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Description

The invention relates to a method and a device for operating a converter, in particular for wind energy installations comprising a generator driven via a wind rotor, for feeding electrical power into an electrical grid, wherein the converter comprises an intermediate circuit having an associated energy accumulator. More precisely, it involves decreasing the energy stored in the energy accumulator and feeding power from the intermediate circuit to the electrical grid during an abrupt voltage disturbance, in particular a voltage dip in the electrical grid.

Modern wind energy installations are usually speed-variable, so that the generator produces alternating current with different frequency. A frequency converting is required for feeding this to a fixed-frequency supply grid (usually 50 Hz). One uses frequency converters for this. Traditionally, wind energy installations have been operated in such a way that they are separated from the grid in the event of grid faults, especially short circuits. But with the increasing spread of wind energy installations and the increase in the installed wind power, instead of this there is demanded by the grid operators a grid-supporting operation of the wind energy installations in terms of frequency and voltage.

Basically, there are two major aspects which must be considered in meeting the demand of the grid operators. The first aspect is that, upon an abrupt change in the grid voltage, a rise in the voltage in the intermediate circuit must be limited in order to avoid a switching off of the converter. The second aspect is that the mechanical loading of the drive train leading from the wind rotor to the generator as a result of abrupt grid voltage changes should be reduced as much as possible in terms of magnitude and frequency.

For the first mentioned aspect, it is known to arrange a special circuit between generator and converter, which limits

the voltage rise in the intermediate circuit (WO-A-03/065567). It has further been proposed to limit the voltage rise with an intermediate circuit chopper, which is usually present anyway. Alternatively, it may also be provided to reduce the
5 intermediate circuit voltage and the losses by reducing the switching frequency of the converter, and thus increase the converter current (WO-A-2005/027301). Moreover, it is known (WO-A-2006/069569) to let the voltage drop in the intermediate circuit of the converter as a result of a grid disturbance
10 until finally switching elements of the converter are disconnected. As a result, the converter with its intermediate circuit is electrically disconnected from the grid and thus cannot make any contribution to it.

15 It has been shown that the known measures are each effective only in regard to one of the two aspects, but not the other. Thus, the known measures for decreasing the voltage rise usually result in an increasing of the load on the drive train, and vice versa.

20 Based on the last mentioned prior art, the problem which the invention proposes to solve is to indicate a method and a device for operating a converter with which a better behaviour is achieved.

25 The solution according to the invention lies in a method and in a device according to the features of the independent claims. Advantageous modifications are the subject matter of the dependent claims.

30 In a method for operating a converter, in particular for wind energy installations comprising a generator driven via a wind rotor, for feeding electrical power into an electrical grid even during an abrupt voltage disturbance, in particular a
35 voltage dip in the electrical grid, wherein the converter comprises an intermediate circuit having an associated energy accumulator, it is provided according to the invention to provide a maximum possible energy uptake capacity in the

energy accumulator of the intermediate circuit by reducing the energy level in the intermediate circuit in a deliberate manner to a predeterminable low value of the energy level depending on the capacity of the energy accumulator, wherein
5 after reducing the energy level the energy accumulator is configured for taking up a quantity of energy that arises in the intermediate circuit at the end of the abrupt voltage disturbance.

10 The crux of the invention is the notion of reducing the energy stored in the intermediate circuit to such an extent that the activating of protective devices of the converter which traditionally occurs upon an abrupt voltage disturbance, such as in particular an intermediate circuit chopper or a
15 protective circuit (crowbar) between generator and converter, can be reduced as much as possible. The invention accomplishes this in that the voltage (or the current) in the intermediate circuit, more precisely in its usually capacitive or inductive energy accumulator, is deliberately lowered in order to free
20 up a sufficient accumulator capacity, depending on the magnitude of the voltage jump, so that power peaks occurring at the end of the abrupt voltage disturbance can be absorbed upon the return of the grid voltage. The danger of exceeding critical limit values in the intermediate circuit may thus be
25 averted. The invention thus accomplishes a lessening of the frequency and duration of the activation of the converter protective circuits. This improves not only the quality of the electric power fed to the grid, but also avoids in particular harmful torque fluctuations, and thus avoids the loading or
30 risk of damage to components such as the generator and its drive train resulting from the torque fluctuations. Furthermore, the invention improves the "ride-through" property upon temporary loss and return of the grid voltage, especially during abrupt grid voltage disturbances.

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The term abrupt voltage disturbance encompasses both a sudden lowering of the voltage in the grid, the extreme case being a short circuit, and a sudden rise above the tolerance band

provided for the normal operation.

By a power peak is meant a transient, especially an induced
excess voltage or a transient, especially an induced excess
5 current.

While it is known to decrease the voltage in the intermediate
circuit in the event of a short circuit (WO-A-2005/027301),
this was done solely with the goal of providing more
10 favourable operating relations at the converter for the
feeding of electric power during the period of the voltage
loss to the grid. No heed was paid to the relations upon
return of the grid voltage. In particular, it was not
considered whether the voltage in the intermediate circuit had
15 been reduced so much that as much energy as possible was
accumulated in the energy accumulator of the intermediate
circuit to have an adequate reserve available upon return of
the grid voltage and thus avoid a triggering of the crowbar
circuit. Instead, it depended on random factors whether the
20 voltage return occurred so slowly or so abruptly that the
excess currents arising in the intermediate circuit could be
buffered or not. Now, the invention makes sure that as much
energy uptake capacity as possible is provided in the
intermediate circuit up to the return of the grid voltage. In
25 this way, a distinct improvement in the operating behaviour of
the converter and thus of the entire wind energy installation
can be accomplished in amazingly simple manner. But not only
is the operating behaviour improved, a sparing of the
components of the wind energy installation is also achieved.

30 In general, the method is carried out in such a way that the
lowering down to the low value during the abrupt grid voltage
disturbance occurs according to the invention in preparation
for the return of the grid voltage. Since the time until the
35 return of the grid voltage is usually not known, the lowering
to the low value according to the invention advisedly occurs
at once upon recognizing the grid voltage disturbance. But it
may also be provided for the lowering to be done in

preparation for a grid voltage disturbance occurring at a later time. This preemptive variant offers the benefit that already at the start of the grid disturbance free capacity has been provided to take up excess currents. Preferably, this is
5 done in such a way that the lowering is carried out for the first time in preparation of the anticipated grid voltage disturbance and for a second (or further) time after the occurrence of the grid voltage disturbance has been recognized. In this way, the benefits of the invention extend not only to
10 the return of the grid voltage, but may also be felt already at the start of the grid disturbance.

According to an especially preferred embodiment, the method according to the invention is used in a wind energy
15 installation having a double energized generator. This type of installation in particular traditionally causes great difficulties, since the stator/rotor winding pair acts like a transformer and thus significantly higher voltages are induced in the rotor circuit than in the rest of the power grid. Limit
20 values for the output voltage of the converter are generally exceeded. Short circuit type currents may arise as transients in the rotor and stator. This may result in an unwanted switching off of the machine-side converter. Furthermore, as a result of the high currents in the rotor, an active power is
25 supplied to the intermediate circuit for a brief time which lies above the rated power, so that the voltage in the intermediate circuit rises especially quickly and strongly. Accordingly large were the switching frequency and intensity of the converter protection circuits and the resulting
30 negative consequences for the grid quality and the mechanical loading of the drive train. These adverse effects can be mitigated thanks to the use of the invention at this type of installation.

35 Advisedly, the low value to which the energy in the intermediate circuit is reduced is calculated by the following formula:

$$U_{DCMin} = \text{Max} \left(U_{\text{Netz}} \cdot \sqrt{2} \cdot k_{\text{Last1}}, U_{\text{Netz}} \cdot \sqrt{2} \cdot \frac{N - N_{\text{Syn}}}{N_{\text{Syn}}} \cdot \omega_{21\text{Gener}} \cdot k_{\text{Last2}} \right)$$

where U_{Netz} denotes the root-mean square value of the phase-to-phase electrical grid voltage, N denotes the rotational speed, N_{Syn} denotes the synchronous rotational speed, $\omega_{21\text{Gener}}$ denotes the turns ratio of rotor to stator of the generator, and k_{Last} denotes a load-dependent factor.

The lowering of the energy level in the intermediate circuit to the low value may occur in various ways. Preferably, this occurs by actuating the grid-side inverter to discharge the excess energy in the intermediate circuit usefully into the grid. If this is not desired or not possible, since no more grid voltage exists, then alternatively the chopper circuit can be actuated until such time as the desired energy value is achieved. This procedure utilizes the fact that a chopper circuit is generally available anyway for the protection of the components. This may be used to deliberately lower the energy level in the intermediate circuit. No additional hardware expense need be incurred.

The converter with intermediate circuit usually has a construction in which a generator-side inverter is connected across the intermediate circuit to a grid-side inverter. This design has the advantage of enabling a power flow in both directions, and it is thus particularly suitable for double energized induction machines as the generator. But it should not be ruled out that the generator-side inverter will be designed as a rectifier. When discussing the grid-side inverter in the following, this may therefore also refer to a rectifier.

In order to explain the invention, it shall further be assumed that, as usual, a crowbar circuit is provided for the protection of the generator and the converter. The term crowbar circuit should be understood here generally, not being limited to the most common design as a kind of short

circuiting.

Advisedly, after the occurrence of the voltage dip, a voltage setpoint is assigned to the grid-side inverter, lying above
5 the amplitude value of the interrupted grid voltage. Preferably, the voltage setpoint is at most 15%, further preferably between 5% and 10%, above the amplitude value of the interrupted grid voltage. This actuating of the inverter ensures that current can be fed massively from the
10 intermediate circuit to the grid, while a low voltage is set in the intermediate circuit, depending on the voltage setpoint.

But it may be provided that the generator-side inverter is deactivated during the voltage disturbance until such time as
15 the voltage in the grid has again reached a predetermined value of the rated grid voltage. This procedure not only has the advantage that the likelihood of occurrence of exceeding the critical limits in the intermediate circuit is further reduced significantly. It also has the advantage that only
20 little power is drained from the generator to the intermediate circuit, depending on the size of the voltage jump, so that accordingly only little power needs to be discharged in order to reduce the energy level in the intermediate circuit to the low value. This is especially favourable when the abrupt
25 voltage disturbance is a voltage rise. Regardless of this, a reconnection of the generator-side inverter advisedly occurs only after a minimum time, so that transient processes triggered by an activation of the crowbar can die down.

30 Advisedly, the intermediate circuit is a dc voltage intermediate circuit having a capacitor as the energy accumulator. But this is not absolutely required. If desired, it may also be provided that the intermediate circuit is designed as a dc intermediate circuit with a coil as the
35 energy accumulator.

The invention further relates to a device with the features of the independent device claim. It comprises, as its core, a

setpoint module, which is provided to adjust the level of the energy stored in the intermediate circuit. For a further explanation and for further advantageous embodiments, refer to the preceding remarks.

5

The invention shall be described below with reference to the enclosed drawing, which shows an advantageous exemplary embodiment. There is shown:

10 Fig. 1 a schematic overview of a wind energy installation according to the invention, connected to an electricity supply grid; and

Fig. 2 a circuit diagram of a converter of the wind energy
15 installation in Figure 1;

Fig. 3 a diagram with voltage vs. time curves during a voltage dip in the grid without the invention; and

20 Fig. 4 a diagram with voltage vs. time curves during a voltage dip in the grid according to the invention.

Figure 1 shows schematically a wind energy installation designed to implement the invention, designated as reference
25 number 1. The wind energy installation 1 comprises, in familiar manner, a pod 11 pivotably arranged on a tower 10. At its end face there is rotatably arranged a wind rotor 2. This drives a generator 3 across a rotor shaft, being preferably designed as a double energized induction machine with multi-
30 stranded rotor and stator winding. The stator winding of the generator 3 is connected directly to a multi-stranded connecting cable 18 of the wind energy installation 1. The rotor winding (not shown) is connected to a (generator-side) inverter 41 of a converter 4; in parallel with the rotor
35 winding there is connected a crowbar circuit 40 as a converter protection circuit. By its (grid-side) inverter 48, the converter 4 is connected to the connecting cable 18. Moreover, a control unit 5 is provided for the operation of the

converter 4.

The electric power produced by the generator 3 is taken across the connecting cable 18 to a transformer 19. This is designed to transform the voltage provided by the wind energy installation 1 from the low voltage level to the voltage level of the medium-voltage power grid 9. The transformer 19 can transfer both the power of a single wind energy installation 1 or the power of a plurality of wind energy installations (a wind park).

Figure 2 shows a schematic representation of the converter 4. It comprises, as its main components, a generator-side inverter 41, a grid-side inverter 48 and a capacitive intermediate circuit 42. The inverters 41, 48 of the converter 4 are designed with self-extinguishing semiconductor switches (in the example shown, IGBT 411, 481 with a blocking voltage of 1700 V) plus antiparallel reverse-current diodes 412, 482. With this design, an active power transfer is possible in both directions, while both inverters 41, 48 can additionally and independently of each other exchange reactive power with the generator or the grid, respectively. The actuation of the IGBT 411, 481 occurs by the control unit 5 in known manner, so that it shall not be discussed further in this place.

The intermediate circuit 42 is designed as a dc voltage intermediate circuit. It comprises a plurality of capacitors in parallel and series connection (in the example, with a rated voltage of 1100 V) as the energy accumulator 43. It should be noted that coils are provided accordingly in a dc intermediate circuit.

The intermediate circuit 42 is moreover associated with an intermediate circuit chopper 45. This serves for reducing in controlled manner the energy stored in the intermediate circuit 42. It comprises an IGBT 451 and an antiparallel connected protection diode 452, being in series with a load resistor 453 having a load inductor 454. When the intermediate

circuit chopper 45 is activated, the energy contained in the intermediate circuit 42 and stored substantially in the energy accumulator 43 is rapidly decreased. In this way, a voltage rise in the intermediate circuit 42 to supercritical values can be effectively averted. In this way, the intermediate circuit voltage can then be limited if high active power surges briefly occur from the generator-side inverter 41 that cannot be absorbed by the grid-side inverter 48 with the same rate of increase. This is especially the case with abrupt grid voltage changes. If the power of the intermediate circuit chopper 45 is not enough to handle the brief differential active power of the two inverters 41, 48, the crowbar 40 is activated in known manner. This prevents the supply of active power from the generator-side inverter by short circuiting of the rotor winding.

For the actuating of the intermediate circuit chopper 45, a special control module 51 is formed in the control unit 5. Its function shall be explained more closely in the following. This puts out switching pulses at its output for the intermediate circuit chopper 45, so that it is switched through (triggered) or not depending on the output signal.

The setpoint module 51 has an input to which a voltage meter 50 is connected for the voltage in the intermediate circuit 42. Moreover, it has an optional input, at which a value can be set for a desired pause time. By pause time is meant here the time which will pass before the converter 4, or more precisely the grid-side inverter 48, once more is feeding power to the grid at the end of the abrupt voltage disturbance. This time is denoted as T_s . An empirical value (such as 10 milliseconds) can be used for this, possibly being hard-wired. The time can also be a so-called orientation time, which is the time it takes the inverter 48 to once more become synchronized with the grid. The setpoint module 51 is designed to calculate a charge or energy quantity to be taken up in the intermediate circuit 42 in dependence on the time and a current surge occurring at the end of the abrupt voltage disturbance (e.g.,

return of the grid voltage after a dip or during a short circuit) from the rotor 3 to the intermediate circuit 42 of the converter 4. So that this quantity of charge/energy can be taken up without exceeding critical limit values in the intermediate circuit 42, the setpoint module 51 determines a low value to which the energy accumulator 43 of the intermediate circuit 42 will be discharged after the start of the voltage disturbance, so that sufficient capacity still remains to take up the quantity of charge or energy occurring upon the voltage return. The setpoint module 51 is further designed to actuate the intermediate circuit chopper 45 in such a way that, upon recognizing an abrupt voltage disturbance in the grid 9, the energy accumulator 43 of the intermediate circuit 42 will be discharged to the low value. In the case of the capacitive intermediate circuit 42 represented as an example, this occurs by lowering the intermediate circuit voltage. The capacitors of the energy accumulator 43 are discharged in this way so much that additional active power can be taken up for a limited time. Without the discharging to the low value according to the invention, this kind of power feed could not occur. On the one hand, this achieves a relieving of load on the intermediate circuit chopper 45, and on the other hand it lessens the likelihood of an activation of the crowbar circuit 40. The danger of harmful vibrations in the drive train, especially due to fluctuations in the electrical brake torque by triggering the crowbar circuit 40 at the end of the abrupt voltage disturbance and the return of the grid voltage in its normal range, can thus be averted thanks to the invention.

30

It does not matter whether the full rated voltage has been achieved or not at the end of the voltage return and the dying down of the current surges caused by this in the intermediate circuit 42. If it has been achieved, the grid-side inverter 48 can immediately begin feeding electric power to the grid 9. If it has not yet been achieved, the intermediate circuit 42 will be charged in traditional manner via the rectifier 41 for as long as it takes to reach the rated voltage (typically 1100

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Volt), and then the grid-side inverter 48 will feed power to the grid 9 in normal manner.

5 Figures 3 and 4 show time curves of the voltages in the grid and in the intermediate circuit as well as the activity of the crowbar circuit 40 for the case of a grid voltage dip as the abrupt voltage disturbance. It is assumed that, at time $t=0.1$ seconds, the grid voltage abruptly dips by a value of around 30% of the target voltage. Around 150 milliseconds later, at
10 time $t=0.25$ seconds, the grid voltage returns again. The variation of the grid voltage is shown in an upper curve a) in Figure 4. By means of a voltage detector integrated in the control device 5, a corresponding voltage dip signal can be generated (see curve b). In curve c), the actual voltage in
15 the intermediate circuit 42 is shown by a solid line. One recognizes that a slight voltage rise occurs at the start of the voltage dip. This voltage rise would continue and might ultimately lead to component damage if the crowbar circuit 40 were not triggered for protection (see curve d). Thanks to the
20 activity of the crowbar circuit 40, an excessive voltage rise in the intermediate circuit is thus averted. The voltage in the intermediate circuit 42 drops until it ultimately reaches a value beneath the target value and switches off the crowbar circuit. The voltage in the intermediate circuit 42 may then
25 slowly rise again to its target value (dashed curve c). An energy accumulator situated in the intermediate circuit 42 is accordingly likewise charged to a normal energy value. Thus, a quasi-steady state is achieved, which may last until the end of the voltage dip. If, now, the grid voltage returns again
30 ($t=0.25$ seconds, see Figure a), a high voltage will be induced in the rotor circuit of the double energized generator - as explained above. The voltage in the intermediate circuit 42 rises accordingly (see curve c), until ultimately the crowbar circuit is triggered to protect the components before an
35 overloading occurs (see curve d). The actual voltage in the intermediate circuit 42 then drops by virtue of the activating of the crowbar circuit, until it again reaches a value somewhat below the target voltage and the crowbar circuit

shuts off. With the return of the grid voltage, the voltage dip recognition signal is also reset accordingly (see curve b).

Figure 4 shows corresponding time curves for the voltages and signals in a device and a method according to the invention. Once again, at time $t=0.1$ seconds the grid voltage dips (curve a). The actual voltage in the intermediate circuit 42 rises accordingly, so that the crowbar circuit 40 is triggered to protect against harmful voltage surges. The recognition signal put out by the detector circuit for the voltage dip is shown in curve b). The variation of the voltage in the intermediate circuit corresponds in the beginning to that shown in Figure 3. The voltage at first rises, until the crowbar circuit 40 is triggered and ultimately switches off when the actual voltage (solid curve) in the intermediate circuit 42 has dropped to a value below the original target voltage. Because of the recognized voltage dip (curve b), the setpoint module 51 according to the invention determines a lower energy level for the intermediate circuit 42. In the exemplary embodiment shown, it is a voltage intermediate circuit, so that the starting value put out is a target voltage (dashed curve) (see dashed curve c). It now amounts to only somewhat more than 60% of the original voltage in the intermediate circuit 42. This means that the energy stored in the energy accumulator 43 of the intermediate circuit 42 is lowered to a low value amounting to only around 36% of the original value. Thus, a significant capacity is free in the energy accumulator 43 to take up the current surges occurring in the intermediate circuit 42 upon return of the grid voltage. While the voltage dip continues in the grid, the actual voltage in the intermediate circuit (solid curve c) gradually drops to the low value for the target voltage put out by the setpoint module 051 (dashed curve c). At the moment of the voltage return in the grid (at $t=0.25$ seconds), the voltage rises quickly in the intermediate circuit 42 on account of the voltage transformation in the rotor circuit of the double energized generator. But since the energy accumulator 43 has been discharged to its low value, its free capacity can be utilized in order to take up in the

energy accumulator 43 as much as possible of the energy introduced by the voltage jump in the intermediate circuit 42. Given sufficient free capacity in the energy accumulator 43, this has the desired effect that the actual voltage in the intermediate circuit 42, although rising upon grid return, does not go beyond the original target level. Thus, in many instances a triggering of the crowbar circuit 40 can be avoided. In the further course, the actual voltage in the intermediate circuit 42 gradually approaches the original value once more, while also the target value is once again gradually increased to the rated setpoint. The converter 4 may then once more switch over to standard operation and feed energy to the electricity grid.

Thanks to the target voltage in the intermediate circuit 42 having been reduced to a low value, the capacitor as the energy accumulator 43 in the dc voltage intermediate circuit 42 is discharged so much that it can take up all or at least a portion of the current surges occurring upon the return, depending on the size of the voltage dip. Thus, a triggering of the crowbar upon return of the grid voltage can be averted. Unwanted loading due to torque fluctuations at the generator 3 and the drive train leading to the wind rotor 2 can be lessened in this way.

For the operation of the invention, it does not matter whether the machine-side inverter 41 in the initial phase of the voltage dip after the subsidence of the activity of the crowbar circuit 40 resumes feeding electric power to the intermediate circuit 42 at once, or whether the refeeding is delayed for such a time until the grid voltage has again reached a defined higher value (such as 90% of the rated grid voltage). A delay has the advantage that current surges arising upon voltage return and the resulting feeding of the intermediate circuit 42 by the reverse-current diodes 412 is less, so that the intermediate circuit chopper 45 is only slightly loaded and therefore can be designed smaller.

In conclusion, it should be pointed out that the actual intermediate circuit chopper 45 is optional for the invention. The discharging of energy from the intermediate circuit 42 according to the invention in order to reach a low value may occur by a suitable actuating of the grid-side inverter 48 (this case is the basis for the representation in Fig. 4). Although this presumes that a certain residual voltage is still present in the grid, such is usually the case however with wind energy installations connected across a medium-voltage transformer 19, even during a short circuit. - But it may also be provided to have a larger dimensioned intermediate circuit chopper 45, so that it can also function as a crowbar circuit 40. In this case, the external crowbar circuit 40 may be omitted. This reduces the expense. But it should be noted that in this case at least the reverse-current diodes 412 of the generator-side inverter 41 must be dimensioned large enough.

The operation according to the invention may be summarized as follows. Depending on an operating point of the grid voltage and the rotary speed of the generator, a lowest possible setpoint is determined and set as the low value for the energy in the intermediate circuit. In this way, at many operating points - especially after a dip in the grid voltage - a distinctly reduced quantity of energy of the intermediate circuit will be set as compared to the rated value. Due to an abrupt change in the grid voltage over time, transient power will be introduced into the intermediate circuit and can be taken up in part, according to the previously reduced energy quantity of the intermediate circuit, by the energy accumulator. In particular, the lowering of the intermediate circuit voltage as compared to the rated value during a grid disturbance - as preparation for the return of the grid voltage - brings about a reduction in the frequency of activity of the converter protection circuit, depending on the magnitude and the rate of increase of the return of the grid voltage. The magnitude of the mechanical drive train loading of the wind energy installation as a direct or indirect

consequence of abrupt grid voltage changes is reduced in this way and the frequency of the mechanical loads is decreased, especially after voltage changes of slight magnitude and/or slight rate of increase.

Patentkrav

1. Fremgangsmåde til drift af en omformer, især til vindenergianlæg med en via en vindrotor (2) fremdrevet generator (3), med henblik på tilførsel af elektrisk effekt til et net (9) også under en springagtig spændingsforstyrrelse, især spændingsdyk i nettet (9), hvorved omformeren (4) har en mellemkreds (42) med et tilordnet energilager (43), kendetegnet ved tilvejebringelse af en maksimalt mulig energioptagelseskapacitet i mellemkredsens (42) energilager (43) ved målrettet sænkning af energiniveauet i mellemkredsen (42) til en forudbestemmelig lav værdi af energiniveauet i afhængighed af energilagerets (43) kapacitet, hvorved energilageret (43) efter sænkningen af energiniveauet er udformet til optagelse af en energimængde, der opstår ved afslutningen af den springagtige spændingsforstyrrelse i mellemkredsen (42).
2. Fremgangsmåde ifølge krav 1, kendetegnet ved sænkning af energiniveauet ved aktivering af en mellemkreds-chopper (45), indtil den lave værdi er nået.
3. Fremgangsmåde ifølge krav 1 eller 2, kendetegnet ved forudindstilling af en indstillingsværdi for mellemkredsspændingen for en på netsiden anbragt vekselretter (48) for omformeren (4), som bevirker en afladning af energilageret (43) til den lave værdi.
4. Fremgangsmåde ifølge krav 3, kendetegnet ved udvælgelse af indstillingsværdien for mellemkredsspændingen sådan, at den ved spændingsdyk ligger over spændingen i nettet (9), nærmere bestemt fortrinsvis med højst 15 %.
5. Fremgangsmåde ifølge et af kravene 1 til 4, kendetegnet ved en gentilkobling af vekselretteren (41) på generatorsiden efter dennes deaktivering under netforstyrrelsen, når den lave værdi i mellemkredsen (42) er nået.

6. Fremgangsmåde ifølge krav 5, kendetegnet ved gentilkobling først efter forløbet af en minimumsperiode siden aktiveringen af et omformer-beskyttelseskredsløb (40).

5 7. Fremgangsmåde ifølge et af kravene 1 til 4, kendetegnet ved forsinkelse af tilkoblingen af vekselretteren (41) på generatorsiden, indtil spændingen i nettet (9) har nået en forudbestemt værdi på fortrinsvis 40-80 % af den nominelle netspænding.

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8. Fremgangsmåde ifølge et af kravene 1 til 7, kendetegnet ved anvendelse af en jævnspændingsmellemkreds (42) med en kondensator som energilager (43).

15 9. Fremgangsmåde ifølge krav 8, kendetegnet ved beregning af den lave værdi som en spænding ifølge formlen

$$U_{DCMin} = \text{Max} \left(U_{\text{Netz}} \cdot \sqrt{2} \cdot k_{\text{Last1}}, U_{\text{Netz}} \cdot \sqrt{2} \cdot \frac{N - N_{\text{Syn}}}{N_{\text{Syn}}} \cdot \omega_{21\text{Gener}} \cdot k_{\text{Last2}} \right)$$

med U_{Netz} som effektivværdi af den sammenkædede netspænding, N omdrejningstallet, N_{Syn} synkronomdrejningstallet, $\omega_{21\text{Gener}}$ som vindingsforhold mellem generatorens rotor og stator og k_{Last} som lastafhængig faktor.

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10. Fremgangsmåde ifølge et af kravene 1, 2 eller 5 til 7, kendetegnet ved anvendelse af en jævnstrømsmellemkreds med en spole som energilager.

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11. Fremgangsmåde ifølge et af kravene 1 til 10, kendetegnet ved bestemmelse og sænkning til den lave værdi før detektering af en forventet springagtig spændingsforstyrrelse.

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12. Fremgangsmåde ifølge krav 11, kendetegnet ved fornyet bestemmelse og sænkning efter detektering af den springagtige spændingsforstyrrelse.

35 13. Omformer, især til vindenergianlæg med en via en vindrotor (2) fremdrevet generator (3), med henblik på indførsel af elektrisk effekt i et net (9) også under en

springagtig spændingsforstyrrelse, især spændingsdyk i nettet (9), hvor omformeren (4) har en mellemkreds (42) med et energilager (43), og der er indrettet en styringsindretning (5), kendetegnet ved, at styringsindretningen (5) har et indstillingsværdimodul (51) til indstilling af et energiniveau i mellemkredsen (42), hvilket modul er udformet til at tilvejebringe en maksimalt mulig energioptagelseskapacitet i mellemkredsens (42) energilager (43) ved målrettet sænkning af energiniveauet til en forudbestemmelig lav værdi i afhængighed af en kapacitet for energilageret (43) i mellemkredsen (42), hvor energilageret (43) efter sænkningen af energiniveauet er udformet til optagelse af en energimængde, der opstår ved afslutningen af en springagtig spændingsforstyrrelse.

14. Omformer ifølge krav 13, kendetegnet ved, at indstillingsværdimodulet (51) er udformet til at bestemme en spændingsindstillingsværdi for en på netsiden anbragt vekselretter (48) i omformeren (4), som bevirker en afladning af energilageret (43) til den lave værdi.

15. Omformer ifølge krav 13 eller 14, kendetegnet ved, at mellemkredsen (42) er en jævnspændingsmellemkreds med en kondensator som energilager (43).

16. Omformer ifølge krav 15, kendetegnet ved, at den lave værdi er en spænding ifølge formlen

$$U_{DCMin} = \text{Max} \left(U_{Netz} \cdot \sqrt{2} \cdot k_{Last1}, U_{Netz} \cdot \sqrt{2} \cdot \frac{N - N_{Syn}}{N_{Syn}} \cdot \omega_{21Gener} \cdot k_{Last2} \right)$$

med U_{Netz} som effektivværdi af den sammenkædede netspænding, N omdrejningstallet, N_{Syn} synkronomdrejningstallet, $\omega_{21Gener}$ som vindingsforhold mellem generatorens rotor og stator og k_{Last} som lastafhængig faktor.

17. Omformer ifølge krav 13 eller 14, kendetegnet ved, at mellemkredsen er en jævnstrømsmellemkreds med en spole som energilager.

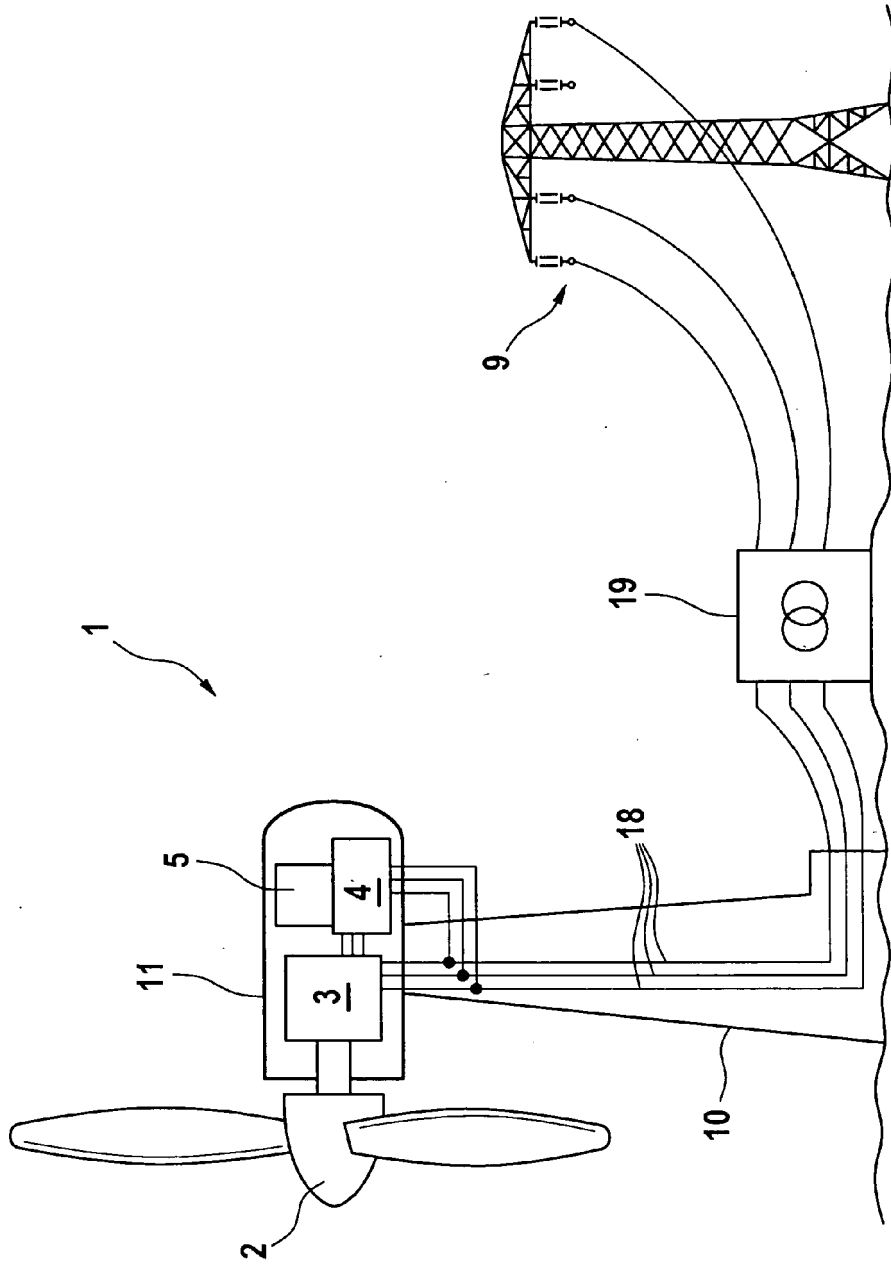


Fig. 1

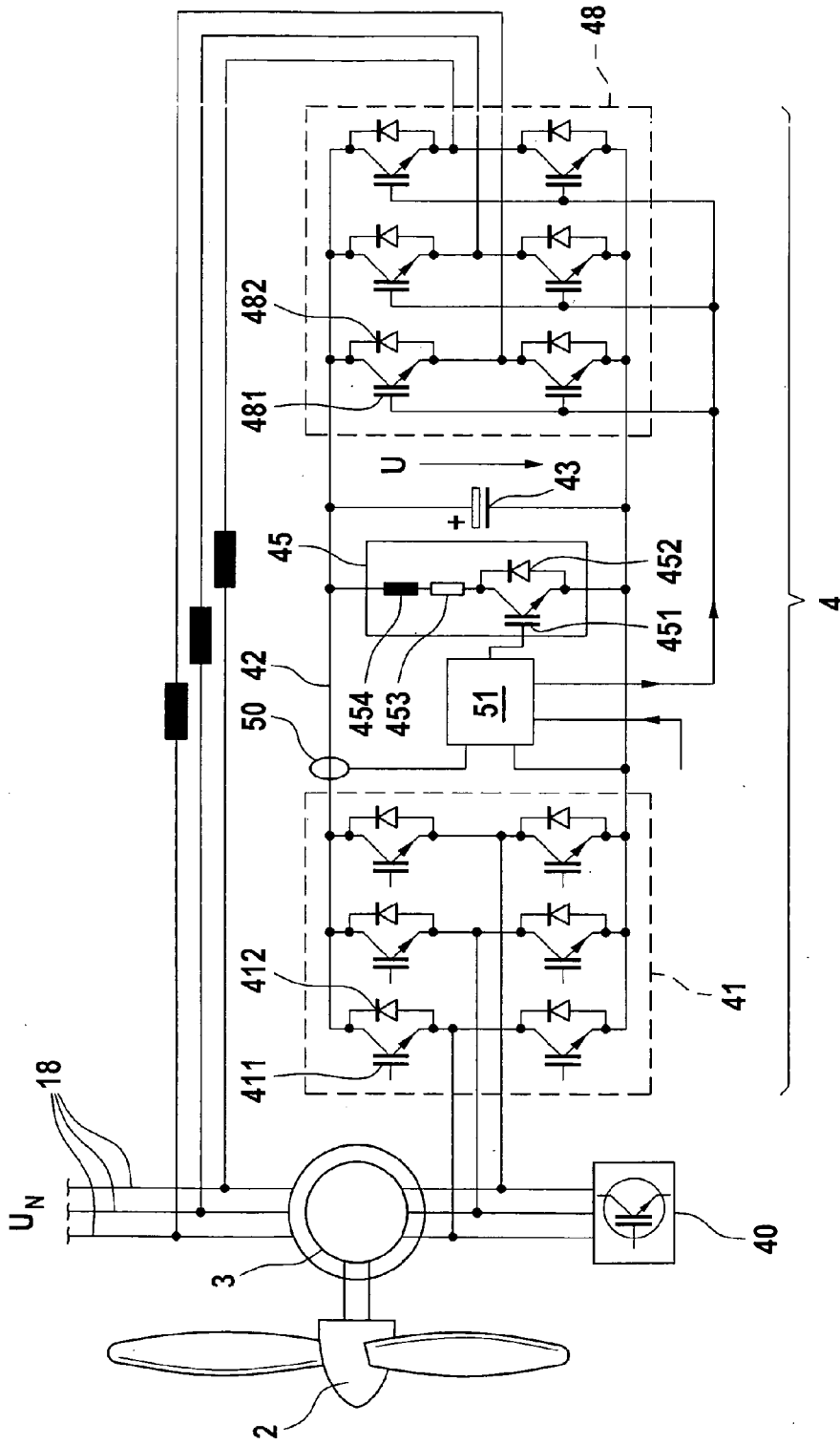


Fig. 2

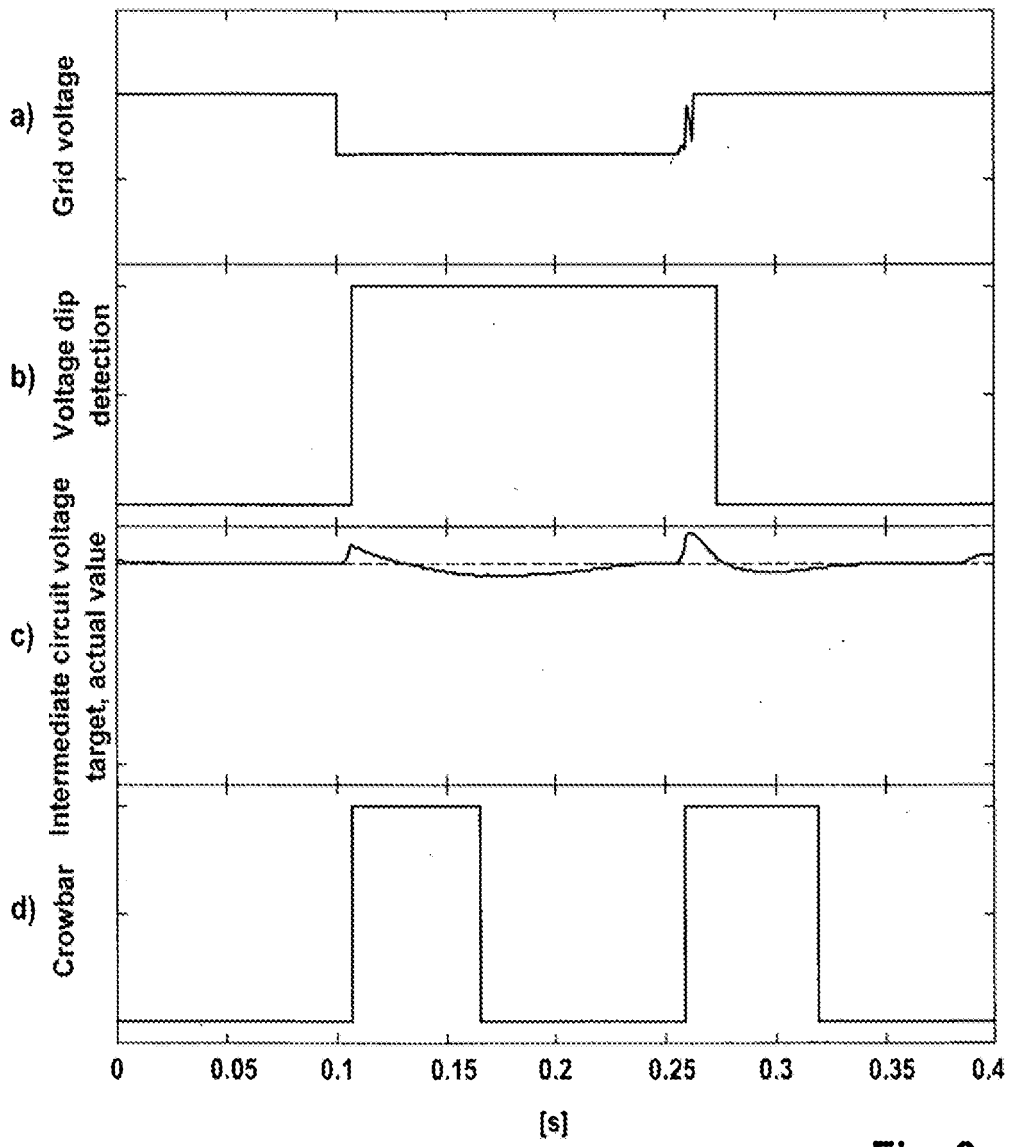


Fig. 3

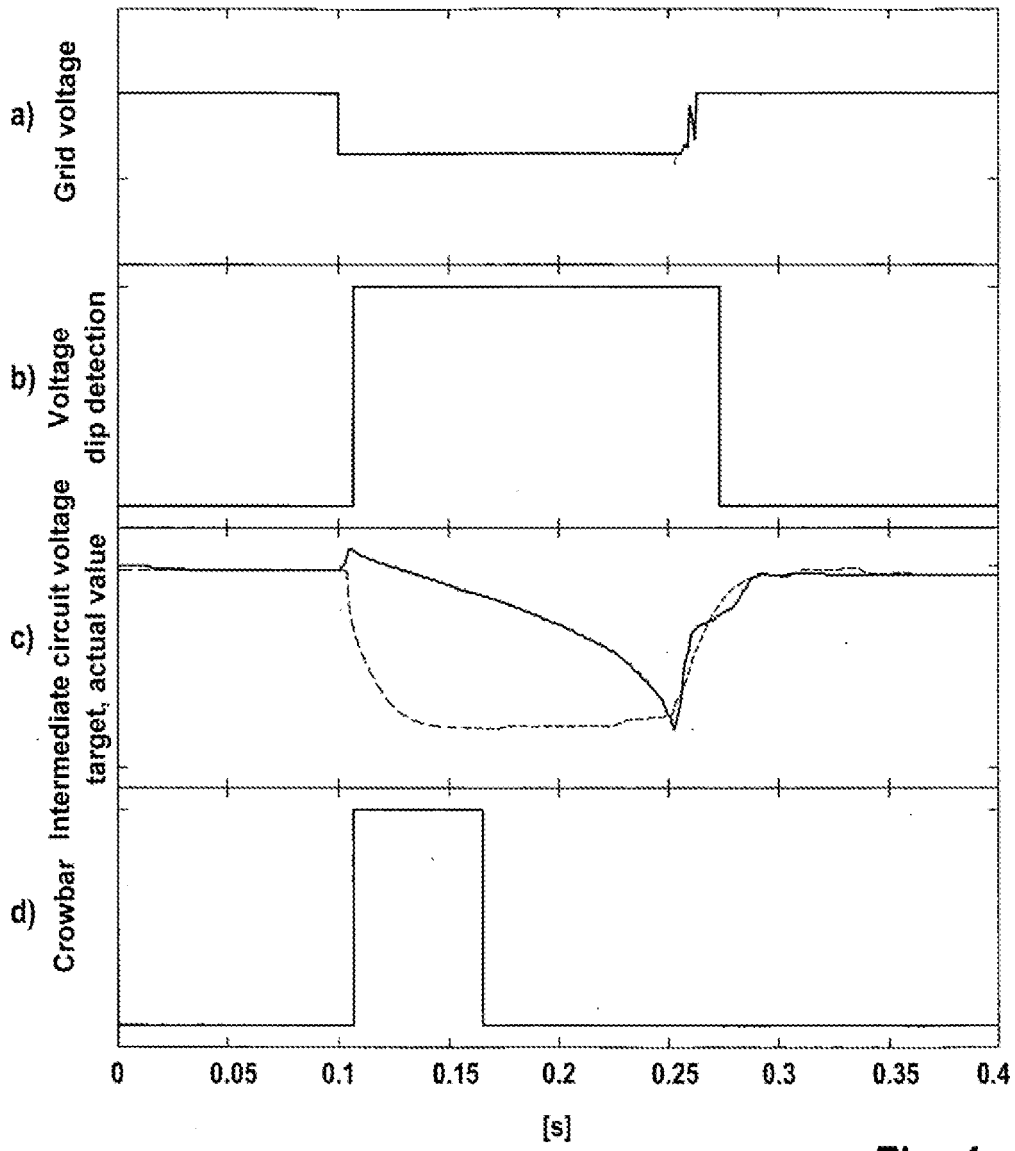


Fig. 4