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CONTROL DEVICE FOR A WIND ENERGY ASSEMBLY AND METHOD FOR OPERATING A WIND  
ENERGY ASSEMBLY

Description

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[0001] The invention relates to a control apparatus for a wind power installation and a method for operating a wind power installation and a corresponding computer program product.

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[0002] Wind energy assemblies are known from the prior art. They usually comprise a rotor, which is rotatably disposed about a substantially horizontal axis on a gondola, wherein the gondola is rotatably disposed about a vertical axis on a tower. The rotor usually comprises rotor blades which are adjustable with respect to the pitch of the rotor blade and, if applicable, drives a generator via a rotor shaft and a gearbox. A wind-induced rotational movement of the rotor can thus be converted into electrical energy, which then can then be fed into an electricity grid via inverters and/or transformers – depending upon the design of the generator at least partly directly. A controller is provided for controlling the various components of a wind power installation, which, on the basis of measurement values obtained directly at the wind power installation or determined externally and control specifications, e.g., by means of the grid operator, controls the wind power installation.

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[0003] Due to the considerable height of wind power installation towers and large rotor blade lengths, in bright sunshine there can be significant optical impairments in the form of periodic shadows being cast due to the rotating rotor blades, even away from the wind power installation. Corresponding shadow-casting, in particular in residential development is undesirable and frequently prohibited by pollution legislation.

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[0004] It is therefore known in the prior art to interrupt the operation of a wind power installation and stop the rotor, when a periodic shadow-casting is determined or to be expected at previously defined immission points, e.g., in residential areas or the like. To this end shutdown devices are known, in which initially general periods of time are stored, during which fundamentally the risk of inadmissible shadow-casting on immission points exists. To this end, those times are computed from the position of the wind power installation and the location of the predefined immission points on the basis of the annual and daily course of the sun, at which shadow-casting on the immission points can fundamentally occur when the sun is shining. Via one or more light sensors disposed at the wind power installation a check is performed during

the periods of time in question as to whether a direct sunlight on the wind power installation causing a relevant shadow-casting is present or whether diffuse lighting conditions, e.g., due to clouding, are present, which do not produce a shadow-casting requiring a shutdown of the wind power installation.

5 [0005] As a rule, the described automatic shutdown device is designed as an external component, which is directly connected or connected via a communications bus to the controller of the wind power installation. This external component uses periods of time stored therein and sensors disposed thereon or connected thereto to determine whether a shadow-casting requiring the shutdown of the wind power installation is present. If this is the case, an  
10 appropriate signal is transmitted to the controller of the wind power installation, which subsequently shuts down the wind power installation, until the signal is received from the external component, that e.g., due to the movement of the sun no more inadmissible shadow-casting is to be expected.

[0006] The function of the automatic shutdown device and the communication line between  
15 the automatic shutdown device and the controller of the wind power installation is checked on a regular basis. As soon as a malfunction is detected, the wind power installation has to shut down until the malfunction has been eliminated, in order to be able to rule out undesirable and inadmissible shadow-casting under any circumstances. This frequently results in a not inconsiderable loss of revenue, which is disadvantageous.

20 [0007] One example of a solution from the prior art can be found in the "Technical Description" published on 2017-05-11 by Enercon (URL: [https://www.landkreis-stendal.de/de/datei/anzeigen/id/18967,1037/4.2.2\\_technische\\_beschreibung\\_schattenabschaltung.pdf](https://www.landkreis-stendal.de/de/datei/anzeigen/id/18967,1037/4.2.2_technische_beschreibung_schattenabschaltung.pdf)).

[0008] The invention addresses the question of creating a control apparatus for a wind power  
25 installation and a method for operating a wind power installation in which the disadvantages from the prior art no longer occur or only occur to a lesser extent.

[0009] This problem is solved by a control apparatus according to the main claim and a method according to the coordinate claim 7 and a computer program product according to the coordinate claim 12. Advantageous further developments are the subject matter of the  
30 dependent claims.

[0010] Thus, the invention relates to a control apparatus for a wind power installation, which is designed to control the components of the wind power installation during normal operation on the basis of input signals and to shut down the wind power installation when a stop signal is

received from a shadow-casting module as an input signal, wherein periods of time in which inadmissible shadow-casting is possible are stored in the control apparatus directly and the control apparatus is designed to shut down the wind power installation in the periods of time stored in the control apparatus if the shadow-casting module fails or malfunctions.

5 [0011] The invention further relates to a method for operating a wind power installation that is shut down in the event of an appropriate stop signal from a shadow-casting module in order to avoid inadmissible shadow-casting, wherein failure or malfunction of the shadow-casting module results in the wind power installation being shut down in periods of time in which inadmissible shadow-casting is fundamentally possible that are stored in the control apparatus  
10 of the wind power installation.

[0012] The invention also relates to a computer program product comprising program parts that, when loaded into the control apparatus of a wind power installation, are designed to perform a method according to the invention.

[0013] First, some terms used in connection with the invention are explained.

15 [0014] The term "shutting down a wind power installation" denotes the temporary shutting down of the rotor, during which time no electrical active power from the wind power installation is fed into the grid.

[0015] "Failure or malfunction of the shadow-casting module" means that any stop signals of the shadow-casting module are no longer being generated or no longer being properly  
20 generated and/or being transmitted to the control apparatus. The shadow-casting module can itself be affected by the failure or a malfunction. However, it is also possible that the communication between the in principle properly functioning shadow-casting module and the control apparatus is impaired, which nevertheless will be considered as a failure or malfunction of the shadow-casting module.

25 [0016] A "control apparatus for a wind power installation" is directly associated with the individual, controllable components of the wind power installation or via the control units assigned to the components and able to control the operation of the wind power installation by activating the individual components. For this control, various input signals, e.g., measurement values detected by sensors, but also specifications from the grid operator, are taken into  
30 consideration and converted into control signals according to predetermined rules. The control apparatus is routinely designed as a memory programmable controller, into which the control logic can be programmed. Controllable components include e.g., the various drives for azimuth and blade pitch adjustment, the inverter, frequently with a dedicated control unit, and

controllable switches. The control apparatus can be supplied with input signals from wind velocity and direction measurement devices, temperature sensors and voltage and current transducers. Control signals input via a terminal at the wind power installation or transmitted via a remote access data transmission network by the wind power installation operator or the operator of the supply network, into which the wind power installation feeds power, are considered input signals in connection with the invention for the control apparatus, which are taken into consideration in the control of the wind power installation.

[0017] An input signal to be taken into consideration in the case of the controller of the wind power installation is a stop signal generated by a shadow-casting module. As is known from the prior art, the shadow-casting module uses prespecified periods of time during which relevant shadow-casting can fundamentally occur, and the light situation determinable via one or more light or brightness sensors to determine whether an inadmissible shadow-casting is present. The periods of time can in the process be determined from the positions of a wind power installation and its immission points, at which a periodic shadow-casting of the wind power installation is inadmissible, and from the annual and daily course of the sun and can be stored in the shadow-casting module. It is also possible to make only the information required for the computation of the periods of time to the shadow-casting module and have the shadow-casting module itself compute the periods of time in question.

[0018] The invention is based on the knowledge that the loss of revenue occurring in the event of a malfunction of the shadow-casting module in the prior art can be reduced by simple and cost-effective measures. In so doing, it was recognized that, while the risk of the loss of revenue by a malfunction of the shadow-casting module due to a fundamentally high reliability of the shadow-casting modules does not justify an actual redundancy of the shadow-casting module for reasons of cost and complexity, however a potential loss of revenue in the event of a malfunction of the shadow-casting module can nevertheless be significantly reduced by the further development of the control apparatus according to the invention. Since, according to the invention, the control apparatus does not have to resort to any additional input quantities to this end, neither additional sensors nor an expensive redesign of the control apparatus is necessary. In particular, in the case of a memory programmable control apparatus the further development according to the invention can be realized routinely as programmable additional logic.

[0019] The invention has recognized that, with respect to the loss of revenue through a malfunction of the shadow-casting module in comparison to the general shutting down of the

installation provided in the prior art, it is more favorable to shut down the wind power installation fundamentally only during those periods of time at which shadow-casting is possible in principle, without however having to check the required lighting conditions for an actual shadow-casting. To this end, those periods of time in which inadmissible shadow-casting is possible are stored directly in the control apparatus. In the event of a failure or malfunction of the shadow-casting module, the control apparatus shuts down the wind power installation during precisely these stored periods of time. In the other periods of time – since there is no danger of an inadmissible shadow-casting – an operation of the wind power installation is possible.

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[0020] In the simplest case, the periods of time stored in the control apparatus can be seasonal time statements for sunup and sundown, if applicable in each case with a predefined offset. In this case the operation of the wind power installation is limited to twilight and night time, during which a shadow-casting is fundamentally to be excluded.

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[0021] However, it is also possible to have the periods of time in which inadmissible shadow-casting is possible stored in the control unit in the form of corresponding time statements in terms of the geographical position of the wind power installation, the geographical position of the regions in which a shadow-casting is inadmissible, and the trajectory of the sun. These time statements can ultimately match the specifications that are also stored in a shadow-casting module.

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[0022] Finally, it is of course also possible to have the control unit itself compute the periods of time in which inadmissible shadow-casting is possible, using the geographical position of the wind power installation, the geographical position of the areas in which a shadow-casting is inadmissible, and the trajectory of the sun. In this case, the control apparatus – analogous to a corresponding shadow-casting module – must be provided with the information required for the computation of the periods of time, whereupon the periods of time can then be computed by the control apparatus itself.

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[0023] Even if the invention can fundamentally also be used in control apparatuses in which a shadow-casting module is implemented as a software module, it is preferable if the control apparatus is designed to receive signals from an external shadow-casting module embodied separately from the control apparatus.

[0024] It is further preferable if the control apparatus is designed to receive a malfunction signal from the shadow-casting module and/or to determine the absence of status signals from the shadow-casting module, so as, on receiving a corresponding malfunction signal and/or in

the absence of a corresponding status signal, to shut down the wind power installation in the periods of time stored in the control apparatus. The control apparatus is thus able to directly respond to a malfunction signal of the shadow-casting module. Moreover, it can autonomously detect a failure of the shadow-casting module on the basis of the absence of status signals of the shadow-casting module. These status signals can be signals sent on a regular basis from the shadow-casting module during normal operation or only on request of the control apparatus. It is also possible to identify a malfunction of the shadow-casting module when the shadow-casting module sends a stop signal at a time during which, according to the periods of time stored in the control apparatus, shadow-casting requiring the shutdown of the installation is fundamentally not possible. It is therefore preferable if the control apparatus is designed to ignore stop signals from the shadow-casting module as erroneous after receiving a stop signal from the shadow-casting module outside the periods of time stored in the control apparatus and to shut down the wind power installation in the periods of time stored in the control apparatus.

[0025] For the description of the method according to the invention, reference is made to the above explanations.

[0026] The invention will now be described by way of example on the basis of an advantageous embodiment with reference to the attached drawings. In the figures:

Figure 1: shows a schematic representation of a wind power installation with a control apparatus according to the invention along with shadow-casting; and

Figure 2: shows a schematic detailed representation of the gondola of the wind power installation from figure 1.

[0027] Figure 1 shows a schematic representation of a wind power installation 1 with its generated shadow. As explained in greater detail subsequently in connection with figure 2, the control apparatus of the wind power installation according to the invention is designed such that its operation occurs according to the method in accordance with the invention.

[0028] The wind power installation 1 comprises a tower 2, upon the tip of which a gondola 3 rotatable in azimuth direction is disposed. A rotor 4 with three rotor blades 5 rotatable about a substantially horizontal axis is attached to the gondola 3, which drives a generator 8 disposed in the interior of the gondola (see figure 2) to convert wind energy into electrical energy.

[0029] The shadow of the wind power installation 1 in the case of a position of the sun 90 shown by way of example and cloud-free skies is indicated by the dotted line 91. The region in which a period shadow-casting arises when the rotor 4 is rotating is indicated by line 92.

[0030] As shown in figure 1, the shadow 91 and in particular the periodic shadow-casting 92 fall on an apartment building 95, which is undesirable and usually prohibited by pollution legislation. As a result, the fundamental request is made to shut down the wind power installation 1 in the situations in which a corresponding shadow-casting on defined regions or immission points is present.

[0031] Figure 2 shows the gondola 3 of the wind power installation 1 including the controller, with the previously described shutting down when shadow-casting takes place on previously defined regions.

[0032] The rotor 4, whose rotor blades 5 may be adjusted with respect to the blade angle by pitch adjustment drives not shown in the figure, drives the generator 8 via a rotor shaft 6 and an interposed gearbox 7, which is a double-fed asynchronous generator. One portion of the electrical energy generated by the generator 8 travels via the inverter 9 with dedicated inverter controller 9', the other portion travels directly to a transformer (not shown) disposed at the base of the tower 2 and from there to a supply network. As an alternative, the wind power installation is also equipped with a cage rotor generator and full converter. Furthermore, an azimuth adjustment drive 10, with which the gondola 3 can be rotated about the axis of the tower 2, a brake 11 for braking the rotor 4, an anemometer with a wind direction indicator 12, tachometer 13, a voltage and current measurement device 14 and a shadow-casting module 21 with brightness sensor 22 are provided in the gondola 3.

[0033] All components 8-14, 21, 22, which are controllable and/or which provide measurement data relevant for the operation of the wind power installation 1, are connected to the central control apparatus 20. In addition, the control apparatus 20 can receive external control specifications – e.g., from the wind power installations and/or supply network operator – as input signals via the data line 15.

[0034] The control apparatus 20 is designed to control the individual components 8-14, 21, 22 of the wind power installation as a function of the information received by these components 8-14, 21, 22 as input signals, so that at any time the wind power installation 1 feeds the maximum possible power to the supply network corresponding to the control specifications received via the data line 15.

[0035] The shadow-casting module 21 is designed according to the state of the art. Periods of time are stored in this external module 21 during which fundamentally an inadmissible shadow-casting is possible. These periods of time can be determined from the position of the wind power installation 1, the position of the immission points (cf. e.g., location of the

residential development 91 in figure 1), and the annual and daily course of the sun 90. For these periods of time, it holds true that when the sun is shining an inadmissible shadow-casting is present. To check whether the prevailing lighting conditions actually lead to an inadmissible shadow-casting, with the help of the brightness sensor 22 a check is performed as to whether direct sunlight actually exists or whether e.g., due to clouding only diffuse lighting conditions obtain. In the latter case, no inadmissible shadow-casting occurs, so that the shadow-casting module 21 only transmits a stop signal to the control apparatus 20 during the mentioned periods of time when there is direct sunlight. When the control apparatus 20 receives a corresponding stop signal as an input signal, the control apparatus 20 shuts down the wind power installation 1 and does not start it up again until it receives the information from the shadow-casting module 21 that inadmissible shadow-casting is no longer present.

[0036] The periods of time during which an inadmissible shadow-casting can fundamentally occur are likewise stored in the control apparatus 20 itself. The periods of time stored in the control apparatus 20 cover at least the periods of time that are stored in the shadow-casting module 21. The control apparatus 20 is designed to shut down the wind power installation 1 in the event of failure or malfunction of the shadow-casting module 21 during the periods of time stored in the control apparatus 20 itself. As a result, there can be no inadmissible shadow-casting. Simultaneously, the wind power installation 1 can be operated outside of the stored periods of time.

[0037] The control apparatus 20 can detect a failure or a malfunction of the shadow-casting module 21 in different ways.

[0038] For one thing, the shadow-casting module 21 itself can report a malfunction to the control apparatus 20 in the form of a malfunction signal. For another thing, provision can be made that the shadow-casting module 21 sends status signals to the control apparatus 20 on a regular basis. An absence of these status signals indicates a malfunction or a failure of the shadow-casting module 21 itself or of the communication line between control apparatus 20 and shadow-casting module 21. Also, the receipt of a stop signal from the shadow-casting module 21 outside of the periods of time stored in the control apparatus, during which only inadmissible shadow-casting can occur, will be detected as obviously incorrect. As a result, the signals of the shadow-casting module 21 are ignored and a malfunction of the shadow-casting module 21 is assumed. In all cases, a failure or a malfunction of the shadow-casting module 21 is detected and the wind power installation 1 is shut down in the periods of time stored in the control apparatus 20.

## PATENTKRAV

1. Styringsanordning (20) til et vindenergianlæg (1), der er udformet til styring af komponenterne (8-14) i vindenergianlægget (1) i normal drift afhængigt af indgangssignalerne og til frakobling af vindenergianlægget (1) ved modtagelse af et stopsignal fra et slagskyggemodul (21) som indgangssignal, hvor tidsrum, i hvilke der kan forekomme uacceptabel slagskygge, er lagret direkte i styringsanordningen (20), og styringsanordningen (20) er udformet til at frakoble vindenergianlægget (1) i tilfælde af et svigt eller en fejlfunktion i slagskyggemodulet (21) i tidsrummene, der er lagret i styringsanordningen (20),

10 **kendetegnet ved, at**

styringsanordningen (20) er udformet til at modtage et fejlfunktionssignal fra slagskyggemodulet (21) for ved modtagelse af et tilsvarende signal at frakoble vindenergianlægget (1) i tidsrummene, der er lagret i styringsanordningen (20).

15 2. Styringsanordning ifølge krav 1,

**kendetegnet ved, at**

styringsanordningen (20) er udformet til at modtage signaler fra et eksternt slagskyggemodul (21), der er udført adskilt fra styringsanordningen (20).

20 3. Styringsanordning ifølge et af de foregående krav,

**kendetegnet ved, at**

styringsanordningen (20) er udformet til at modtage statussignaler fra slagskyggemodulet (21) for ved udeblivelse af tilsvarende signaler at frakoble vindenergianlægget (1) i tidsrummene, der er lagret i styringsanordningen (20).

25 4. Styringsanordning ifølge et af de foregående krav,

**kendetegnet ved, at**

styringsanordningen (20) er udformet til efter modtagelsen af et stopsignal fra slagskyggemodulet (21) uden for tidsrummene, der er lagret i styringsanordningen (20), at ignorere stopsignaler fra slagskyggemodulet (21) som værende fejlagtige og frakoble vindenergianlægget (1) i tidsrummene, der er lagret i styringsanordningen (20).

5. Styringsanordning ifølge et af de foregående krav,

**kendetegnet ved, at**

tidsrummene, i hvilke der kan forekomme uacceptabel slagskygge, er defineret af tidsangivelser, der er lagret i styringsanordningen (20).

10 6. Styringsanordning ifølge et af de foregående krav,

**kendetegnet ved, at**

tidsrummene, i hvilke der kan forekomme uacceptabel slagskygge, er beregnet, fortrinsvis af styringsanordningen selv, ved hjælp af den geografiske position af vindenergianlægget (1), den geografiske position af områderne, i hvilke der kan forekomme uacceptabel slagskygge, samt solens himmelpositioner.

7. Fremgangsmåde til drift af et vindenergianlæg (1), der til undgåelse af uacceptabel slagskygge i forbindelse med et tilsvarende stopsignal frakobles af et slagskyggemodul (21), hvor vindenergianlægget (1) i tilfælde af et svigt eller en fejlfunktion i slagskyggemodulet (21) frakobles i tidsrum, som er lagret i styringsanordningen (20), og i hvilke der principielt kan forekomme uacceptabel slagskygge,

**kendetegnet ved, at**

vindenergianlægget (1) ved modtagelse af et fejlfunktionssignal fra slagskyggemodulet (21) frakobles i tidsrummene, der er lagret i styringsanordningen (20).

8. Fremgangsmåde ifølge krav 7,

**kendetegnet ved, at**

vindenergianlægget (1) ved udeblivelse af statussignaler fra  
slagskyggemodulet (21) frakobles i tidsrummene, der er lagret i  
5 styringsanordningen (20).

9. Fremgangsmåde ifølge et af kravene 7 eller 8,

**kendetegnet ved, at**

yderligere stopsignaler fra slagskyggemodulet (21) ved modtagelse af  
et stopsignal fra slagskyggemodulet (21) uden for tidsrummene, der er lagret i  
10 styringsanordningen (20), ignoreres som værende fejlagtige, og  
vindenergianlægget (1) frakobles i tidsrummene, der er lagret i  
styringsanordningen (20).

10. Fremgangsmåde ifølge et af kravene 7 til 9,

**kendetegnet ved, at**

15 de lagrede tidsrum er defineret ved hjælp af tidsangivelser.

11. Fremgangsmåde ifølge et af kravene 7 til 10,

**kendetegnet ved, at**

tidsrummene, i hvilke der kan forekomme uacceptabel slagskygge,  
beregnes, fortrinsvis af styringsanordningen selv, ved hjælp af den geografiske  
20 position af vindenergianlægget (1), den geografiske position af områderne, i  
hvilke der kan forekomme uacceptabel slagskygge, samt solens  
himmelpositioner.

12. Computerprogramprodukt, der omfatter programdele, der, når de er  
indlæst i styringsanordningen (20) til et vindenergianlæg (1), er konstrueret til  
25 udførelse af en fremgangsmåde ifølge et af kravene 7 til 11.

[Fig. 1]

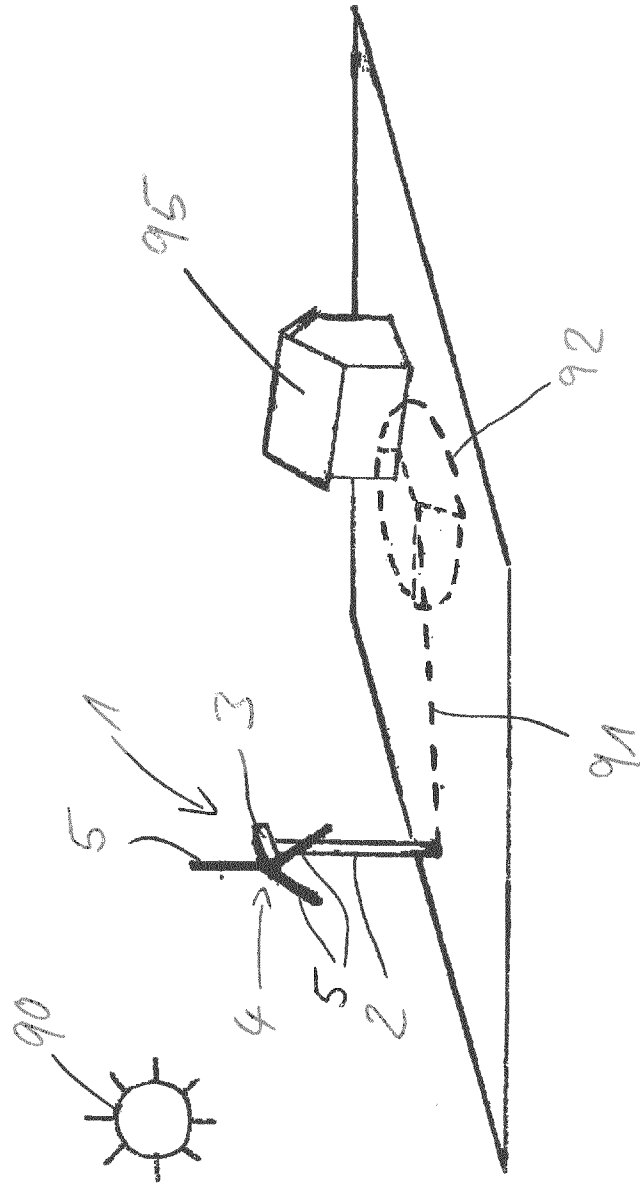


Fig. 1

