R$_{ECC}$) and the self-inductance (L$_E$CC) of the earth continuity conductor (ECC), the ground resistance (R$_g$) of the ground connections (**20**, **30**, **40**) of the grounding elements and/or the surge arrester device(s) (**3**, **4**), the mutual inductance (M$_R$, M$_S$, M$_T$) between said earth continuity conductor (ECC) and each of the first, second and third conductors (R, S, T), and the mutual inductance (M$_{SR}$, M$_{SS}$, M$_{ST}$) between said earth continuity conductor (ECC) and the shield in fault (S$_R$, S$_S$, S$_T$) from the fault point (F) to the point where the shields are connected to ground (G).

5. The method according to claim **4**, wherein the location of the fault point is calculated using the following formula:

$$0 = I_{ECCF}(R_g + R_g + R_{ECC} + jwL_{ECC}) - I_{ECCNFR}R_g - I_{ECCN-} \\ {}_{FR}R_g + jwxI_{CNF1}M_{CNF1} + jwxI_{CNF2}M_{CNF2} + \\ jwxI_{CF1}M_{CF} + jw(1-X)I_{CNF1}M_{CNF1} + jw(1-X) \\ I_{CNF2}M_{CNF2} - jw(1-X)I_{CF2}M_{CF} + jw(1-X)I_{SF}M_{SF}$$

wherein,

I$_{ECCF}$=The current circulating through the section of the earth continuity conductor (ECC) which is in fault,

I$_{ECCNFL}$=The current circulating through the section of the earth continuity conductor (ECC) to the left of the section in fault; in the event that there is no section to the left of the section in fault its value will be zero,

I$_{ECCNFR}$=The current circulating through the section of the earth continuity conductor (ECC) to the right of the section in fault; in the event that there is no section to the right of the section in fault its value will be zero,

R$_g$=The ground resistance of the grounding of the shields or of the grounding of the surge arrester device,

R$_{ECC}$=The self-resistance of the earth continuity conductor (ECC) of the section in fault, calculated taking into account the characteristics of the cable (**1**),

L$_{ECC}$=The self-inductance of the earth continuity conductor (ECC) of the section in fault, calculated taking into account the characteristics of the cable (**1**),

I$_{CNF1}$=Current circulating through a first conductor which is not in fault, both at the first end (**10**) of the cable (**1**) and at the second end (**11**) of the cable (**1**),

I$_{CNF2}$=Current circulating through a second conductor which is not in fault, both at the first end (**10**) of the cable (**1**) and at the second end (**11**) of the cable (**1**),

I$_{CF1}$=Current circulating through the conductor in fault at the first end (**10**) of the cable (**1**),

I$_{CF2}$=Current circulating through the conductor in fault at the second end (**11**) of the cable (**1**),

$I_{CF1} \neq I_{CF2}$

I$_{SF}$=Current circulating through the shield in fault in the section in fault; if the current flows from the first end to the second end, it will be considered positive; in contrast, if it flows from the second end to the first end, it will be considered negative,

M$_{CNF}$1=Mutual inductance between the first conductor which is not in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**),

M$_{CNF}$2=Mutual inductance between the second conductor which is not in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**),

M$_{CF}$=Mutual inductance between the conductor which is in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**),

M$_{SF}$=Mutual inductance between the shield which is in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**), and

x=The distance to the fault point from the end of the section in fault at which the surge arrester device is arranged to the fault point (F).

6. The method according to claim **4**, wherein when the cable (**1**) comprises more than one section (P$_1$, P$_2$), the ground resistance (R$_g$) of the ground connections (**20**, **30**, **40**) of the grounding elements and/or the surge arrester device(s) (**3**, **4**) is determined by means of a model of the earth continuity conductor (ECC) of one of the sections (P$_1$, P$_2$) which is not in fault, said model comprising the self-resistance (R$_{ECC}$) and the self-inductance (L$_E$CC) of the earth continuity conductor (ECC), the ground resistance (R$_g$) of the ground connections (**20**, **30**, **40**) of the grounding elements and/or the surge arrester device(s) (**3**, **4**), the mutual inductance (M$_R$, M$_S$, M$_T$) between said earth continuity conductor (ECC) and each of the conductors (R, S, T), the only unknown being said ground resistance (R$_g$).

7. The method according to claim **5**, wherein when the cable (**1**) comprises more than one section (P$_1$, P$_2$), the ground resistance (R$_g$) of the ground connections (**20**, **30**, **40**) of the grounding elements and/or the surge arrester device(s) (**3**, **4**) is determined by means of a model of the earth continuity conductor (ECC) of one of the sections (P$_1$, P$_2$) which is not in fault, said model comprising the self-resistance (R$_{ECC}$) and the self-inductance (L$_{ECC}$) of the earth continuity conductor (ECC), the ground resistance (R$_g$) of the ground connections (**20**, **30**, **40**) of the grounding elements and/or the surge arrester device(s) (**3**, **4**), the mutual inductance (M$_R$, M$_S$, M$_T$) between said earth continuity conductor (ECC) and each of the conductors (R, S, T), the only unknown being said ground resistance (R$_g$).

8. The method according to claim **6**, wherein the ground resistance (R_g) is calculated using the following formula:

$$0 = I_{ECCNF}(R_g + R_g + R_{ECC} + jwL_{ECC}) - I_{ECCL}R_g - I_{ECCR}R_g + jwI_{CNF1}M_{CNF1} + jwI_{CNF2}M_{CNF2} + jwI_{CF}M_{CF}$$

wherein,

I_{ECCNF}=The current circulating through the section which is not in fault the model of which is used to calculate ground resistance (R_g),

I_{ECCL}=The current circulating through the section to the left of the section which is not in fault; in the event that there is no section to the left of the section which is not in fault, its value will be zero,

I_{ECCR}=The current circulating through the section to the right of the section which is not in fault; in the event that there is no section to the right of the section which is not in fault, its value will be zero,

R_g=The ground resistance of the grounding of the shields or of the grounding of the surge arrester device at one of the ends of the section in fault,

R_{ECC}=The self-resistance of the earth continuity conductor (ECC) of the section in fault, calculated taking into account the characteristics of the cable (**1**),

L_{ECC}=The self-inductance of the earth continuity conductor (ECC) of the section in fault, calculated taking into account the characteristics of the cable (**1**),

I_{CNF1}=Current circulating through a first conductor which is not in fault at the first end (**10**) of the cable (**1**),

I_{CNF2}=Current circulating through a second conductor which is not in fault at the first end (**10**) of the cable (**1**),

I_{CF}=Current circulating through the conductor in fault; if the current flows from the first end to the second end, it will be considered positive; in contrast, if it flows from the second end to the first end, it will be considered negative,

M_{CNF1}=Mutual inductance between the first conductor which is not in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**),

M_{CNF2}=Mutual inductance between the second conductor which is not in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**), and

M_{CF}=Mutual inductance between the conductor which is in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable **1**.

9. The method according to claim **7**, wherein the ground resistance (R_g) is calculated using the following formula:

$$0 = I_{ECCNF}(R_g + R_g + R_{ECC} + jwL_{ECC}) - I_{ECCL}R_g - I_{ECCR}R_g + jwI_{CNF1}M_{CNF1} + jwI_{CNF2}M_{CNF2} + jwI_{CF}M_{CF}$$

wherein,

I_{ECCNF}=The current circulating through the section which is not in fault the model of which is used to calculate ground resistance (R_g),

I_{ECCL}=The current circulating through the section to the left of the section which is not in fault; in the event that there is no section to the left of the section which is not in fault, its value will be zero,

I_{ECCR}=The current circulating through the section to the right of the section which is not in fault; in the event that there is no section to the right of the section which is not in fault, its value will be zero,

R_g=The ground resistance of the grounding of the shields or of the grounding of the surge arrester device at one of the ends of the section in fault,

R_{ECC}=The self-resistance of the earth continuity conductor (ECC) of the section in fault, calculated taking into account the characteristics of the cable (**1**),

L_{ECC}=The self-inductance of the earth continuity conductor (ECC) of the section in fault, calculated taking into account the characteristics of the cable (**1**),

I_{CNF1}=Current circulating through a first conductor which is not in fault at the first end (**10**) of the cable (**1**),

I_{CNF2}=Current circulating through a second conductor which is not in fault at the first end (**10**) of the cable (**1**),

I_{CF}=Current circulating through the conductor in fault; if the current flows from the first end to the second end, it will be considered positive; in contrast, if it flows from the second end to the first end, it will be considered negative,

$M_{CNF}1$=Mutual inductance between the first conductor which is not in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**),

$M_{CNF}2$=Mutual inductance between the second conductor which is not in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable (**1**), and

M_{CF}=Mutual inductance between the conductor which is in fault and the earth continuity conductor (ECC), calculated taking into account the characteristics of the cable **1**.

10. The method according to claim **4**, wherein when the cable (**1**) comprises a single section (P_1) the ground resistance (R_g) of the ground connections (**20**, **30**) of the grounding element and the surge arrester device (**3**) is estimated.

11. The method according to claim **5**, wherein when the cable (**1**) comprises a single section (P_1) the ground resistance (R_g) of the ground connections (**20**, **30**) of the grounding element and the surge arrester device (**3**) is estimated.

12. A system for locating a fault point (F) on a high-voltage three-phase AC cable (**1**) comprising a first end (**10**) and a second end (**11**) and at least one section (P_1, P_2) extending between said ends (**10**, **11**), the cable (**1**) comprising first, second and third conductor (R, S, T) and respective first, second and third shield (S_R, S_S, S_T), the first, second and third shields (S_R, S_S, S_T) being connected to a surge arrester device (**3**, **4**) connected to ground (G) at one end of said at least one section (P_1, P_2) and the first, second and third shields (S_R, S_S, S_T) being connected to a grounding element at the other end of said at least one section (P_1, P_2), the cable (**1**) comprising an earth continuity conductor (ECC) establishing a common ground (G) connecting the ground connections (**20**, **30**, **40**) of the grounding element(s) (**2**) and the surge arrester device(s) (**3**, **4**), the system comprising:

first current measuring equipment (**5**) configured for measuring the conductor current (I_{R1}, I_{S1}, I_{T1}, I_{R2}, I_{S2}, I_{T2}) circulating through each of the first, second and third conductors (R, S, T) both at the first end (**10**) and at the second end (**11**) of the cable (**1**);

second current measuring equipment (**6**) configured for measuring the shield current (I_{SR1}, I_{SS1}, I_{ST1}, I_{SR2}, I_{SS2}, I_{ST2}) of each of the first, second and third shields (S_R, S_S, S_T) in each section (P_1, P_2) at a point close to the grounding element;

third current measuring equipment (**7**) configured for measuring the earth continuity conductor current (I_{ECC1}, I_{ECC2}) of the earth continuity conductor (ECC) in each section (P_1, P_2) at a point close to the grounding element (**2**); and

a computer configured for executing the method according to any of claims **1** to **11** based on the current measurements performed by said first, second and third current measuring equipment (**5**, **6**, **7**).

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