CLAIMS

1. Arrangement (102) for controlling a synchronous generator (105) having a stator (129) comprising at least one stator winding (131) and having a rotor (137) with an electromagnet (139) driven by a field current (127), the rotor (137) being rotatable relative to the stator (129), the electromagnet (139) being inductively coupled to the stator winding (131), the arrangement (102) comprising:

a measurement system adapted to measure at least one quantity (167, 165, 168, 169, 171);

a controller (103) adapted to cause shutting down the field current (127), if the quantity satisfies at least one criterion associated with at least one malfunction,

wherein the at least one quantity (167, 165, 168, 169, 171) includes at least one quantity (169, 171) indicative of a operating condition of a rectifier circuit (115) connected to the output terminal (133) of the stator winding (131),

wherein the at least one quantity (167, 165, 168, 169, 171) further includes a stator current (167) and an output current (165) measured for the stator winding (131) to obtain a current difference for providing differential protection for the stator winding (131).

2. Arrangement according to claim 1, wherein the quantity is indicative of a temperature (169) of the rectifier circuit (115) connected at the output terminal (133) of the stator winding (131),

wherein the at least one criterion comprises that the temperature is greater than a temperature threshold,

or wherein the quantity is indicative of a DC voltage (171) between DC output terminals (180) of the rectifier circuit (115).

3. Arrangement according to claim 1 or 2, wherein the at least one quantity (167, 165, 168, 169, 171) further includes a quantity indicative of a operating condition of a magneti-

zation circuit (145, 147), in particular magnetization circuit current and/or magnetization circuit voltage.

4. Arrangement according to any of the preceding claims, wherein the quantity is indicative of a stator winding current (167) and/or wherein the quantity is indicative an output current (165) at an AC-output terminal (133) of the stator winding (131),
wherein the at least one criterion comprises that the stator current is above a stator current threshold and/or that the output current (177) is above an output current threshold (303),
wherein the malfunction is a short circuit state of a load connected to the output terminal.

5. Arrangement according to one of the preceding claims, wherein the controller is adapted to integrate a square of the stator winding current and/or of the output current (177) over a certain time range to obtain an integration value,
wherein the at least one criterion comprises that the integration value is greater than an integration threshold,
wherein the malfunction is an overload state of a load connected to the output terminal.

6. Arrangement according to one of the preceding claims, wherein the controller is adapted to determine

a difference between the stator winding current (167) and the output current (165) to obtain a current difference,
wherein the at least one criterion comprises that the current difference is greater than an current difference threshold,
wherein the malfunction comprises a malfunction of the generator and/or

a difference or differences between current flow of different phases of the stator winding current and/or the output current to obtain a phase associated current difference,
wherein the at least one criterion comprises that the phase associated current difference is greater than an phase associated current difference threshold,

wherein the malfunction comprises a malfunction of the generator.

7. Arrangement according to one of the preceding claims, wherein the quantity is indicative of a temperature (169) of a diode (163) of the rectifier circuit (115),
wherein the at least one criterion comprises that a change of the temperature is greater that a temperature change threshold.

8. Arrangement according to one of the preceding claims, wherein the quantity is indicative of an output voltage (168) at an AC-output terminal of the stator winding (131),
wherein the at least one criterion comprises that the output voltage is greater than an output voltage upper threshold,
wherein the malfunction is an overvoltage condition at the output terminal.

9. Arrangement according to one of the preceding claims, wherein the quantity is indicative of an output voltage (168) at an AC-output terminal (133) of the stator winding (131),
wherein the at least one criterion comprises that the output voltage is smaller than an output voltage lower threshold,
wherein the malfunction is an undervoltage condition at the output terminal.

10. Arrangement according to one of the preceding claims, wherein the quantity is indicative of an output frequency (168) of an output voltage or output current at an AC-output terminal of the stator winding,
wherein the at least one criterion comprises that the output frequency deviates more than a frequency deviation threshold from a target frequency.
wherein the malfunction is an erroneous frequency at the output terminal.

11. Generator system (101), comprising:

an arrangement (102) according to one of the preceding claims;

the synchronous generator (105) having the stator (129) comprising the at least one stator winding (131) and having the rotor (137) with the electromagnet (139) driven by the field current (127), the rotor being rotatable relative to the stator, the electromagnet (139) being inductively coupled to the stator winding (131); and

a system (125) for providing the field current (127), wherein the controller (103) is adapted to cause shutting down the field current (127) by supplying a control signal (159) to system (125) for providing the field current.

12. Generator system according to claim 11, wherein the system (125) for providing the field current comprises a slip ring mechanically coupled to the rotor and electrically coupled to the electromagnet and a brush contacting the slip ring, wherein shutting down the field current comprises interrupting current flow supplied to the brush.

13. Generator system according to claim 11, wherein the system (125) for providing the field current (127) comprises:

a rotating coil (141) mechanically coupled to the rotor (137);

a rotatable rectifier (143) mechanically coupled to the rotor (137) and electrically coupled to the rotating coil (141) and providing the field current (127) to the electromagnet (139) of the rotor (137);

a stator electromagnet (145) inductively coupled to the rotating coil (141);

a stator electromagnet supply system (147) for supplying an exciting voltage to the stator electromagnet (145), wherein shutting down the field current (127) comprises interrupting the exciting voltage to the stator electromagnet.

14. Generator system according to claim 13, wherein the stator electromagnet supply system (147) comprises at least one

controllable switch (155), in particular isolated gate bipolar transistor, driven by a gate driver circuit (157), wherein shutting down the field current (127) comprises supplying a shut-down signal (159) to the gate driver (157).

15. Generator system according to claim 14, further comprising an emergency stop switch (161) between the at least one controllable switch (155) and the stator electromagnet (145).

16. Generator system according to one of claims 11 to 15, further comprising:

a generator rectifier (115) connected to the AC-output terminal (133), in particular three AC-output terminals, the rectifier comprising in particular a diode (163) and a temperature sensor (170) for measuring the temperature (169) of the diode (163),
wherein in particular the rectifier is the only load connected to the output terminal (133) of the generator (105).

17. Energy system, in particular vessel energy system (100), comprising:

a generator system (101) according to one of claims 11 to 16 arranged for converting mechanical energy provided by a combustion engine (107) to electrical energy;

a DC-distribution system (123) coupled to the a DC-output terminal (180) of the rectifier circuit (115) for distributing the electrical energy, in particular to at least one propulsion motor.

CLAIMS

1. Arrangement (103) for controlling a synchronous generator (105) having a stator (129) comprising at least one stator winding (131) and having a rotor (137) with an electromagnet (139) driven by a field current (127), the rotor (137) being rotatable relative to the stator (129), the electromagnet (139) being inductively coupled to the stator winding (131), the arrangement (103) comprising:

a measurement system adapted to measure at least one quantity (167, 165, 168, 169, 171);

a controller adapted to cause shutting down the field current (127), if the quantity satisfies at least one criterion associated with at least one malfunction,

wherein the at least one quantity (167, 165, 168, 169, 171) includes at least one quantity (169, 171) indicative of a operating condition of a rectifier circuit (115) connected to the output terminal (133) of the stator winding (131),

wherein the at least one quantity (167, 165, 168, 169, 171) further includes a stator current (167) and an output current (165) measured for the stator winding (131) to obtain a current difference for providing differential current protection for the stator winding (131).

2. Arrangement according to claim 1, wherein the quantity is indicative of a temperature (169) of the rectifier circuit (115) connected at the output terminal (133) of the stator winding (131),

wherein the at least one criterion comprises that the temperature is greater than a temperature threshold,

or wherein the quantity is indicative of a DC voltage (171) between DC output terminals (180) of the rectifier circuit (115).

3. Arrangement according to claim 1 or 2, wherein the at least one quantity (167, 165, 168, 169, 171) further includes a quantity indicative of a operating condition of a magnetization circuit (145, 147), in particular magnetization circuit current and/or magnetization circuit voltage.

4. Arrangement according to any of the preceding claims, wherein the quantity is indicative of a stator winding current (167) and/or wherein the quantity is indicative an output current (165) at an AC-output terminal (133) of the stator winding (131),
wherein the at least one criterion comprises that the stator current is above a stator current threshold and/or that the output current (177) is above an output current threshold (303),
wherein the malfunction is a short circuit state of a load connected to the output terminal.

5. Arrangement according to one of the preceding claims, wherein the controller is adapted to integrate a square of the stator winding current and/or of the output current (177) over a certain time range to obtain an integration value,
wherein the at least one criterion comprises that the integration value is greater than an integration threshold,
wherein the malfunction is an overload state of a load connected to the output terminal.

6. Arrangement according to one of the preceding claims, wherein the controller is adapted to determine
a difference between the stator winding current (167) and the output current (165) to obtain a current difference,
wherein the at least one criterion comprises that the current difference is greater than an current difference threshold,
wherein the malfunction comprises a malfunction of the generator and/or
a difference or differences between current flow of different phases of the stator winding current and/or the output current to obtain a phase associated current difference,
wherein the at least one criterion comprises that the phase associated current difference is greater than an phase associated current difference threshold,
wherein the malfunction comprises a malfunction of the generator.

7. Arrangement according to one claims 1 to 5, wherein the controller is adapted to determine a difference between the

stator winding current (167) and the output current (165) to obtain a current difference, wherein the stator winding current is measured at one or more positions at the stator winding and/or the output current is measured at one or more positions close to or at the output terminal.

8. Arrangement according to one of the preceding claims, wherein the quantity is indicative of a temperature (169) of a diode (163) of the rectifier circuit (115),
wherein the at least one criterion comprises that a change of the temperature is greater that a temperature change threshold.

9. Arrangement according to one of the preceding claims, wherein the quantity is indicative of an output voltage (168) at an AC-output terminal of the stator winding (131),
wherein the at least one criterion comprises that the output voltage is greater than an output voltage upper threshold,
wherein the malfunction is an overvoltage condition at the output terminal.

10. Arrangement according to one of the preceding claims, wherein the quantity is indicative of an output voltage (168) at an AC-output terminal (133) of the stator winding (131),
wherein the at least one criterion comprises that the output voltage is smaller than an output voltage lower threshold,
wherein the malfunction is an undervoltage condition at the output terminal.

11. Arrangement according to one of the preceding claims, wherein the quantity is indicative of an output frequency (168) of an output voltage or output current at an AC-output terminal of the stator winding,
wherein the at least one criterion comprises that the output frequency deviates more than a frequency deviation threshold from a target frequency.
wherein the malfunction is an erroneous frequency at the output terminal.

12. Generator system (101), comprising:

an arrangement (103) according to one of the preceding claims;

the synchronous generator (105) having the stator (129) comprising the at least one stator winding (131) and having the rotor (137) with the electromagnet (139) driven by the field current (127), the rotor being rotatable relative to the stator, the electromagnet (139) being inductively coupled to the stator winding (131); and

a system (125) for providing the field current (127), wherein the controller is adapted to cause shutting down the field current (127) by supplying a control signal (159) to system (125) for providing the field current.

13. Generator system according to claim 12, wherein the system (125) for providing the field current comprises a slip ring mechanically coupled to the rotor and electrically coupled to the electromagnet and a brush contacting the slip ring, wherein shutting down the field current comprises interrupting current flow supplied to the brush.

14. Generator system according to claim 12, wherein the system (125) for providing the field current (127) comprises:

a rotating coil (141) mechanically coupled to the rotor (137);

a rotatable rectifier (143) mechanically coupled to the rotor (137) and electrically coupled to the rotating coil (141) and providing the field current (127) to the electromagnet (139) of the rotor (137);

a stator electromagnet (145) inductively coupled to the rotating coil (141);

a stator electromagnet supply system (147) for supplying an exciting voltage to the stator electromagnet (145), wherein shutting down the field current (127) comprises interrupting the exciting voltage to the stator electromagnet.

15. Generator system according to claim 14, wherein the stator electromagnet supply system (147) comprises at least one controllable switch (155), in particular isolated gate bipolar transistor, driven by a gate driver circuit (157),

wherein shutting down the field current (127) comprises supplying a shut-down signal (159) to the gate driver (157).

16. Generator system according to claim 15, further comprising an emergency stop switch (161) between the at least one controllable switch (155) and the stator electromagnet (145).

17. Generator system according to one of claims 12 to 16, further comprising:

a generator rectifier (115) connected to the AC-output terminal (133), in particular three AC-output terminals, the rectifier comprising in particular a diode (163) and a temperature sensor (170) for measuring the temperature (169) of the diode (163),

wherein in particular the rectifier is the only load connected to the output terminal (133) of the generator (105).

18. Energy system, in particular vessel energy system (100), comprising:

a generator system (101) according to one of claims 11 to 16 arranged for converting mechanical energy provided by a combustion engine (107) to electrical energy;

a DC-distribution system (123) coupled to the a DC-output terminal (180) of the rectifier circuit (115) for distributing the electrical energy, in particular to at least one propulsion motor.