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The present invention relates to a method for operation of a wind energy installation having an electrical generator, which can be driven by a rotor, for emission of electrical power to an electrical load, in particular an electrical grid.

- 5 The invention also relates to a wind energy installation having a rotor and having an electrical generator, which is coupled to the rotor, for emission of electrical power to an electrical load, in particular an electrical grid.

In the case of known wind energy installations for production of electrical energy from
10 wind energy, the generator is operated in parallel with the electrical load, frequently an electrical grid. This means that as long as the available wind is sufficient, the wind energy installation will produce electrical energy and will feed it into the grid.

However, if a disturbance occurs in the grid, for example as a result of a short circuit in
15 the grid, the wind energy installations have until now been disconnected from the grid, and have not been reconnected to the grid until normal operating conditions have been restored.

This means that it is no longer possible to quickly support the grid after the occurrence
20 of a disturbance as is necessary, in particular, in the event of major voltage and/or power demand fluctuations. WO 9952193 discloses an example from the prior art.

The object of the present invention is thus to specify a control process for one or more
25 wind energy installations, which as far as possible counteracts fluctuations in the grid.

This object is achieved according to a method of the type mentioned at the outset, in that the power which is emitted from the generator to the load is regulated as a function of a current which is emitted to the load.

- 30 In the case of an apparatus of the type mentioned at the outset, the object is achieved by means of a control device with a current sensor for sensing an electric current which

is emitted to the load, so that the power which is emitted from the generator to the load can be regulated as a function of the current which is sensed by the current sensor.

This allows the required power to be produced and fed in in the event of fluctuating power demands from the grid.

In order to prevent overloading of parts of the wind energy installation and/or of the grid in the event of a disturbance in the grid, for example as a result of a short circuit in the grid, the wind energy installation is controlled such that the current which is emitted to the grid does not exceed a predetermined value.

In one particularly preferred embodiment of the invention, the magnitude of this maximum current which can be emitted is regulated for each phase of the grid in order on the one hand to allow the grid to be supported as well as possible without on the other hand subjecting components to the risk of damage.

In this case, the wind energy installation can be operated in a particularly preferred manner in accordance with the requirements from a remote control centre. This makes it possible, for example, for a power supply organization to demand the current actually required to support the grid from the wind energy installation.

Further advantageous embodiments are specified in the dependent claims.

One embodiment of the invention will be described in more detail in the following text with reference to the figures, in which:

- Fig. 1 shows a simplified illustration of a wind energy installation feeding a grid;
- Fig. 2 shows a control device according to the invention for operation of a wind energy installation; and
- Fig. 3 shows a block diagram of the major components of the open-loop and closed-loop control arrangement.

A wind energy installation 2 which has a rotor 4 and is illustrated in a simplified form in Fig. 1 is connected to an electrical grid 6 which, for example, may be a public grid. Two or more electrical loads 8 are connected to the grid. The electrical generator (which is not illustrated in Fig. 1) for the wind energy installation 2 is coupled to an electrical open-loop and closed-loop control arrangement 10, which first of all rectifies the alternating current produced in the generator and then converts it to an alternating current at a frequency which corresponds to the grid frequency. Instead of a grid 6, an individual load could also be supplied with electrical energy from the wind energy installation 2. The open-loop and closed-loop control arrangement 10 has a control device according to the invention.

Fig. 2 shows the control device according to the invention. The rotor 4 (which is illustrated in a simplified form) is coupled to a generator 12 which produces electric power as a function of the wind speed and thus the power of the wind. The alternating current which is produced in the generator 12 is first of all rectified and is then converted to an alternating current whose frequency corresponds to the grid frequency.

The current fed into the grid 6 (Fig. 1) is determined by means of a current sensor (not illustrated). In this case, the current is compared with a predetermined value $I(\max)$.

If the current which is fed into the grid 6 exceeds the predetermined maximum value $I(\max)$, the control device adjusts the power that is produced by the overall wind energy installation (and/or its generator) such that the current which is fed in does not exceed the predetermined limit value $I(\max)$. In the event of a short circuit, it is possible, for example, for the wind energy installation to feed considerably less power into the grid than before although the power which is thus not fed into the grid is used in some other way outside of the grid, for example for a dump load (resistance) or for feeding the power that is not emitted into the grid to capacitors or other buffer stores. As soon as the grid is completely available once again, the stored energy can also be emitted into the grid again.

This means that, even in the event of a short circuit in the grid, the wind energy installation can still emit power to the grid and can support the grid without the current exceeding the predetermined limit value as a consequence of the short circuit.

5 Fig. 3 shows components of the open-loop and closed-loop control arrangement 10 in Fig. 1. The open-loop and closed-loop control arrangement 10 has a rectifier 16 in which the alternating current produced by the generator is rectified. An inverter 18 which is connected to the rectifier 16 converts the direct current back to an alternating current whose frequency corresponds to the grid frequency. This current is fed into the
10 grid 6 via three phases, L1, L2 and L3. The inverter 18 is controlled by means of a microcomputer 20, which is part of the control device. For this purpose, the microprocessor 20 is coupled to the inverter 18. The input variables for controlling the current with which the electrical power made available by the wind energy installation 2 is fed into the grid 6 by the instantaneous current or the instantaneous currents, the
15 grid frequency, the electrical power P of the generator, the power factor \cos and the power gradient dP/dt . The current to be fed in is controlled according to the invention in the microprocessor 20. In this case, the current in each of the phases L1, L2 and L3 is detected separately, and its magnitude is taken into account in the control process according to the invention.

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If the measured current(magnitude) $I(\text{act})$ in one phase now rises above a predetermined maximum value, the inverter 18 is controlled such that the current(magnitude) falls below the predetermined maximum value $I(\text{max})$ and the electrical energy which is then produced from the wind energy and is not fed into the
25 grid owing to the current limiting is used in some other way, for example being emitted via a resistance (dump load), or being stored in a buffer store (for example a capacitor, Ultracap).

In this case, the wind energy installation can be controlled autonomously. The wind
30 energy installation then detects a short circuit in the grid by, for example, monitoring the voltage in the individual phases of the grid and/or their phase angle. If the voltages and/or phase differences reach predetermined limit values, the wind energy

installation identifies a short circuit and operates in accordance with an algorithm that is provided for this situation.

5 The external access (22) provides the capability for, for example, the power supply organizations to whose grid the wind energy installation is connected to intervene in the operation of the wind energy installation and, for example, to vary the magnitude of the current to be fed in, the nature of the current (real current, reactive current) and/or the phase angle etc. This allows the power supply organization to set precisely those values (the current, the voltage, the electrical power) for the power to be fed into
10 the grid from the wind energy installation which correspond to the demand from the grid operator.

Patentkrav

1. Fremgangsmåde til drift af et vindenergianlæg med en elektrisk generator, der kan drives af en rotor, til afgivelse af elektrisk effekt til en elektrisk forbruger, nemlig et elnet, hvor effekten, der afgives fra generatoren (12) til forbrugeren (6), reguleres afhængigt af en strøm, der afgives til forbrugeren (6), hvor den afgivne strøm ikke overskrider en forudbestemmelig mængde, har et forudbestemmeligt fasniveau og/eller indeholder en forudbestemmelig blindstrøm-andel,
- hvor mængden, fasniveauet og/eller blindstrøm-andelen for hver fase ved flerfasede systemer ikke overskrider den forudbestemmelige værdi, hvor vindenergianlægget har en ekstern styreindgang, ved hjælp af hvilken der modtages koblingskommandoer fra netværksoperatøren eller energiforsyningsvirksomheden, som driver nettet, og vindenergianlægget styres afhængigt af disse styresignaler fra netværksoperatøren i henhold til netværksoperatørens behov, og der således tilføres elektrisk effekt til nettet, eksempelvis den effektive ydelse, blindeffekten, strømniveauet, spændingsniveauet eller fasniveauet i en form, således som dette kræves af netværksoperatøren,
- at den afgivne strøm er en vekselstrøm med forudbestemmelig frekvens, og at den forudbestemmelige frekvens foretrukket svarer i det væsentlige til netfrekvensen, og at så, når strømmen, der afgives fra generatoren til forbrugeren, overskrider en forudbestemmelig maksimumværdi ($I(\max)$), ved hjælp af en reguleringsindretning af vindenergianlægget effekten, der genereres af det samlede vindenergianlæg og/eller dets generator, indstilles således, at den tilførte strøm ikke overskrider den forudbestemte maksimumværdi ($I(\max)$), hvor dette ved en kortslutning i nettet sker ved, at vindenergianlægget tilfører en betydeligt lavere effekt til nettet end tidligere, men effekten, der således ikke tilføres nettet, anvendes på anden måde uden for nettet, eksempelvis til en dumpload (modstand), eller tilførslen af effekten, der ikke afgives til nettet, sker til kondensatorer eller andre mellemlagre, og at, når nettet igen står helt til rådighed, den lagrede energi så også afgives til nettet.
2. Fremgangsmåde ifølge krav 1,
- kendetegnet ved, at** effekten, der afgives fra generatoren (12) til forbrugere-

ren, reguleres afhængigt af den mængde af strøm, der afgives til forbrugeren.

3. Fremgangsmåde ifølge krav 1,

5 **kendetegnet ved, at** der for hver fase kan forudbestemmes en værdi, som er uafhængig af de øvrige faser.

4. Fremgangsmåde ifølge et af de foregående krav,

10 **kendetegnet ved, at** strømmen for hver fase, der er berørt af en kortslutning, begrænses til øjebliksværdien på tidspunktet for kortslutningen.

5. Vindenergianlæg, hvor vindenergianlægget er indrettet til at udføre en fremgangsmåde ifølge et af kravene 1 til 4, med en rotor og en med rotoren koblet elektrisk generator til afgivelse af elektriske effekter til et elnet, **kendetegnet ved** en reguleringsindretning med en strømaftager til optagelse af den elektriske strøm, der afgives til et net (6), således at effekten, der afgives fra generatoren til nettet (6), kan reguleres afhængigt af strømmen, som optages af strømaftageren.

20 6. Vindenergianlæg ifølge krav 5,

kendetegnet ved, at reguleringsindretningen har en mikroprocessor (20) og en ekstern styreindgang (22) til transmission af data til reguleringsindretningen.

25 7. Vindenergianlæg ifølge et af kravene 5 - 6,

kendetegnet ved en indretning til registrering af en kortslutning i nettet.

8. Vindenergianlæg ifølge krav 7,

30 **kendetegnet ved** en spændingsregistreringsindretning til registrering af spændingen i mindst en fase i nettet.

9. Vindenergianlæg ifølge krav 7 eller 8,

kendetegnet ved en faseovervågningsindretning til registrering af fase niveaue for strømmene og/eller spændingerne i mindst en fase i nettet.

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5 **10.** Vindenergianlæg ifølge et af kravene 5 til 9 med en generator til afgivelse af elektrisk effekt til et elnet, **kendetegnet ved, at** vindenergianlægget forbliver på nettet, når en kortslutning eller en sammenlignelig driftsforstyrrelse indstiller sig i nettet, eksempelvis spændingen får en værdi, som afviger mere end 20 % og foretrukket mere end 40% fra indstillingsværdien.

10 **11.** Vindenergianlæg ifølge et af kravene 5 til 10, med en generator til afgivelse af elektrisk effekt til et elnet og en ekstern styreindgang med transmission af data til en reguleringsindretning af vindenergianlægget, hvor der via den eksterne styreindgang modtages koblingskommandoer fra netværksoperatøren eller energiforsyningsvirksomheden, som driver nettet, og vindenergianlægget styres afhængigt af disse styresignaler fra netværksoperatøren i henhold til netværksoperatørens behov, og der således tilføres elektrisk effekt til nettet, eksempelvis den effektive ydelse, vindeffekten, strømniveauet, 15 spændingsniveauet eller fasniveauet i en form, således som dette kræves af netværksoperatøren.

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Fig. 1

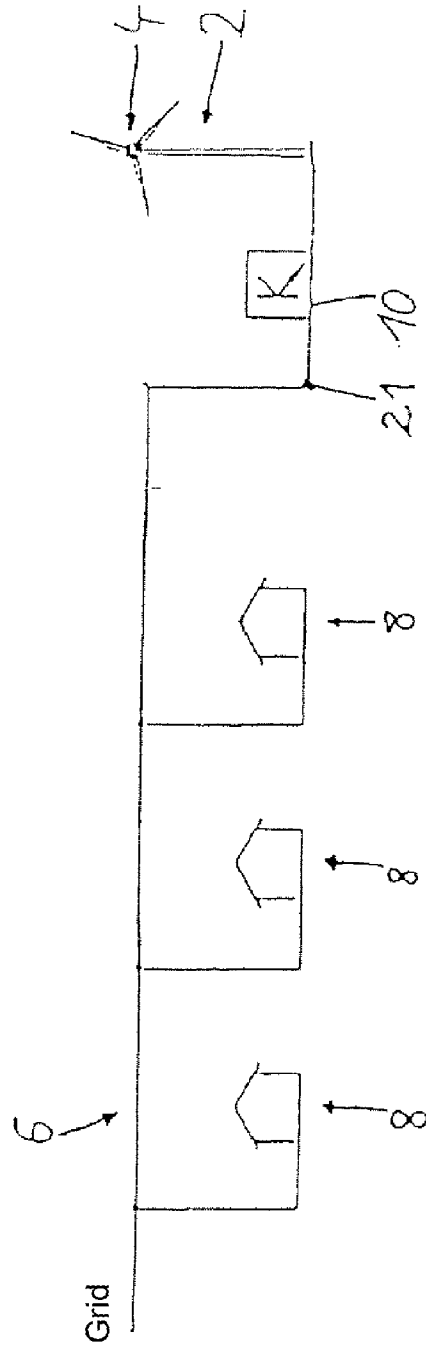


Fig. 2

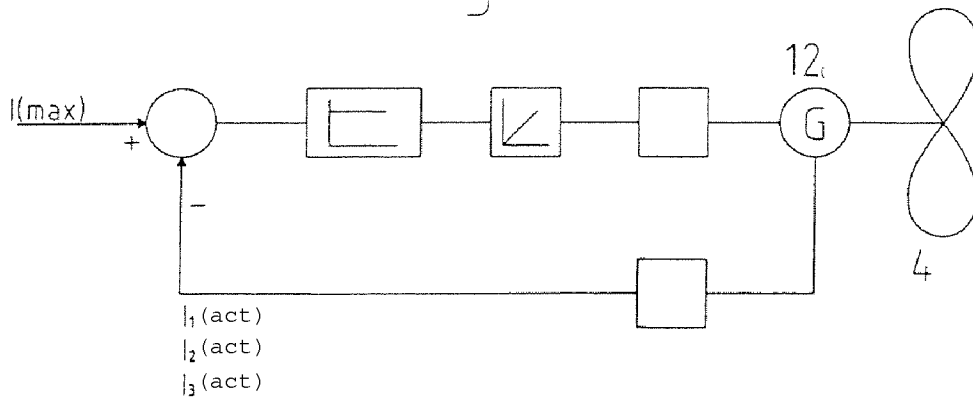


Fig. 3

