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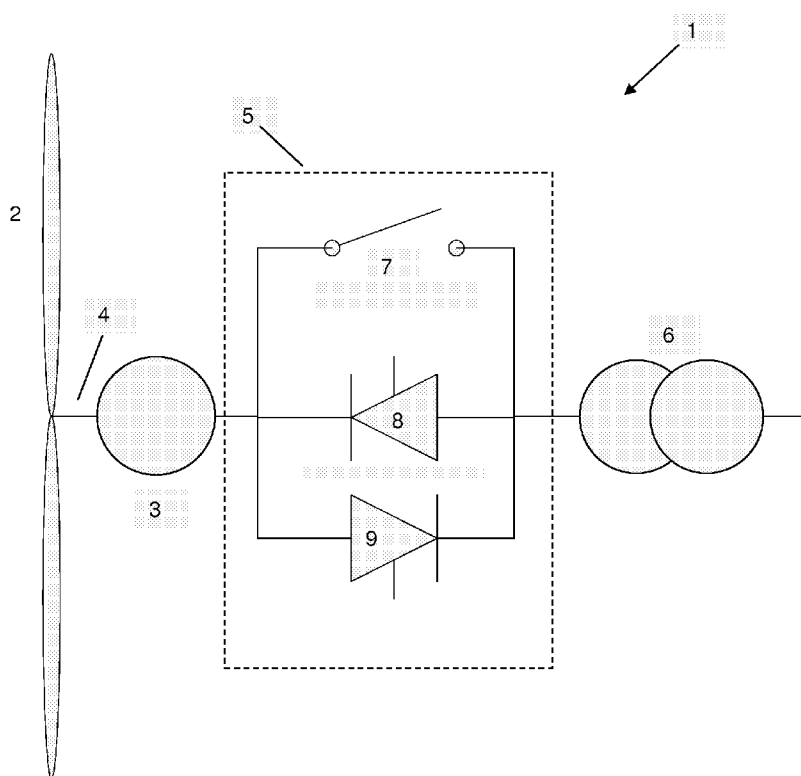
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(54) Title: METHOD AND ARRANGEMENT FOR PERFORMING VOLTAGE RIDE THROUGH IN CASE OF POWER GRID FAILURES



(57) Abstract: The present invention relates to a coupling arrangement for a wind turbine to enable ride through during power grid failures, the coupling arrangement comprising a controllable contact element being operable in a conducting and a non-conducting mode of operation, a group of controllable switching elements comprising first and second controllable switching elements, sensor means adapted to detect a working condition of the power grid, and control means adapted to control the controllable contact element and the group of controllable switching elements in response to a control signal provided by the sensor means.

Fig. 1

METHOD AND ARRANGEMENT FOR PERFORMING VOLTAGE RIDE THROUGH IN CASE OF POWER GRID FAILURES

FIELD OF THE INVENTION

The present invention relates to a coupling arrangement and a method for performing low
5 voltage ride through of a wind turbine connected to a power grid during a power grid failure. It is an advantage of the present invention that wind turbines or even wind turbine plants may remain connected to power grids during power grid failures with minimum losses. In this way wind turbines or wind turbine plants take an active part in recovering power grid failures.

BACKGROUND OF THE INVENTION

10 Various arrangements have been suggested to keep wind turbines connected to a power grid during power grid failures. A power grid failure is here to be understood as a measurable voltage dip on the power grid. An advantage of keeping wind turbines connected to a power grid is of particular importance in connection with large wind turbines or large wind power plants in combination with weak and/or small power grids.

15 WO 03/058789 relates to a power grid connection system for a wind turbine generator. The connection system according to WO 03/058789 comprises a wind turbine driven rotor and a stator electrically connected to a power grid via the power grid connection system. An electrical transient detection device is provided for delivering control signals to a controller.

The power grid connection system according to WO 03/058789 comprises current limiters in
20 the form of impedances electrically connected between the power grid and the stator windings of the generator. The current limiters are activated by the controller in response to detection of electrical transients because such electrical transients indicate power grid failures.

The system according to WO 03/058789 is capable of keeping the wind turbine generator
25 connected to the power grid during power grid failures. In this way the wind turbine generator may take an active part in stabilizing the power grid during such power grid failures.

It is a disadvantage of the power grid connection system suggested in WO 03/058789 that,
during normal working conditions, a pair of anti/parallel power electronic switches, such as
30 for example thyristors, carries, for each phase, the full current generated by the wind turbine generator. The fact that a pair of anti/parallel thyristors carries the full current generated by

wind power generator during normal working conditions introduces unnecessary losses due to non-neglectable impedances of the thyristors.

It is an object of the present invention to provide a simple and more efficient coupling arrangement to ensure low-loss ride through of a wind turbine or wind turbine plant
5 connected to a power grid during power grid failure.

SUMMARY OF THE INVENTION

The above-mentioned object is complied with providing, in a first aspect, a coupling arrangement for a wind turbine, the coupling arrangement being adapted to be electrically coupled to a stator winding of an associated wind turbine generator, and to an associated
10 power grid, the coupling arrangement comprising

- a controllable contact element being operable in a conducting and a non-conducting mode of operation, wherein the controllable contact element is adapted to be operated in the conducting mode of operation during normal power grid working conditions, and wherein the controllable contact element is adapted to be operated in
15 the non-conducting mode of operation during a power grid failure,
- a group of controllable switching elements comprising first and second controllable switching elements, wherein the controllable first and second switching elements are adapted to be operated in a non-conducting mode of operation during normal power grid working conditions, and wherein the controllable first and second switching
20 elements are adapted to be activated during a power grid failure,
- sensor means adapted to detect a working condition of the power grid, and
- control means adapted to control the controllable contact element and the group of controllable switching elements in response to a control signal provided by the sensor means.

25 The coupling arrangement ensures that for example a wind turbine generator may remain connected to a power grid during power grid failures. This phenomena is normally referred to as voltage or low voltage ride through.

In wind turbines adapted to ride through a power grid failure in the form of a grid voltage dip the coupling arrangement is used to control inrush currents and limit the torque on the

generator shaft during grid voltage recovery. During normal operation conditions the controllable contact element is closed and the first and second controllable switching elements are bypassed and therefore turned off. If a grid voltage dip is detected, the first and second controllable switching elements are activated so that they are fully capable of overtaking the current when the controllable contact element is opened. The first and second controllable switching elements are now ready to control the inrush current and the torque on the generator shaft when the grid voltage recovers. This implies that the coupling arrangement according to the present invention is capable of reducing the loads on wind turbine gearboxes and the rest of the mechanical wind turbine system. In this way it may be prevented that the maximum mechanical load of the gearbox is not exceeded.

In case of the three-phase generator system a coupling arrangement is required for each phase of the generator system. The working condition of the power grid may be determined by measuring a grid voltage level of one or more phases. Hence, normal working conditions may be present as long as the measured grid voltage level is in the vicinity of a nominal grid voltage level. The term vicinity is here to be understood as a grid voltage dip of up to 25-30% of the nominal grid voltage level.

The first and second switching elements may be arranged in parallel with the controllable contact element. In addition, the first and second switching elements may be arranged in an anti/parallel arrangement where the first and second switching elements are arranged to conduct positive voltage half cycles of opposite directions.

The first switching element may comprise a first thyristor. Similarly, the second switching element may comprise a second thyristor. Alternatively, the first and second switching elements may comprise a first and a second IGBT, respectively. The controllable contact element may be an electronic contactor or a high power circuit breaker.

The sensor means may comprise voltage sensor means adapted to measure a power grid voltage. The voltage sensor means may have a bandwidth of several kHz or even higher. The voltage may be measured on the grid-side of the group of controllable switching elements.

Furthermore, the sensor means may be adapted to provide a control signal to the control means in response to a measured power grid voltage level. Such control signal may be a voltage representation of the measured power grid voltage level. If the measured power grid voltage level drops below a predetermined level, such as below 70 percent of the nominal grid voltage, the control means may initiate triggering of the controllable switching elements. When the controllable switching elements are fully conducting, i.e. capable of carrying the

current generated by the associated wind turbine generator, the control means brings the controllable contact element to the non-conducting mode of operation as long as needed, i.e. as long as the power grid failure is present. When the power grid voltage has recovered to at least 80 percent of the nominal grid voltage level the controllable contact element is switched
5 to the conducting mode of operation and the controllable switching elements are de-activated by removing the triggering pulses.

In a second aspect, the present invention relates to a wind turbine comprising a first coupling arrangement electrically coupled to a first stator winding of a generator of the wind turbine, and to an associated power grid, the first coupling arrangement comprising

- 10 - a first controllable contact element being operable in a conducting and a non-conducting mode of operation, wherein the first controllable contact element is adapted to be operated in the conducting mode of operation during normal working conditions, and wherein the first controllable contact element is adapted to be operated in the non-conducting mode of operation during a power grid failure,
- 15 - a first group of controllable switching elements comprising first and second controllable switching elements, wherein the controllable first and second switching elements are adapted to be operated in a non-conducting mode of operation during normal working conditions, and wherein the controllable first and second switching elements are adapted to be activated during a power grid failure,
- 20 - first sensor means adapted to detect a working condition of the power grid, and
- first control means adapted to control the first controllable contact element and the first group of controllable switching means in response to a first control signal provided by the first sensor means.

Again, the working condition of the power grid may be determined by measuring a grid
25 voltage level of one or more phases. Hence, normal working conditions may be present as long as the measured grid voltage level is in the vicinity of a nominal grid voltage level.

The wind turbine according to the second aspect may further comprise transformer means electrically coupled to the first coupling arrangement and the power grid. The transformer may be a three-phase transformer adapted to transform the generator voltage level to a
30 suitable power grid voltage level which may be higher than the generator voltage level.

The first group of controllable switching elements may be arranged in parallel with the first controllable contact element. Also, the first and second switching elements of the first group of controllable switching elements may be arranged in a anti/parallel arrangement. The first switching element may comprise a first thyristor. Similarly, the second switching element
5 may comprise a second thyristor. Alternatively, the first and second switching elements may comprise a first and a second IGBT, respectively. The controllable contact element may be an electronic contactor or a high power circuit breaker.

Similar to the first aspect of the present invention the first sensor means may comprise voltage sensor means adapted to measure a power grid voltage. The voltage sensor means
10 may have a bandwidth of several kHz or even higher. The voltage may be measured on the grid-side of the first group of controllable switching elements.

Alternatively or in addition, the wind turbine may further comprise current sensor means adapted to measure a current flowing between the power grid and the wind turbine. The current sensor means may have a bandwidth of several kHz or even higher.

15 Furthermore, the first sensor means may be adapted to provide a control signal to the first control means in response to a measured power grid voltage level. Such control signal may be a voltage representation of the measured power grid voltage level. If the measured power grid voltage level drops below a predetermined level, such as below 70 percent of the nominal grid voltage, the first control means may initiate triggering of the controllable
20 switching elements of the first group. When said controllable switching elements are fully conducting, i.e. capable of carrying the current generated by the associated wind turbine generator, the first control means brings the first controllable contact element to the non-conducting mode of operation as long as needed, i.e. as long as the power grid failure is present. When the power grid voltage has recovered to at least 80 percent of the nominal
25 grid voltage level the first controllable contact element is switched to the conducting mode of operation and the controllable switching elements of the first group are de-activated by removing the triggering pulses.

The wind turbine according to the second aspect may further comprise a second coupling arrangement electrically coupled to a second stator winding of the generator of the wind
30 turbine, and to the associated power grid, the second coupling arrangement comprising

- a second controllable contact element being operable in a conducting and a non-conducting mode of operation, wherein the second controllable contact element is adapted to be operated in the conducting mode of operation during normal working

conditions, and wherein the second controllable contact element is adapted to be operated in the non-conducting mode of operation during a power grid failure,

- 5 - a second group of controllable switching elements comprising first and second controllable switching elements, wherein the controllable first and second switching elements are adapted to be operated in a non-conducting mode of operation during normal working conditions, and wherein the controllable first and second switching elements are adapted to be activated during a power grid failure,
- 10 - second sensor means adapted to detect a working condition of the power grid, and
- 10 - second control means adapted to control the second controllable contact element and the second group of controllable switching means in response to a second control signal provided by the second sensor means.

In addition, the wind turbine according to the second aspect may further comprise a third coupling arrangement electrically coupled to a third stator winding of the generator of the wind turbine, and to the associated power grid, the third coupling arrangement comprising

- 15 - a third controllable contact element being operable in a conducting and a non-conducting mode of operation, wherein the third controllable contact element is adapted to be operated in the conducting mode of operation during normal working conditions, and wherein the third controllable contact element is adapted to be operated in the non-conducting mode of operation during a power grid failure,
- 20 - a third group of controllable switching elements comprising first and second controllable switching elements, wherein the controllable first and second switching elements are adapted to be operated in a non-conducting mode of operation during normal working conditions, and wherein the controllable first and second switching elements are adapted to be activated during a power grid failure,
- 25 - third sensor means adapted to detect a working condition of the power grid, and
- third control means adapted to control the third controllable contact element and the third group of controllable switching means in response to a third control signal provided by the third sensor means.

In terms of implementation the second and third coupling arrangements may be configured following the design routes outlined in connection with the first coupling arrangement. Similarly, the second and third coupling arrangements may be operated as outlined in connection with the first coupling arrangement.

- 5 Thus, by applying a first, a second and a third coupling arrangement as suggested above a complete three-phase coupling arrangement is provided. The first, second and third coupling arrangements may be connected to a three-phase wind turbine generator whereby each phase of the wind turbine generator becomes operatively connected to a three-phase power grid via a coupling arrangement according to the first aspect of the present invention.
- 10 In a third aspect, the present invention relates to a method for performing ride through during a power grid failure in a wind turbine connected to a power grid, the method comprising the steps of
- providing, for each phase of a generator of the wind turbine, a coupling arrangement comprising a group of controllable switching elements comprising first and second
15 controllable switching elements, said group of controllable switching elements being provided in parallel with a provided controllable contact element of the coupling arrangement, said controllable contact element being operable in a conducting and a non-conducting mode of operation,
 - activating the controllable first and second switching elements when a power grid
20 failure is detected, and
 - switching the controllable contact element from the conducting mode of operation to the non-conducting mode of operation when the controllable first and second switching elements have been activated.

25 As previously stated ride through means that the wind turbine generator remains connected to a power grid during power grid failures. In this way wind turbines or even wind turbine plants may take an active part in recovering power grid failures.

The coupling arrangement may be electrically coupled to a stator winding of the wind turbine generator. In addition the coupling arrangement may be electrically coupled to the power grid, optionally through a power grid transformer.

30 A power grid failure may be detected when a power grid voltage level is reduced to less than 90 percent, such as less than 80 percent, such as less than 70 percent, of a nominal power

grid voltage level. Thus, a power grid voltage dip to less than 70 percent of a nominal power grid voltage level normally indicates that a power grid failure has occurred. Voltage sensor means may be provided to measure and monitor the grid voltage. The voltage sensor means may be adapted to provide a control signal to a control means in response to a measured power grid voltage level. Such control signal may be a voltage representation of the measured power grid voltage level. Thus, if the measured power grid voltage level drops below a predetermined level, such as the above-mentioned 70 percent of the nominal grid voltage, the control means may initiate triggering of the controllable switching elements. The first and second switching elements may be arranged in an anti-parallel arrangement, and they may each comprise a thyristor.

When the controllable switching elements are fully conducting, i.e. capable of carrying the current generated by the associated wind turbine generator, the control means brings the controllable contact element to the non-conducting mode of operation as long as needed, i.e. as long as the power grid failure is present.

When the power grid voltage has recovered to at least 80-90 percent of the nominal grid voltage level the controllable contact element is switched to the conducting mode of operation and the controllable switching elements are de-activated by removing the triggering pulses.

In a fourth aspect, the present invention relates to a method for performing ride through during a power grid failure in a wind turbine connected to a power grid, the method comprising the steps of

- electrically connecting, optionally through a transformer, a wind turbine generator stator winding to the power grid via a group of controllable switching elements comprising first and second controllable switching elements at least during part of the duration of the power grid failure, said group of controllable switching elements being provided in parallel with a controllable contact element,
- breaking an electrical connection between the wind turbine generator stator winding and the power grid by operating the controllable contact element in a non-conducting mode of operation at least during part of the duration of the power grid failure, and
- re-establishing said electrical connection between the wind turbine generator stator winding and the power grid by operating the controllable contact element in a conducting mode of operation when the power grid failure is no longer present.

When the electrical connecting between the wind turbine generator stator winding and the power grid by operating the controllable contact element in a conducting mode of operation has been re-established the first and second controllable switching elements may be de-activated. De-activation may be accomplished by not providing triggering pulses to the
5 controllable switching elements.

In terms of implementation the method according to the fourth aspect may be implemented following the design routes outlined in connection with the method according to the third aspect.

BRIEF DESCRIPTION OF THE INVENTION

10 The present invention will now be explained in further details with reference to accompanying Fig. 1 which illustrates a coupling arrangement according to the present invention.

While the invention is susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in Fig. 1 and will be described in details
15 herein. It should be understood, however, that the invention is not intended to be limited to the particular forms disclosed. Rather, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

20 In its broadest aspect the present invention relates to a coupling arrangement and to an associated method for ensuring low-loss ride through during a power grid failure. Ride through is here to be understood as keeping a wind turbine or a wind turbine plant connected to a power grid during a power grid failure causing a measurable voltage dip on the power grid. By maintaining the electrical connection between the wind turbine or the wind turbine
25 plant and the power grid the wind turbine or wind turbine plant may take an active part in stabilizing the power grid during a grid failure. By stabilizing the power grid normal operation conditions may be reached within a shorter period of time.

Fig. 1 shows the relevant parts of a wind turbine 1 according to the present invention. Fig. 1 depicts a set of rotatably mounted rotor blades 2 connected to a rotor (not shown) of the generator system 3 via a rotor blade shaft 4. Optionally, a gearing (not shown) may be
30 inserted between the rotor blades 2 and the rotor of the generator system 3.

The generator system 3 may comprise various types of generators, such as three phase or n-times three phase induction or synchronous generators. The synchronous generator can be magnetized either from permanent magnets, from an excitation system or a combination thereof.

- 5 A coupling arrangement 5 is electrically connected to each power generating phase of the generator system 3. For simplicity reasons only one phase is schematically depicted in Fig. 1. Preferably, the coupling arrangement 5 is connected to the power grid (not shown) via a grid transformer 6 – the latter transforming the generator voltage to a suitable power grid voltage. The generator voltage is typically below 1 kV or in the medium voltage range 2 kV to
10 10 kV.

The coupling arrangement 5 comprises a bypass contactor 7 and a pair of anti/parallel thyristors 8, 9. The thyristors 8, 9 could in principle be replaced by a pair of IGBTs with appropriate control electronics, such as a suitable controller for generating triggering pulses in the form of PWM pulses.

- 15 The bypass contactor 7 is intended to be closed during normal working conditions, i.e. when no power grid failure is present. Thus, during normal working conditions the power generated by the generator system 3 is provided to the power grid with minimum losses because the generated power flows freely to the power grid via the bypass contactor 7. As long as no power grid failure is detected the thyristors 8, 9 are kept deactivated, i.e. no triggering
20 pulses are provided to the thyristors 8, 9.

- When a power grid failure is detected in form of a voltage dip the thyristors 8, 9 are activated by generating and providing triggering pulses to said thyristors. A voltage dip to around 70 percent of the nominal grid voltage level may initiate triggering of the thyristors. The delay angle, ϕ , of the triggering pulses may be varied from 180 degrees, corresponding to a fully
25 blocked thyristor, to zero degrees which corresponds to a fully conducting thyristor. However, the nature of the power grid failure and thereby the size of the voltage grid dip may also cause the thyristors to be operated at a reduced mode – for example at a delay angle of 30 degrees.

- When the thyristors 8, 9 have been activated at the desired level the connection through the
30 bypass contactor can be broken so that the ride through is established via a connection provided through thyristors 8, 9. Thus, during a detected grid failure the connection between the wind turbine and the power grid is maintained through thyristors 8, 9 for a given phase.

When the working conditions are normalized, i.e. when the power grid voltage has recovered to around 85-100 percent of its nominal value the bypass contactor 7 is closed and the triggering pulses to the thyristors 8, 9 are removed causing the thyristors to automatically close down.

- 5 To determine whether a power grid failure is present a voltage sensor and a suitable electronic control circuit for controlling the bypass contactor and the thyristors is required. Such voltage sensor and electronic control circuit are well-known elements in the field of power electronics.

- 10 Also, the delay angle of the triggering pulses to the thyristors may be generated in response to a measured torque on the rotor blade shaft 4. Thus, by providing means for constantly measuring the torque on the rotor blade shaft 4 or using other ways of deriving the torque, such as estimation based on other turbine parameter, the delay angle of the triggering pulses can be adjusted so as to reduce the risk the damaging the rotor blade shaft 4 or damaging a gearing during power grid failures.

CLAIMS

1. A coupling arrangement for a wind turbine, the coupling arrangement being adapted to be electrically coupled to a stator winding of an associated wind turbine generator, and to an associated power grid, the coupling arrangement comprising
- 5 - a controllable contact element being operable in a conducting and a non-conducting mode of operation, wherein the controllable contact element is adapted to be operated in the conducting mode of operation during normal power grid working conditions, and wherein the controllable contact element is adapted to be operated in the non-conducting mode of operation during a power grid failure,
- 10 - a group of controllable switching elements comprising first and second controllable switching elements, wherein the controllable first and second switching elements are adapted to be operated in a non-conducting mode of operation during normal power grid working conditions, and wherein the controllable first and second switching elements are adapted to be activated during a power grid failure,
- 15 - sensor means adapted to detect a working condition of the power grid, and
- control means adapted to control the controllable contact element and the group of controllable switching elements in response to a control signal provided by the sensor means.
2. A coupling arrangement according to claim 1, wherein the first and second switching
- 20 elements are arranged in parallel with the controllable contact element.
3. A coupling arrangement according to claim 1 or 2, wherein the first and second switching elements are arranged in a anti/parallel arrangement.
4. A coupling arrangement according to any of claims 1-3, wherein the first switching element comprises a first thyristor.
- 25 5. A coupling arrangement according to any of claims 1-4, wherein the second switching element comprises a second thyristor.
6. A coupling arrangement according to any of claims 1-3, wherein the first and second switching elements comprise a first and a second IGBT, respectively.

7. A coupling arrangement according to any of claims 1-6, wherein the sensor means comprises voltage sensor means adapted to measure a power grid voltage, and wherein the sensor means is adapted to provide a control signal to the control means in response to a measured power grid voltage level.

5 8. A wind turbine comprising a first coupling arrangement electrically coupled to a first stator winding of a generator of the wind turbine, and to an associated power grid, the first coupling arrangement comprising

- 10 - a first controllable contact element being operable in a conducting and a non-conducting mode of operation, wherein the first controllable contact element is adapted to be operated in the conducting mode of operation during normal working conditions, and wherein the first controllable contact element is adapted to be operated in the non-conducting mode of operation during a power grid failure,
- 15 - a first group of controllable switching elements comprising first and second controllable switching elements, wherein the controllable first and second switching elements are adapted to be operated in a non-conducting mode of operation during normal working conditions, and wherein the controllable first and second switching elements are adapted to be activated during a power grid failure,
- first sensor means adapted to detect a working condition of the power grid, and
- 20 - first control means adapted to control the first controllable contact element and the first group of controllable switching means in response to a first control signal provided by the first sensor means.

9. A wind turbine according to claim 8, further comprising transformer means electrically coupled to the first coupling arrangement and the power grid.

25 10. A wind turbine according to claim 8 and 9, wherein the first group of controllable switching elements are arranged in parallel with the first controllable contact element.

11. A wind turbine according to any of claims 8-10, wherein the first and second switching elements of the first group of controllable switching elements are arranged in a anti/parallel arrangement.

12. A wind turbine according to any of claims 8-11, wherein the first switching element comprises a first thyristor.
13. A wind turbine according to any of claims 8-12, wherein the second switching element comprises a second thyristor.
- 5 14. A wind turbine according to any of claims 8-11, wherein the first and second switching elements comprise a first and a second IGBT, respectively.
15. A wind turbine according to any of claims 8-14, wherein the first sensor means comprises voltage sensor means adapted to measure a power grid voltage, and wherein first sensor means is adapted to provide a first control signal to the first control means in response to a
10 measured power grid voltage level.
16. A wind turbine according to any of claims 8-15, further comprising current sensor means adapted to measure a current flowing between the power grid and the wind turbine.
17. A wind turbine according to any of claims 8-16, further comprising a second coupling arrangement electrically coupled to a second stator winding of the generator of the wind
15 turbine, and to the associated power grid, the second coupling arrangement comprising
- a second controllable contact element being operable in a conducting and a non-conducting mode of operation, wherein the second controllable contact element is adapted to be operated in the conducting mode of operation during normal working conditions, and wherein the second controllable contact element is adapted to be
20 operated in the non-conducting mode of operation during a power grid failure,
 - a second group of controllable switching elements comprising first and second controllable switching elements, wherein the controllable first and second switching elements are adapted to be operated in a non-conducting mode of operation during normal working conditions, and wherein the controllable first and second switching
25 elements are adapted to be activated during a power grid failure,
 - second sensor means adapted to detect a working condition of the power grid, and
 - second control means adapted to control the second controllable contact element and the second group of controllable switching means in response to a second control signal provided by the second sensor means.

18. A wind turbine according to any of claims 8-17, further comprising a third coupling arrangement electrically coupled to a third stator winding of the generator of the wind turbine, and to the associated power grid, the third coupling arrangement comprising

- 5 - a third controllable contact element being operable in a conducting and a non-conducting mode of operation, wherein the third controllable contact element is adapted to be operated in the conducting mode of operation during normal working conditions, and wherein the third controllable contact element is adapted to be operated in the non-conducting mode of operation during a power grid failure,
- 10 - a third group of controllable switching elements comprising first and second controllable switching elements, wherein the controllable first and second switching elements are adapted to be operated in a non-conducting mode of operation during normal working conditions, and wherein the controllable first and second switching elements are adapted to be activated during a power grid failure,
- 15 - third sensor means adapted to detect a working condition of the power grid, and
- third control means adapted to control the third controllable contact element and the third group of controllable switching means in response to a third control signal provided by the third sensor means.

19. A method for performing ride through during a power grid failure in a wind turbine connected to a power grid, the method comprising the steps of

- 20 - providing, for each phase of a generator of the wind turbine, a coupling arrangement comprising a group of controllable switching elements comprising first and second controllable switching elements, said group of controllable switching elements being provided in parallel with a provided controllable contact element of the coupling arrangement, said controllable contact element being operable in a conducting and a
- 25 non-conducting mode of operation,
- activating the controllable first and second switching elements when a power grid failure is detected, and
- switching the controllable contact element from the conducting mode of operation to the non-conducting mode of operation when the controllable first and second
- 30 switching elements have been activated.

20. A method according to claim 19, wherein the coupling arrangement is electrically coupled to a stator winding of the generator, and to the power grid.

21. A method according to claim 19 or 20, wherein a power grid failure is detected when a power grid voltage level is reduced to less than 90 percent, such as less than 80 percent,
5 such as less than 70 percent, of a nominal power grid voltage level.

22. A method according to any of claims 19-21, wherein the first and second switching elements are arranged in a anti/parallel arrangement.

23. A method according to any of claims 19-22, wherein each of the first and second switching elements comprises a thyristor.

10 24. A method according to any of claims 19-23, further comprising the step of switching the controllable contact element to the conducting mode of operation when the power grid failure is no longer present.

25. A method according to any of claims 19-24, further comprising the step of deactivating the controllable first and second switching elements when the power grid failure is no longer
15 present.

26. A method according to claim 24 or 25, wherein a power grid failure is no longer present when a power grid voltage level exceeds 90 percent, such as 85 percent, of a nominal power grid voltage level.

20 27. A method for performing ride through during a power grid failure in a wind turbine connected to a power grid, the method comprising the steps of

- electrically connecting, optionally through a transformer, a wind turbine generator stator winding to the power grid via a group of controllable switching elements comprising first and second controllable switching elements at least during part a the duration of the power grid failure, said group of controllable switching elements being
25 provided in parallel with a controllable contact element,
- breaking an electrical connection between the wind turbine generator stator winding and the power grid by operating the controllable contact element in a non-conducting mode of operation at least during part of the duration of the power grid failure, and

- re-establishing said electrical connecting between the wind turbine generator stator winding and the power grid by operating the controllable contact element in a conducting mode of operation when the power grid failure is no longer present.

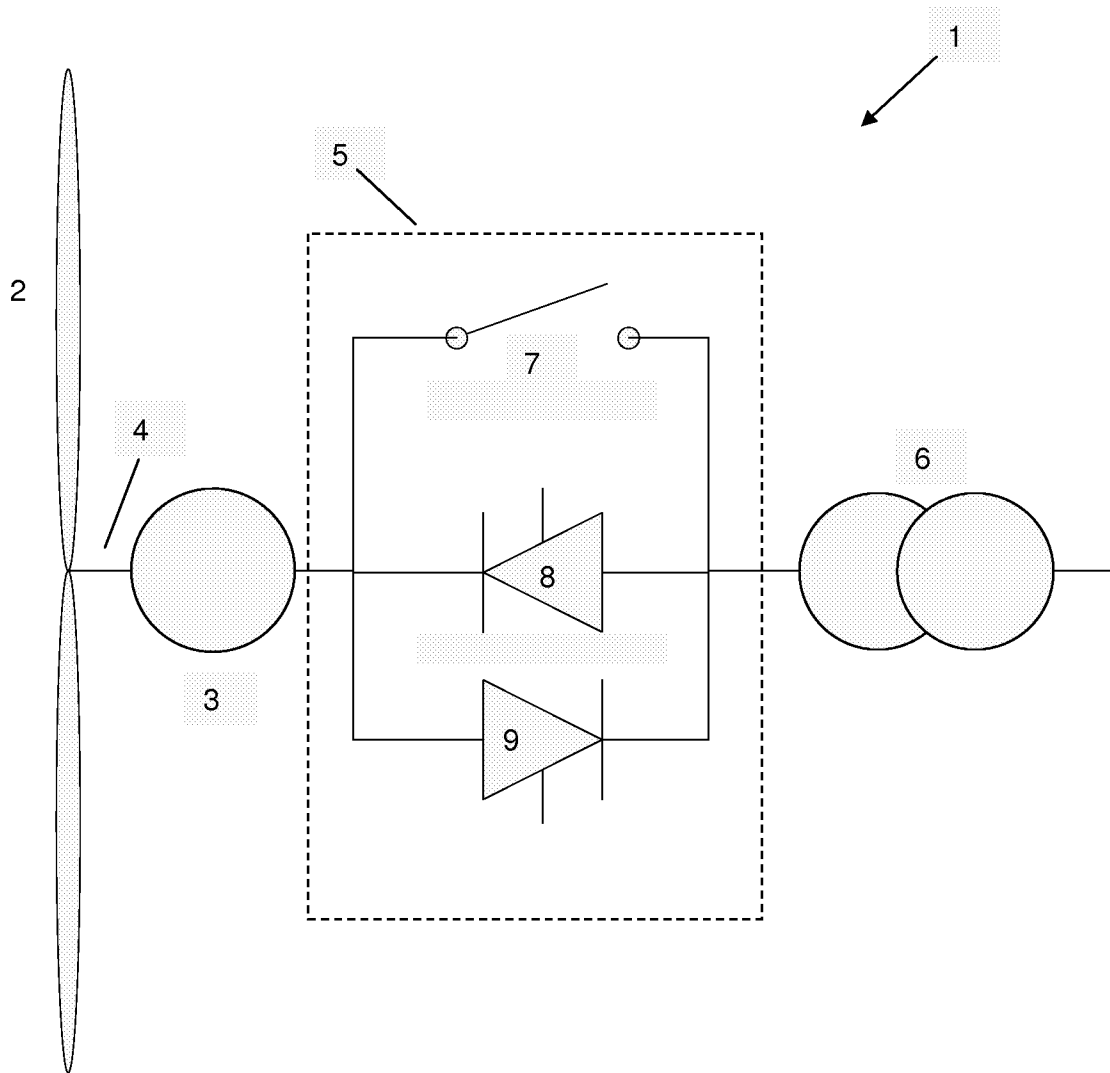


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2007/055350

A. CLASSIFICATION OF SUBJECT MATTER

INV. H02J3/24 H02J3/38 H02H7/06

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H02J H02H

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/200337 A1 (SCHREIBER DEJAN [DE] ET AL) 15 September 2005 (2005-09-15) the whole document	1-27
X	WO 2007/027141 A (ABB RESEARCH LTD [CH]; GERTMAR LARS [SE]; CHRISTENSEN HANS CHRISTIAN []) 8 March 2007 (2007-03-08) abstract paragraph [0052] paragraph [0054] claims 7-10 figures 1,4	1-27

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

- 'A' document defining the general state of the art which is not considered to be of particular relevance
- 'E' earlier document but published on or after the international filing date
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Date of the actual completion of the international search

14 March 2008

Date of mailing of the international search report

04/04/2008

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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CHEN Z ET AL: "Stability improvement of induction generator-based wind turbine systems" IET RENEW. POWER GNERATION, vol. 1, no. 1, 12 March 2007 (2007-03-12), pages 81-93, XP006028299 abstract figure 2 -----	1,3-5,8, 11-13, 19,21-23
A	US 6 134 124 A (JUNGREIS AARON M [US] ET AL) 17 October 2000 (2000-10-17) abstract figures -----	1,3-5,8, 11-13, 19,21-23
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2007/055350

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