(19) DANMARK

(10) DK/EP 1754887 T3

(12) Oversættelse af europæisk patentskrift

Patent- og Varemærkestyrelsen

(51) Int.Cl.: *F 03 D 11/00 (2006.01)*

(45) Oversættelsen bekendtgjort den: **2016-01-11**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2015-10-21**

(86) Europæisk ansøgning nr.: **05107571.1**

(86) Europæisk indleveringsdag: **2005-08-17**

(87) Den europæiske ansøgnings publiceringsdag: **2007-02-21**

(84) Designerede stater: **DE DK ES**

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(54) Benævnelse: **Indretning til at detektere lynnedslagsskade på en vindmøllevinge**

(56) Fremdragne publikationer:
WO-A-2004/111686
WO-A-2005/068834
DE-A1- 10 065 314
DE-A1- 10 259 680
DE-U1-202004 001 090
US-A- 4 026 660
US-A1- 2004 130 842

DESCRIPTION

Field of the Invention

[0001] The present invention relates to a device for detecting damage of a rotor blade of a wind energy turbine due to a lightning strike which has hit the rotor blade.

Related Prior Art

[0002] Lightning protection of the rotor blades of a wind energy turbine is basically known. Such a protection system comprises a conductor extending through and/or along the rotor blade for conducting to ground the current generated in case of a lightning strike hitting the rotor blade. Nowadays lightning protection systems for wind energy turbine rotor blades do not monitor whether or hot a rotor blade has been damaged by a lightning strike. However, the aerodynamic properties of the rotor blade can be affected by damages. This in turn means that the wind energy turbine might be less efficient. Also the lifetime of the rotor blade can be shortened due to lightning strikes, which is an effect that also cannot be monitored by the known systems.

[0003] From WO-A-2004/111686 it is known to register lightning strikes in a wind turbine. A rotor blade of the wind turbine is provided with resistors heated when the blade is hit by a lightning strike. In DE-A-102 59 680 a rotor blade is disclosed having an electrical conductor which changes its resistance when bent. Accordingly, the degree of bending the rotor blade due to wind forces acting on the blade can be measured. Also in DE-A-100 65 314 a similar system for detecting wind loads in a rotor blade of a wind turbine is described. Finally, DE-U-20 2004 001 090 discloses a detector for detecting cracks in a rotor blade using a gas.

[0004] WO-A-01/33234 discloses a detection and recording system for high intensity electric currents such as lightning currents in a lightning conductor in a wind turbine. The known system comprises a detector containing a power supply, a measuring circuit, and a converter means. The measuring circuit is inductively coupled to the lightning conductor through a measuring coil. The converter means of the conductor is non-galvanically coupled to a recording means such as a computer. The power supply receives its electrical energy directly from the lighting current flowing through the lightning conductor which is inductively coupled to the power supply through a power coil which makes the known system non-sensitive to mains supply drop-outs.

[0005] Accordingly, there is a need for a system that makes it possible to estimate lifetime and behaviour of the components of a wind energy turbine.

SUMMARY OF THE INVENTION

[0006] The present invention provides a device and method for detecting damage of a wind energy turbine rotor blade or other parts of a wind energy turbine due to a lightning strike, comprising the features of claims 1 and 4, respectively. Moreover, the present invention provides the use of several magnetic and/or electric field sensors distributed along the length of a rotor blade of a wind energy turbine for detecting damage of the wind energy turbine. The dependent claims relate to individual embodiments of the invention.

[0007] According to the invention, several magnetic and/or electric field sensors (hereinbelow referred to as field sensors) are embedded in a rotor blade of a wind energy turbine. By these field sensors the magnetic and/or electric field concentration (hereinbelow referred to as field concentration) along the extension of the rotor blade can be measured on the basis of variations of the field concentration compared to the field concentration of an undamaged rotor blade, and damage of the rotor blade due to a lightning strike (i.e. delamination of and/or holes in the composite material of the rotor blade or other components of a wind energy turbine like the hub, the nacelle or its housing) can be calculated in an evaluation unit connected to the field sensors for receiving the measurement signals thereof. Further, a ground current sensor can be provided which is also connected to the evaluation unit. Finally, by applying an analytic model of the lightning behaviour of the rotor blade and/or of other parts and/or of the whole wind energy turbine, the type and extent of the damage due to a lightning strike can be calculated. This all gives one the possibility to establish a wind energy turbine lightning lifetime meter to reach a deeper understanding of the lightning protection behaviour of the wind energy turbine. The output of such an advanced lightning detection system could be integrated in the data warehouse of past lightning failure analyses, and an advanced maintenance strategy for the wind energy turbine, in particular for an offshore wind energy turbine application, could be developed.

[0008] In a preferred embodiment of the present invention, the field concentration sensors are ferromagnetic loop-wires embedded in the shell of a rotor blade. These sensors can be connected via fiber wires to be lightning resistant. An antenna or several antennas can be also arranged in the rotor blade. This antenna is the ground conductor for conducting the lightning current to ground.

BRIEF DESCRIPTION OF THE DRAWING

[0009] The present invention will be described in more detail referring to the drawing which schematically shows the main components of the lightning detection system according to the invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

[0010] A lightning life meter according to the invention consists of sensors e. g. sensors embedded in the composite material of a rotor blade, integrated current probes in the sensitive data wires, online measurement of field concentration along the rotor blade and, if desirable, in the electronic parts of a wind energy turbine, and ground current measurement, together with an analytic model of the lightning behaviour of the components of a wind energy turbine and, in particular, of its rotor blades. The lightning life meter comprises a lightning detection system measuring the current range and time stamp of a lightning strike. Such a measurement system may comprise an antenna on the tower and/or magnetic cards in the blades. With such a wind energy turbine lightning life meter a better understanding of the lightning protection behaviour of the wind energy turbine is possible. The output of such an advanced lightning detection system could be integrated in the data warehouse for over lifetime lightning failure analysis and an advanced maintenance strategy particularly for offshore applications could be developed.

[0011] As schematically shown in the drawing, the lightning detection device 10 comprises several loop-wire like magnetic field concentration sensors 12 distributed along the extension of a rotor blade 14 in its shell. A conductor 16 extends through the rotor blade 14 and the ground current conducted by the conductor 16 in case a lightning strike is measured by a sensor 18. The magnetic field concentration sensors 12 as well as the ground current sensor 18 are connected to an evaluation unit 20. Based on the measured magnetic field concentration along the length of the rotor blade 14 and the ground current, the level and extent of a damage of the rotor blade resulting from a lightning strike can be calculated. Together with an analytic model of the lightning behaviour of the wind energy turbine, a lightning lifetime meter can be established.

[0012] Although the invention has been described and illustrated with reference to specific illustrative embodiments thereof, it is not intended that the invention be limited to those illustrative embodiments. Those skilled in the art will recognise that variations and modifications can be made without departing from the true scope of the invention as defined by the claims that follow. It is therefore intended to include within the invention all such variations and modifications as fall within the scope of the appended claims.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO2004111686A **[0003]**
- DE10259680A **[0003]**
- DE10065314A **[0003]**
- DE202004001090U **[0003]**
- WO0133234A **[0004]**

Patentkrav

1. Indretning til at detektere skade af en vindmølle og, i særdeleshed, af en vindmøllerotorvinge, på grund af et lynnedslag, **kendetegnet ved at** omfatte

- flere magnetiske og/eller elektriske feltsensorer (12) fordelt langs længden af en rotorvinge (14) af vindmøllen til at måle den magnetiske og/eller elektriske feltkoncentration langs rotorvingen (14), og
- en evalueringsenhed (20) forbundet til de magnetiske og/eller elektriske feltsensorer (12) til at modtage de målte signaler deraf,
- hvor evalueringsenheden (20) er konfigureret til at beregne skade af vindmøllen og, i særdeleshed, af rotorvingen (14) forårsaget af et lynnedslag baseret på den målte koncentration af det magnetiske og/eller elektriske felt langs længden af rotorvingen (14) og den magnetiske og/eller elektriske feltkoncentration af en uskadt rotorvinge (14).

2. Indretning ifølge krav 1, hvor med evalueringsenheden (20), baseret på den målte koncentration af det magnetiske og/eller elektriske felt langs længden af rotorvingen (14) og en analytisk model af lynopførslen af vindmøllen og dens komponenter, typen, niveauet og/eller omfanget af en skade af rotorvingen (14) og/eller komponenterne af vindmøllen forårsaget af et lynnedslag beregnes.

3. Indretning ifølge krav 1 eller 2, yderligere **kendetegnet ved** en sensor (18) til at detektere jordstrømmen og forbundet til evalueringsenheden (20), hvor evalueringsenheden (20) er konfigureret til at beregne skade og, hvis tilvejebragt, type, niveau og/eller omfang af en skade af rotorvingen (14) og/eller komponenterne af vindmøllen forårsaget af et lynnedslag.

4. Fremgangsmåde til at detektere skade af en vindmølle og, i særdeleshed, af en vindmøllerotorvinge, på grund af et lynnedslag, omfattende trinnene

- at tilvejebringe en rotorvinge (14) af vindmøllen med flere magnetiske og/eller elektriske feltsensorer (12) fordelt langs længden af rotorvingen (14),
- at beregne skade af vindmøllen og, i særdeleshed, af rotorvingen (14) forårsaget af et lynnedslag baseret på feltkoncentrationen af en skadet rotorvinge (14) og den magnetiske og/eller elektriske feltkoncentration af

en uskadt rotorvinge (14) målt af sensorerne (12) som reaktion på et lynnedslag.

5. Fremgangsmåde ifølge krav 4, hvor med evalueringsenheden (20), baseret på den målte koncentration af det magnetiske og/eller elektriske felt langs længden af rotorvingen (14) og en analytisk model af lynopførslen af vindmøllen og dens komponenter, typen, niveauet og/eller omfanget af en skade af rotorvingen (14) og/eller komponenterne af vindmøllen forårsaget af et lynnedslag beregnes.

6. Fremgangsmåde ifølge krav 4 eller 5, yderligere omfattende at detektere en jordstrøm ved hjælp af en strømsensor, hvor den målte jordstrøm fødes ind i evalueringsenheden (20) til beregning af skade og, hvis tilvejebragt, type, niveau og/eller omfang af en skade af rotorvingen (14) og/eller komponenterne af vindmøllen forårsaget af et lynnedslag.

7. Anvendelse af flere magnetiske og/eller elektriske feltsensorer (12) fordelt langs længden af en rotorvinge (14) af en vindmølle til at detektere skade af vindmøllen og, i særdeleshed, af vindmøllerotorvingen, på grund af et lynnedslag, hvor den magnetiske og/eller elektriske feltkoncentration langs rotorvingen (14) måles og skade af vindmøllen og, i særdeleshed af rotorvingen (14) forårsaget af et lynnedslag bestemmes baseret på den målte koncentration af den magnetiske og/eller elektriske feltkoncentration langs længden af rotorvingen (14) og den magnetiske og/eller elektriske feltkoncentration af en uskadt rotorvinge (14).

DRAWINGS