(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
9 January 2014 (09.01.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/006662 Al

(51) International Patent Classification:
G01R 31/12 (2006.01) *G01R 31/28* (2006.01)

(21) International Application Number:
PCT/JP2012/004398

(22) International Filing Date:
6 July 2012 (06.07.2012)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant *(for all designated States except US):* **MITSUBISHI HEAVY INDUSTRIES, LTD.** [JP/JP]; 16-5, Konan 2-chome, Minato-ku, Tokyo, 1088215 (JP).

(72) Inventor; and
(75) Inventor/Applicant *(for US only):* **BALDINI, Francesco** [IT/GB]; C/O Mitsubishi Power Systems Europe, Ltd., 20, North Audley Street, London, Greater London, W1K6WL (GB).

(74) Agent: SEISHIN IP PATENT FIRM, P. C ; Room 1003, Ambassador Roppongi Buildings, 16-13, Roppongi 3-chome, Minato-ku, Tokyo, 1060032 (JP).

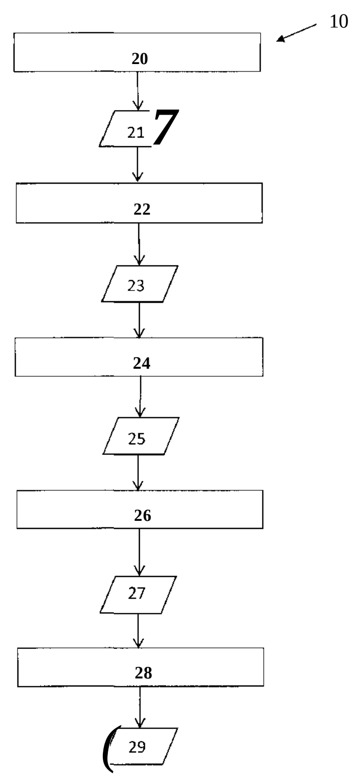
(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

[Continued on next page]

(54) Title: METHOD FOR DIAGNOSING AN ELECTRIC DEVICE

[Fig. 3]



(57) Abstract: The invention relates to a method for diagnosing an electric device, preferably a high-voltage device, comprising the steps of acquisition of measured values of operational parameters of the electric device to obtain a first set of data, which first set of data is analogue data, amplifying the first set of data and converting the amplified first set of data from analogue to digital to obtain a second set of data from the first set of data, filtering the second set of data by means of predetermined filtering processes to obtain a third set of data from the second set of data, processing the third set of data by means of at least one statistical algorithm to obtain a set of statistical features of the third set of data, these statistical features of the third set of data forming a fourth set of data, and applying a neural network processing step to the fourth set of data by utilizing a neural network in order to classify the fourth set of data so as to obtain a fifth set of data that characterizes an diagnostic status of the electric device.

WO 2014/006662 A1

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Description

Title of Invention: METHOD FOR DIAGNOSING AN ELECTRIC DEVICE

Technical Field

[0001] The invention relates to a method for diagnosing an electric device, preferably a high voltage device.

Background Art

[0002] The process of determining the diagnostic status of an electric device is a very crucial task. Typically, electric devices, especially high voltage devices, are prone to defects or failures which can severely influence the operation and the lifetime of the device. Usually, a severe damage is the result of smaller defects or failures leading to this damage. However, if these smaller, not quite so severe, defects go unnoticed very costly or ultimate failure of the electric devices can result.

An approach to avoid severe damages resulting from smaller defects is to determine the diagnostic status of an electric device which preferably comprises information of defects or failures of the electric device. One example of small defects or failures is partial discharges which affect the insulation in an electric device. Even though partial discharges are considered small defects, they can after a while lead to the failure of the entire insulation which can result in a very severe damage of the electric device. In order to detect small defects such as partial discharges extensive measurements are necessary which typically have to be carried out on particular components of the electric device so that diagnosing the electric device results in a down time in which the electric device cannot operate.

Concerning the example of partial discharges, detailed visual inspections are usually necessary to detect voids or cracks in the insulation of the electric device caused by the partial discharges. If the electric device is a motor or a generator, this kind of diagnosing method would usually result in a complete dewinding and rewinding of the coils of the generator or motor yielding extremely high costs, extensive inspection time and a long down-time of the generator or motor.

Online diagnose methods for electric devices which can assess the diagnostic status of an electric device during normal operation are known. However, the known methods do not render the same quality of the results of the diagnosis as it is usual for other methods which are not online, usually due to a very high noise level and the difficult and comprehensive processing of data.

Summary of Invention

[0003] It is an object of the present invention to provide an improved method for diagnosing an electric device, preferably a high-voltage device.

[0004] According to the present invention, the diagnosis method comprises the following steps: measured values of operational parameters of the electric device are acquired to obtain a first set of data, which first set of data is analogue data. The first set of data is amplified and the amplified first set of data is converted from analogue to digital to obtain a second set of data from the first set of data. The second set of data is filtered by means of predetermined filtering processes to obtain a third set of data from the second set of data. The third set of data is processed by means of at least one statistical algorithm to obtain a set of statistical features of the third set of data. These statistical features of the third set of data form a fourth set of data on which a neural network processing step is applied by utilizing a neural network in order to classify the fourth set of data so as to obtain a fifth set of data that characterizes a diagnostic status of the electric device. Preferably, the above described steps are performed consecutively in the above described order.

[0005] The term "electric device" refers to any device which produces electricity, is powered by electricity or conducts electricity. High voltage devices are electric devices which operate or function at high voltages or produce high voltages.

[0006] Diagnosing signifies the process of attempting to determine or identify a diagnostic status of the electric device. A diagnostic status of the electric device could be related to any kind of information of failures or defects of the electric device. Concerning a failure or a defect, the diagnostic status preferably comprises information about the severity, location, duration or any other kind of significant information of the failure or defect. In particular, the diagnostic status of the electric device may refer, for instance, to an aging status of insulation elements of the electric device.

[0007] The invention comprises the step of the acquisition of measured values of operational parameters of the electric device in order to obtain a first analogue set of data. An operational parameter is defined by characterizing the operation of the electric device. The acquisition is preferably achieved by measuring values of an operational parameter of the electric device over a certain period of time. In particular, an input to the electric device is provided. The response of the electric device to the provided input is measured by measuring the operational parameters of the electric device.

[0008] The first set of data is amplified and converted from analogue to digital to obtain a second set of data. The second set of data is filtered by means of predetermined filtering processes to obtain a third set of data from the second set of data. The filtering step can comprise analogue filtering processes as well as digital filtering processes. Digital filtering is preferably applied in order to delete parts of the second set of data which can be misleading for the further diagnosis process, especially for the classification of the fourth set of data. Concerning the digital filtering process, it is preferably ensured that a reference between the measured values of the operational parameters and the provided input to the electric device is determined. Further preferably, the filtering processes are conducted automatically. Preferably, the filtering processes comprise noise filtering, waveform superimposing or disturbance and interference suppression of abnormal signal waveforms.

[0009] The third set of data is processed by means of at least one statistical algorithm to obtain a set of statistical features of the third set of data. Preferably, each applied statistical algorithm renders one statistical feature providing specific information of the third set of data so that the obtained set of features, representing a fourth set of data, characterizes the third set of data.

[0010] A neural network processing step is applied to the fourth set of data in order to classify the fourth set of data so as to obtain a fifth set of data that characterizes a diagnostic status of the electric device. The fifth set of data can be a signal distribution, a signal pattern or any other kind of data. Classifying signifies assigning the fourth set of data to at least one of previously set classes. Each of these classes preferably represents a diagnostic status of the electric device so that after the classification step the diagnostic status of the electric device is determined. Preferably, the diagnostic status of the electric device comprises failures of the device so that the fifth set of data characterizes a classification of a type of failures of the electric device. By this way, corrective actions can be planned long before a severe damage to the electric device occurs, resulting in reduced unscheduled down-time of the electric device.

[0011] In a preferred embodiment, a neural network is established by training a learning algorithm on a set of test data prior to applying a neural network processing step on the fourth set of data. The establishment of the neural network is based on a data driven technique using test data for training. The test data preferably comprises a plurality of stored samples of data patterns characterizing diagnostic statuses of the electric device. More preferably, the test data comprises input data given to the neural network. This input data simulates various diagnostic statutes of the electric device. Furthermore, the test data includes the answer at which the network should arrive, i.e. resulting class to which the neural network processing step should classify the input data.

[0012] By feeding the network in this way, a learning algorithm of the neural network is forced to adapt by rebuilding its logical structures. The network will thus develop classification capabilities which go beyond the test data set. This capability, namely to classify unknown data which has not been part of the test data, is the generalization capability of the network and is one of the major advantages of neural networks, since it will almost never be possible to feed a network all possible patterns but only on a selection.

[0013] Concerning the amount of data in the test data, a compromise has to be found between a too small data set, not allowing a comprehensive leaning effect of the network, and a too big data set, having the risk of overfitting the neural network, i.e. that the network is overly specialized on the training set of data and loses its capability of generalizing. After establishing a neural network with the test set of data, the classification process does not only rely on comparing the actual set of data with the stored samples of data patterns but also on the generalization abilities of the network.

[0014] According to a further embodiment of the invention, the operational parameters of the electric device comprise an electric voltage. Further preferably, the input provided to the electric device is also a voltage. The response of the electric device to the input voltage in form of a voltage is measured. Preferably, the amplitude of the input voltage follows a repetitive time behavior so that the pattern of the input voltage is repeated every cycle, as it is the case in voltages with a sinus or square waveform. The measured values of the operational parameters comprise the response of the electric device to the input voltage. When filtering the measured processed values it is important to keep the reference phase between the input voltage and the values of the operational parameters in form of a voltage.

[0015] Preferably, the electric voltage is measured at electrical connection ports of the electric device. Typically, connection ports are weak links in an electric device, prone to effects such as partial discharges.

[0016] Further preferably, the values of the operational parameters of the electric device comprise portions of the electric voltage, said portions of the electric voltage resulting from partial discharges within the electric device and wherein the fifth set of data characterizes a classification of the diagnostic status of electric insulation elements of the electric device with respect to said partial discharges. The values of the operational parameter preferably comprise the input voltage applied to the electric device and the response of the electric device superimposed on the input voltage. The response of the electric device in particular results from partial discharge phenomena in the electric device. Usually, the partial discharges occur within electric insulation elements of the electric device and are defined as localized dielectric breakdowns of a small portion of an electrical insulation of the electric device. Partial discharges usually begin within voids, cracks or inclusions within an insulation element. Typically, partial discharge phenomena occur under high voltage stress. The amplitude of the partial discharge processes is usually much smaller than the amplitude of the input voltage. This makes the amplification of the first set of data very important. When applying an input voltage to the electric device, partial discharges are preferably triggered by this input voltage resulting in the portions of the measured electric voltage. The portions of the measured electric voltage comprise information about the partial discharges induced by the input voltage which is given to the electric device.

[0017] The fifth set of data obtained by the method of the invention preferably characterizes a classification of the diagnostic status of electric insulation elements of the electric device with respect to the partial discharges. Such a diagnostic status could comprise the location and the size of defects, such as voids or cracks, in the electric insulation elements. Further preferably, the fifth set of data is additionally postprocessed for evaluation in order to obtain final diagnostic data from it. Such diagnostic data can comprise information about the general aging status of the insulation elements of the electric device or information about an actual approximation of a residual lifetime of at least parts of the electric device, preferably the insulation elements of the electric device. This information can be extremely important for maintenance. Estimating the residual lifetime of parts of the electric device, in particular the insulation elements, by means of the present diagnosing method eliminates the need for opening electric devices and inspecting them visually or by means of any other more complicated and elaborate diagnosis method.

[0018] Preferably, the portions of the electric voltage are extracted from the measured electric voltage by means of averaging the measured voltage and superimposing a compensating voltage pattern. Typically, the input voltage is applied to the electric device for a certain number of cycles of the input voltage. Consequently, the measured voltage displays the same time behavior as the input voltage for the same number of cycles. Even though all of the cycles of the input voltage have the exact same shape of amplitude, the response of the electric device to the input voltage in form of portions of the electric voltage resulting from partial discharge processes will never be exactly the same. As a consequence, an average distribution of the cycles of the data is calculated which displays for every phase the averaged measured value. This average distribution represents the averaged measured values of the operational parameter of the electric device over one phase cycle. Preferably, the average distribution is an average voltage distribution of the averaged measured electric voltage of the electric device over one cycle. The resulting average distribution is representative for the electric device for the certain period of time in which the measurement took place. In particular, the average distribution is representative for the partial discharges occurring in the electric device so that it corresponds to a partial discharge pulse pattern. In order to extract the information about the partial discharges from the input voltage serving as a trigger for the partial discharge processes and as a carrier voltage, a compensating voltage pattern is superimposed with the measured electric voltage. Compensating signifies that the compensating voltage pattern displays the reverse pattern of the input voltage. After superimposing these two voltages with mutually reverse patterns the resulting voltage at every degree equals zero. However, the portions of the electric voltage resulting from the partial discharges are not cancelled out and are therefore extracted as a characteristic distribution formed by a pulse pattern.

[0019] According to a further embodiment, the averaging step is performed on the third set of data. Further preferably, the average distribution is normalized, i.e. each value is divided by the maximum absolute value recorded for the corresponding distribution. In such a way, a normalized average distribution is obtained which is related to the type of failures to be classified.

[0020] According to another preferred embodiment of the invention, an average distribution of the third set of data is transformed into an Rn vector so as to perform phase analysis, amplitude analysis or repetition rate analysis. A statistical estimator is a mathematical operator which is applied to data, typically in the form of distributions, in order to extract specific information. In particular, the set of statistical estimators comprises Kurtosis, Skewness, Cross Correlation, Asymmetry, Weibull Alpha or Weibull Beta operators. Each statistical estimator renders at least one statistical feature which describes features of the third set of data, especially the distribution of the third set of data. By applying a number of statistical estimators to the third set of data a set of statistical features is obtained. This set of statistical features characterizes the third set of data. Most preferably, the set of statistical features represents a fingerprint of the third set of data.

[0021] In a further preferred embodiment, the statistical estimators to be applied to the third set of data are customized to the electrical device by selecting them according to characteristics of the electric device. Preferably, the statistical estimators are adapted in order to fit the specific electric device. Customizing the set of statistical estimators as well as the statistical estimators to the specific electric device is very crucial since only after this step all of the necessary and desired information can be extracted from the measured values of operational operators. Selecting the right kind of statistical estimators greatly improves the ability of the diagnosis method to discriminate between different distributions of the third set of data. Since the set of statistical features obtained by the application of the selected statistical estimators is fed into the neutral network for classification, selecting suitable estimators greatly improves the classification step of the neural network. Preferably, various extensive measurements are conducted to characterize the electric device in great detail. These characteristics of the electric device as well as the kind of information which is desired to be extracted by the diagnosis method determine the selection of the statistical estimators. By applying this customization step, the method is not only able to generally classify diagnostic statuses of the electric device which would render only very rough and not sufficiently detailed information. In contrast, by customizing the statistical estimators the method is able to provide detailed, specific and reliable information about the diagnostic status of the electric device. The quality and reliability of the resulting diagnostic statuses equal those achieved by visual inspection methods but with much less effort and related costs.

[0022] In a further embodiment, each piece of data in the set of statistical features forming the fourth set of data shows a specific type of failure and/or a specific approximation of the residual lifetime of the electric device. This is related to the fact that each piece of data of the fourth set of data originates from one statistical estimator rendering specific information. Further preferably, selecting suitable statistical estimators renders a fourth set of data which includes all of the necessary and desired information about the diagnostic status of the electric device.

[0023] According to another preferred embodiment of the invention, each piece of data in the set of statistical features forming the fourth set of data is analyzed by means of the neural network. This neural network concludes a diagnosis of the specific type of failures and/or the specific approximation of a residual lifetime of the electric device. Preferably, the neural network yields information about defects in the insulation elements of the electric device. By the classification step of the normal network, the defects in the insulation elements can be exactly determined, such as their size and their location.

[0024] Preferably, the diagnosis concluded by the neural network is performed after an appropriate amount of data sets is collected under real operation conditions of the electric device. This amount of data sets is typically employed to characterize the specific electric device and then select and adapt suitable statistical estimators for processing the third set of data.

[0025] In another preferred embodiment of the invention, the diagnosis is performed in intervals to determine a countermeasure of the specific type of failures recognized. These time intervals can be chosen according to maintenance schedules or due to conclusions from previous diagnostic statuses of the electric device. By regularly employing the above method, a diagnostic status of the electric device can be monitored and the change of the diagnostic status can be determined so that a countermeasure and the appropriate time frame for applying the countermeasure can be determined. A countermeasure can be any corrective or predictive measure to influence the diagnostic status of the electric device. In the preferable case that the diagnoses aims to determine defects of insulation elements of an electric device or the aging status of the insulation elements, an appropriate time frame for replacing the insulation elements as a countermeasure can be concluded.

[0026] According to a further embodiment of the invention, the method of the invention is applied to an electric device which is a component of a wind turbine generator. Such electrical devices preferably comprise generators, transformers or high voltage cables. Especially concerning off-shore wind turbine generators, the method of the invention enables a remote diagnosis of the diagnostic status of the electric devices in the wind turbine. As a consequence, less down-town time of a wind turbine generator results due to severe failures of insulation elements of electric devices in the wind turbine generator. The monitoring and the maintenance of the electric devices can be achieved substantially more cost and time effective.

Brief Description of Drawings

[0027] The invention will be described below with reference to the following schematic figures:

[fig. 1]Figure 1 is a cross sectional view of an insulation element.

[fig.2]Figure 2 is a measured voltage on an electric device.

[fig.3]Figure 3 is a flow chart of a method according to the invention.

Description of Embodiments

[0028] Figure 1 shows a cross-sectional view of an insulation element 11 which is located between two conductors 12, 13. Within the insulating material 14 of the insulation element 11 voids 15, 16 are formed. Voids are hollow spaces within the insulating material which are filled with gas. The dielectric constant of the voids 15, 16 is considerably less than the dielectric constant of the surrounding insulating material 14. This fact results in electric fields across the voids 15, 16 which are essentially higher than along an equally great distance within the insulating material 14. If the voltage across a void 15, 16 exceeds the electric breakdown voltage level for the gas within the void, a partial discharge process will occur which bridges a part of the insulation element 11. Once begun, partial discharges can affect the insulation elements severely by progressively deteriorating the insulating material 14 electrically and physically. The effect of partial discharges usually cumulates so that conducting discharge channels are formed. This process typically results ultimately in the electrical breakdown of the entire insulation element 11 which in turn can lead to a complete failure or destruction of the electric device.

[0029] In figure 2 values of a measured electric voltage 17 are shown. In figure 2 these measured values of the measured electric voltage 17 form a pulse pattern over two phase cycles 19. Typically, the acquisition of data comprises hundreds of cycles. As it can be seen in figure 2, the measured electric voltage 17 is composed of a sine voltage pattern 17a, which has been applied to the electric device to trigger partial discharge processes, and portions 17b of the electric voltage 17 which result from partial discharges within insulation elements of the electric device. The amplitudes 18b of these portions 17b of the electric voltage 17 are typically significantly smaller than the amplitudes 18a of the sine voltage pattern 17a.

[0030] Figure 3 shows a flow chart of a method 10 according to the present invention.

Preferably, the displayed steps of the flow chart are conducted consecutively from the upper end of the flow chart towards its lower end. The first step 20 comprises the acquisition of measured values of operational parameters of the electric device for obtaining an analogue first set of data 21. In the second step 22 the first set of data 21 is amplified and converted from analogue to digital to obtain a second set of data 23. In the third step 24 the second set of data 23 is filtered by means of predetermined filtering processes so that a third set of data 25 from the second set of data 23 is obtained. The third set of data 25 is processed in a fourth step 26 by applying at least one statistical algorithm for obtaining a set of statistical features which from a fourth set of data 27. A neural network processing step is applied in a fifth step 28 to the fourth set of data 27 by utilizing a neural network in order to classify the fourth set of data 27. In this way, a fifth set of data 29 is obtained characterizing a diagnostic status of the electric device.

Claims

[Claim 1] A method for diagnosing an electric device, preferably a high-voltage device, comprising the steps of
a) acquiring measured values of operational parameters of the electric device to obtain a first set of data, said first set of data is analogue data,
b) amplifying the first set of data and converting the amplified first set of data from analogue to digital to obtain a second set of data from the first set of data,
c) filtering the second set of data by means of predetermined filtering processes to obtain a third set of data from the second set of data,
d) processing the third set of data by means of at least one statistical algorithm to obtain a set of statistical features of the third set of data, said statistical features of the third set of data forming a fourth set of data, and
e) applying a neural network processing step to the fourth set of data by utilizing a neural network in order to classify the fourth set of data so as to obtain a fifth set of data that characterizes a diagnostic status of the electric device.

[Claim 2] The method according to claim 1,
wherein prior to step e) a neural network is established by training a learning algorithm on a set of test data.

[Claim 3] The method according to claim 1,
wherein the operational parameters of the electric device comprise an electric voltage.

[Claim 4] The method according to claim 3,
wherein the electric voltage is measured at electrical connection ports of the electric device.

[Claim 5] The method according to claim 2,
wherein the test data comprises a plurality of stored samples of data patterns characterizing diagnostic statuses of the electric device.

[Claim 6] The method according to claim 1,
wherein the fifth set of data characterizes a classification of a type of failures of the electric device.

[Claim 7] The method according to claim 3,
wherein the measured values of the operational parameters of the electric device comprise portions of the electric voltage, said portions of the electric voltage resulting from partial discharges within the

electric device, wherein the fifth set of data characterizes a classification of the status of electric insulation elements of the electric device with respect to said partial discharges.

[Claim 8] The method according to claim 7, wherein the portions of the electric voltage are extracted from the measured electric voltage by means of averaging the measured voltage and superimposing a compensating voltage pattern.

[Claim 9] The method according to claim 7, wherein the partial discharges occur within said electric insulation elements of the electric device.

[Claim 10] The method according to claim 7, comprising an additional step of postprocessing for evaluation of the fifth set of data so as to obtain final diagnostic data from the fifth set of data, preferably aging status information of the insulation elements of the electric device or information about an actual approximation of a residual lifetime of at least parts of the electric device.

[Claim 11] The method according to claim 1, wherein an average distribution of the third set of data is transformed by means of the statistical estimators into an Rn vector so as to perform phase analysis, amplitude analysis or repetition rate analysis.

[Claim 12] The method according to claim 11, wherein a set of statistical estimators comprises Kurtosis, Skewness, Cross Correlation, Asymmetry, Weibull Alpha or Weibull Beta operators.

[Claim 13] The method according to claim 11, wherein the statistical estimators to be applied are customized to the electrical device by selecting them according to characteristics of the electric device.

[Claim 14] The method according to claim 7, wherein processing of the third set of data results in a normalized average distribution related to the type of failures to be classified.

[Claim 15] The method according to claim 12, wherein each piece of data in the set of statistical features forming the fourth set of data shows a specific type of failures and/or a specific approximation of the residual lifetime of the electric device.

[Claim 16] The method according to claim 1, wherein each piece of data in the set of statistical features forming the fourth set of data is analyzed by means of the neural network which concludes a diagnosis of the specific type of failures and/or the specific approximation of a residual lifetime of the electric device.

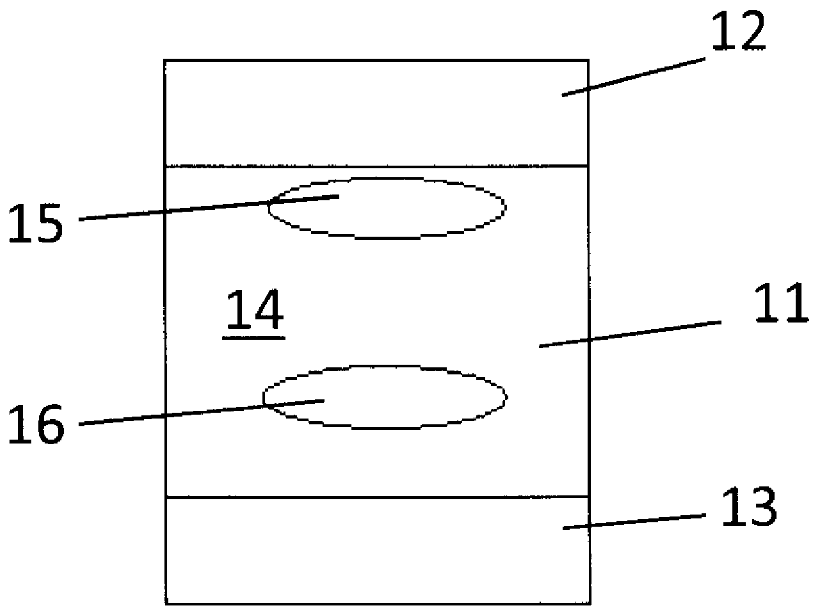
[Claim 17] The method according to claim 16,
wherein the diagnosis is performed after an appropriate amount of data sets is collected under real operation conditions of the electric device.

[Claim 18] The method according to claim 16,
wherein the diagnosis is performed in intervals to determine a countermeasure of the specific type of failures recognized.

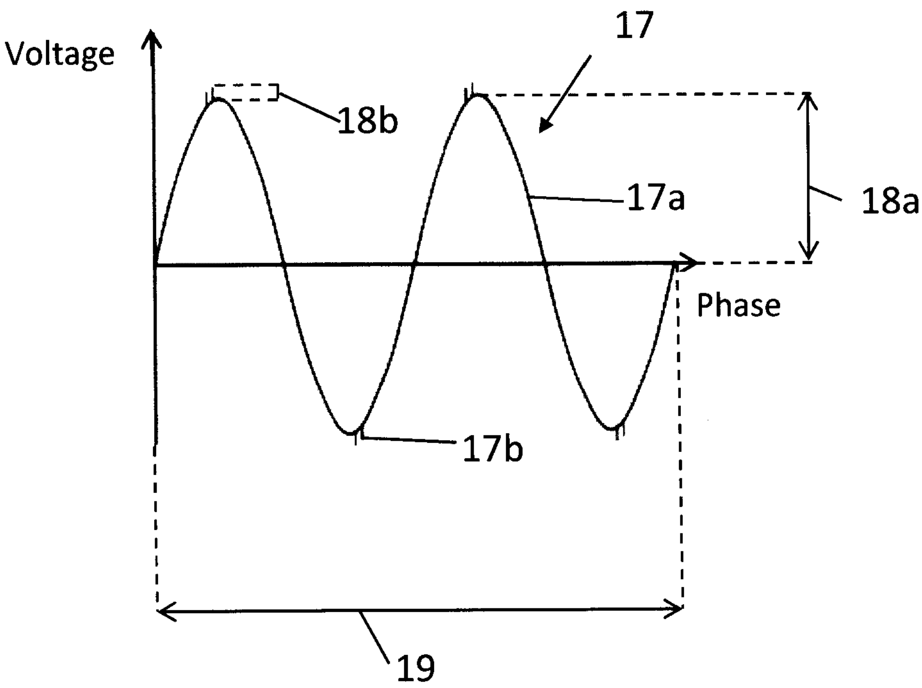
[Claim 19] The method according to claim 1,
wherein the filtering processes comprise noise filtering, waveform superimposing or disturbance and interference suppression of abnormal signal waveforms.

[Claim 20] The method according to claim 1,
wherein the method is applied to an electric device, such as a generator, a transformer or a high voltage cable, said electric device preferably being a component of a wind turbine.

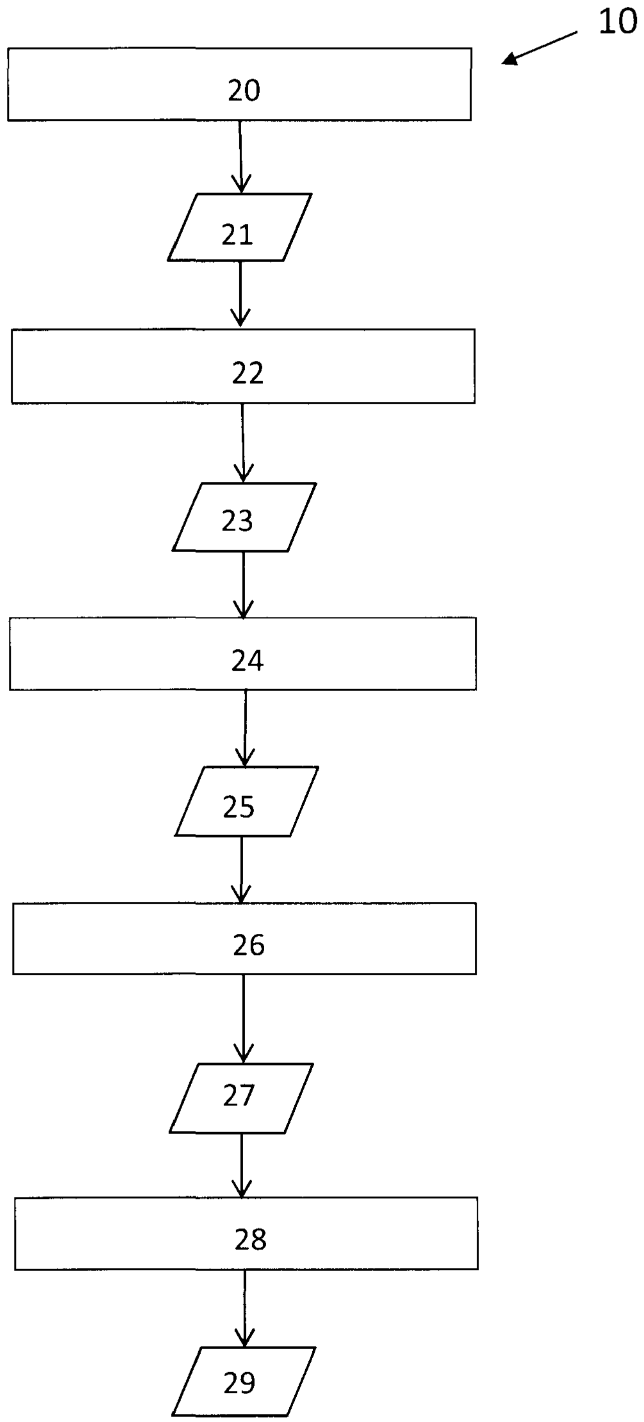
[Fig. 1]



[Fig. 2]



[Fig. 3]



INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2012/004398

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01R31/12 G01R31/28
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/177420 A1 (FOURNIER DANIEL [CA] ET AL) 9 July 2009 (2009-07-09) paragraphs [0060], [0085], [0098], [0110], [0114], [0134], [0144], [0148] abstract; figures 11,12 -----	1-20
X	IBRAHIM Y SHURRAB ET AL: "Partial discharge on-line monitoring of outdoor insulators", ELECTRICAL INSULATION (ISEI), CONFERENCE RECORD OF THE 2012 IEEE INTERNATIONAL SYMPOSIUM ON, IEEE, 10 June 2012 (2012-06-10), pages 391-394, XP032211442, DOI: 10.1109/ELINSL.2012.6251496 ISBN: 978-1-4673-0488-7 the whole document -----	1-20

-/- ·

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" documentwhich may throw doubts on priority claim(s) orwhich is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 March 2013	20/03/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Dogueri , Ali Kerem

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	TAO HONG ET AL: "Detection and Classification of Partial Discharge Using a Feature Decomposition-Based Modular Neural Network", IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 50, no. 5, 1 October 2001 (2001-10-01), XP011025365, ISSN: 0018-9456 the whole document -----	1-20
A	KRANZ H-G: "DIAGNOSIS OF PARTIAL DISCHARGE SIGNALS USING NEURAL NETWORKS AND MINIMUM DISTANCE CLASSIFICATION", IEEE TRANSACTIONS ON ELECTRICAL INSULATION, 31968 1, vol. 28, no. 6, 1 December 1993 (1993-12-01), pages 1016-1024, XP002073089, D0I: 10.1109/14.249375 the whole document -----	1-20

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/JP2012/004398

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009177420 Al	09-07-2009	AT 527548 T	15-10-2011
		CA 2508428 Al	20-11-2006
		EP 1883829 Al	06-02-2008
		ES 2372021 T3	13-01-2012
		JP 2008541099 A	20-11-2008
		US 2009177420 Al	09-07-2009
		WO 2006122415 Al	23-11-2006