A DC-POWER SYSTEM WITH SYSTEM PROTECTION CAPABILITIES

TECHNICAL FIELD

The present disclosure generally relates to power systems and in particular to a DC-power system with protection capabilities.

BACKGROUND

Power systems typically comprise a plurality of components, such as one or more power generation source, drives and energy storage modules. These components are typically interconnected by means of a busbar system in which currents can flow for providing power to one or more loads connected to the power system.

At some point a fault, such as a short circuit will inevitably occur in the power system, either in the busbar system, in one of the components of the system, or in a load. In case of a fault, it is important to isolate the fault from the healthy part of the system such that normal power provision can be continued by means of the healthy part, and for protecting the healthy parts from being damaged. For this purpose, a protection system is typically included in the power system.

A protection system arranged to handle faults in a power system typically comprise monitoring equipment arranged to monitor electrical parameters such as currents in the power system, and circuit breakers controlled by the monitoring equipment. The circuit breakers are arranged in such a way in the power system that selective fault isolation can be obtained in case of a fault.

US2003/0071633 discloses an AC electric power supply network (*sic*) comprising a bus system and feeders for distributing power to remote locations. Between each line and the bus is provided a breaker.

EP1843443 discloses a DC electrical current busbar associated with electrical load circuits and devices as well as sources requires protection. In order to provide such protection Kirchoff's laws are utilised such that electrical current

values are substantially simultaneously taken and summed in order to identify deviations from expected differential threshold values. Upon detection of such deviations and generally as a result of a number of successive deviations an electrical isolation device is utilised in order to isolate electrical current to the busbar. The data set of electrical current values can be utilised in order to provide a back up protection system for individual electrical load devices and circuits, by similar comparison with expected values for those devices and circuits.

GB1151457 discloses a safety device for inverters supplying asynchronous motors. In the background section of this disclosure, it is mentioned that "in the case of faults in the inverter equipment, representing a short circuit of the d.c. circuit, the smoothing capacitor is discharged through the short circuit. Since the smoothing capacitor has a high capacitance, the discharge current may reach very high values. This causes the response of the fuses connected upstream of the current converters in known circuits. In consequence, the converters are disconnected from the short circuit."

WO2011/141052 discloses a plant for transmitting electric power comprises a high voltage DC line, a DC breaker connected in series with the DC line and configured to break a fault current upon occurrence of a fault on said DC line, means configured to detect occurrence of a fault current, a control unit configured to control a said DC breaker for protecting equipment connected to the DC line upon occurrence of a the fault current and means configured to dissipate energy stored in a faulty current path of the DC line between said location and these means upon occurrence of a said fault to the moment of said control of said DC breaker. The energy dissipating means comprises a series connection of an energy consuming braking resistor and a free-wheeling rectifying member connected between ground and said DC line to conduct current while forming a free-wheeling path therethrough upon said control of said DC breaker upon occurrence of a said fault.

Existing protection systems can however in some applications be both very expensive and space consuming.

CLAIMS

1. A DC-power system (1) ~~for powering a vessel,~~ comprising:

a main DC bus (3),

a power generating unit arranged (P1, P2, P3, P4) to feed the main DC bus (3),

an isolator switch~~disconnector~~ (7) arranged between the main DC bus (3) and the power generating unit (P1, P2, P3, P4) for isolating the power generating unit (P1, P2, P3, P4) from the main DC bus (3) in case of a main DC bus fault, and

a drive unit (D1, D2) arranged to be fed by the main DC bus (3), wherein the drive unit (D1, D2) comprises a drive unit bus system (DB), converter units (I1, I2, I3) connected to the drive unit bus system (DB), and fuses (F) arranged between the drive unit bus system (DB) and the converter units (I1, I2, I3) for protecting the converter units (I1, I2, I3) in case of a drive unit fault.~~;~~

2. The DC-power system (1) as claimed in claim 1, wherein the drive unit (D1, D2) comprises a first type of input unit (17) arranged between the main DC bus (3) and the drive unit bus system (DB), and wherein the first type of input unit (17) comprises an isolator switch~~disconnector~~ for disconnecting the drive unit (D1, D2) from the main DC bus (3) in case of a drive unit fault.

3~~2~~. The DC-power system (1) as claimed in claim 2~~1~~, wherein the first type of input unit (17) comprises a current blocking device (11) arranged to block

currents in a direction from the drive unit bus system (DB) to the main DC bus (3) and to allow current to flow from the main DC bus (3) to the drive unit (D1, D2).

43. The DC-power system (1) as claimed in any of the preceding claims, comprising an energy storage unit (E) arranged to feed the main DC bus (3), wherein the energy storage unit (E) comprises an energy storage unit bus system (EB), power provision units (B, C), and fuses (F) arranged between the energy storage unit bus system (EB) and the power provision units (B, C) for protection of the power provision units (B, C) in case of an energy storage unit fault.

54. The DC-power system (1) as claimed in claim 43, wherein the energy storage unit (E) comprises a second type of input unit (9) arranged between the energy storage unit bus system (EB) and the main DC bus (3), wherein the second type of input unit (9) comprises an isolator switch~~disconnector~~ for disconnecting the energy storage unit (E) from the main DC bus (3) in case of an energy storage unit fault.

65. The DC-power system (1) as claimed in claim 54, wherein the second type of input unit (9) comprises a current blocking device (11) arranged to block currents in a direction from the energy storage unit bus system (EB) to the main DC bus (3) and to allow current to flow from the main DC bus (3) to the energy storage unit (E), and a semiconductor switching unit (13) for selectively allowing

current to bypass the current blocking device (11) and flow to the main DC bus (3).

7~~6~~. The DC-power system (1) as claimed in claim 6~~5~~, wherein the current blocking device (11) and the semiconductor switching unit (13) are connected in anti-parallel.

8~~7~~. The DC-power system (1) as claimed in any of the preceding claims, wherein the power generating unit (P1, P2, P3, P4) comprises a generator (G1, G2, G3, G4) and a rectifier (R1, R2, R3, R4), wherein the rectifier (R1, R2, R3, R4) includes a plurality of fuses (F) arranged to protect the rectifier (R1, R2, R3, R4) in case of a rectifier fault.

9~~8~~. The DC-power system (1) as claimed in claim 8~~7~~, wherein the plurality of fuses (F) included in the rectifier (R1, R2, R3, R4) are dimensioned such that they do not blow when subjected to fault currents as a result of faults downstream of the rectifier (R1, R2, R3, R4).

10. The DC-power system (1) as claimed in any of the preceding claims, wherein energy sources can limit their output voltage and currents to a level that would permit isolator switches to operate within their ratings, wherein the isolator switches (7) can disconnect power generating units (P1-P4) from the main DC bus (3).

11~~9~~. The DC-power system (1) as claimed in any of the preceding claims, wherein each converter unit (I1, I2, I3) has terminals connected to the drive unit bus (DB), wherein each terminal of a converter unit (I1, I2, I3) is connected to a fuse (F).

12~~10~~. The DC-power system (1) as claimed in any of claims 3~~2~~-11~~9~~, wherein the current blocking device (11) is a diode.

13~~11~~. The DC-power system (1) as claimed in any of claims 3~~2~~-12~~10~~, wherein the first input unit comprises a semiconductor switching unit connected in anti-parallel with the current blocking device for selectively allowing current to bypass the current blocking device and flow to the main DC bus.

14. A method of handling a fault in a DC-power system (1) comprising a main DC bus (3), power generating units arranged (P1, P2, P3, P4) to feed the main DC bus (3), an isolator switch (7) arranged between the main DC bus (3) and each power generating unit (P1, P2, P3, P4) for isolating the power generating unit (P1, P2, P3, P4) from the main DC bus (3), and a drive unit (D1, D2) arranged to be fed by the main DC bus (3), wherein the drive unit (D1, D2) comprises a drive unit bus system (DB), converter units (I1, I2, I3) connected to the drive unit bus system (DB), and fuses (F) arranged between the drive unit bus system (DB) and the converter units (I1, I2, I3) for protecting the converter units (I1, I2, I3) in case of a drive unit fault, wherein the method comprises:

limiting, in the situation when a fault has occurred in the DC-power system (1), the voltage output and currents of energy sources, to a level that permits isolator switches (7) to operate within their ratings, wherein the isolator switches (7) can disconnect power generating units from the main DC bus (3).

15. The method as claimed in claim 14, wherein the power generating units comprise generators and rectifiers, wherein the limiting involves controlling the rectifiers such that their output voltage and currents are limited to a level that permits isolator switches to operate within their ratings.