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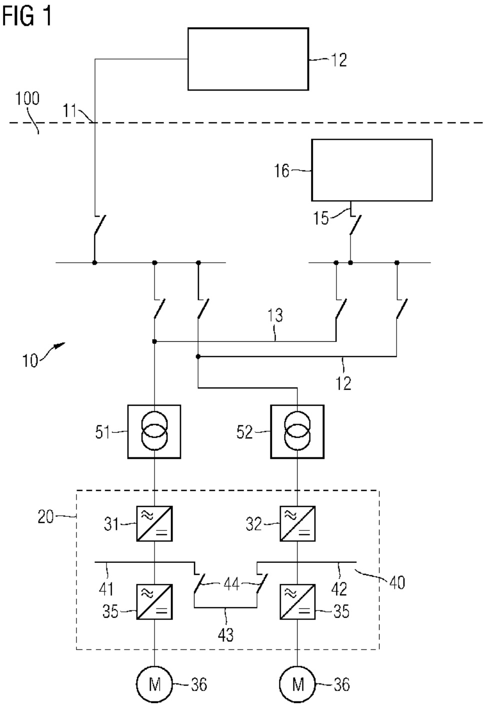
(54) **Title**: POWER SYSTEM FOR A FLOATING VESSEL

FIG 1



(57) **Abstract**: A power system for a floating vessel is provided, in particular for a drilling vessel. The power system includes an external power feed connection (11) which is electrically connectable to an external power source (12) which is external to the floating vessel (100), the external power feed connection (11) being adapted to receive AC electric power from the external power source (12); a further power feed connection (15) adapted to receive AC electric power from a further power source (16); and a drive system (20) for driving electric motors (36) of the floating vessel, wherein the drive system comprises a DC-bus (40) and at least a first rectifier (31) and a second rectifier (32) which are configured to receive AC electric power and to provide DC electric power to the DC-bus (40).

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Description

Power system for a floating vessel

Field of the invention

The present invention relates to a power system for a floating vessel, in particular for a drilling vessel, such as a drill ship, a jack-up rig, a floating drilling platform or the like. The invention further relates to a method of operating a power system of a floating vessel.

Background

In offshore oil production, floating drilling vessels such as offshore platforms, drilling rigs, jack-up rigs or drill ships are used for exploratory offshore drilling and for drilling offshore wells. Several technical difficulties are involved in offshore drilling.

Generally, such drilling vessel will have an onboard power generation system for generating the electric power required to operate the drilling equipment. Drilling equipment may for example comprise a top drive, drawworks for raising and lowering the drill string, mud pumps and the like. A substantial amount of electric power can be required for operating such equipment. In difficult conditions, the drilling equipment may for example require an electric power of up to 10 MW. A drilling vessel further comprises other electric consumers requiring a substantial amount of electric power, such as a jacking system of a jack-up rig, anchor winches, cranes and auxiliary devices (e.g. cooling and lubrication pumps) of such systems.

Onboard power generation may occur by means of a prime mover, such a a diesel engine or a gas turbine, coupled to a generator. Accordingly, such onboard power systems generally have relatively high fuel consumption. This contributes to the substantial operational costs of such vessel. Also, the high and fluctuating load on the generators and prime movers often results in excessive wear of components. If the power generation system needs to be tested, inspected or serviced, a drilling operation generally needs to be interrupted, resulting in significant financial losses for the operator of the vessel.

Accordingly, it is desirable to provide electric power to a vessel from a power source other than the onboard power generation system. In general, this is difficult since the onboard power system is usually configured to operate at a particular AC frequency of the generated AC electric power. Accordingly, if the power system of such floating vessel is to be connected to an external power source, it is required to adjust the AC frequency of the external power source to the AC frequency of the power system of the floating vessel. One possibility might be the use of a containerized frequency converter, which can be connected between the external power source and the power system of the floating vessel to achieve a frequency adaptation. Such solution, however, suffers from the additional space requirements and the additional weight of such converter, as well as from the required installation efforts. The additional weight may be above 100 t, which in turn has significant cost implication, with space and weight on such floating vessel being a valuable asset.

Summary

Accordingly, there is a need for a power system for a floating vessel which mitigates at least some of the drawbacks mentioned above. In particular, there is a need for a power system which enables a flexible use of power provided by a power source external to the floating vessel.

This need is met by the features of the independent claims. The dependent claims describe embodiments of the inventions.

An embodiment of the invention provides a power system for a floating vessel, in particular for a drilling vessel, such as a jack-up rig. The power system comprises an external power feed connection which is electrically connectable (e.g. via a switch) to an external power source which is external to the floating vessel, the external power feed connection being adapted to receive AC (alternating current) electric power from the external power source and a further power feed connection adapted to receive AC electric power from a further power source, in particular from an onboard power generation system. The power system further comprises a drive system, such as a drilling drive system, for driving electric motors of the floating vessel, wherein the drive system comprises a DC-bus and at least a first rectifier and a second rectifier which are configured to receive AC electric power and to provide DC (direct current) electric power to the DC-bus. The external power feed connection is electrically connectable (e.g. via a switch) to the first rectifier of the drive system and the further power feed connection is electrically connectable (e.g. via a switch) to the second rectifier of the drive system such that in operation, electric power can be supplied to the DC-bus from the external power feed connection via the first rectifier and the from the further power feed connection via the second rectifier.

In such configuration, the power system of the floating vessel may be operated with AC electric power at a first frequency received on the external power feed connection and with AC electric power at a different second AC frequency received on the further power feed connection, e.g. from an onboard power generation system or a second external power source. This way, a flexible use of an external power source is enabled while at the same time, a redundant power supply for the drive system is realized. Accordingly, if e.g. the connection to the external power source is cut, the drive system may continue to operate on AC electric power supplied from the further power feed connection. Electric power may be provided to the DC-bus simultaneously from the external power feed connection and from the further power feed connection. Since no additional containerized converter needs to be provided, significant savings in space, weight and cost may be achieved with the power system.

In an embodiment, the power system is configured to have at least a first mode of operation in which the external power feed connection is connected to the first rectifier to supply electric power to the first rectifier, the external power feed connection being disconnected from the second rectifier, in which the further power feed connection is connected to the second rectifier to supply electric power to the second rectifier, the further power feed connection being disconnected from the first rectifier, and in which the first and the second rectifiers provide electric power to the DC bus. The first mode of operation is such that the external power source and the first power source do not need to be synchronized. Accordingly, if the further power source operates at e.g. 50 Hz, external power sources operating at 50Hz or 60Hz can be connected via the external power feed connection. The floating vessel can thus be connected to an offshore power source, e.g. an offshore petroleum production unit, irrespective of the frequency at which the power system of such unit operates. Further, it is possible that the external power feed connection is disconnected or interrupted without prior notice, since the power system for the floating vessel remains operable without any gap in the power supply since the DC bus is fed in parallel from the further power source, e.g. an onboard generator.

The drive system may be a variable speed drive system adapted to drive the electric motors at variable speed. It may accordingly include one or more inverters coupled to the DC-bus and to an electric motor for supplying AC electric power at variable frequency to the respective electric motor.

In an embodiment, the power system is adapted to be capable of operating the drive system at the same time with AC electric power received at a first AC frequency at the external power feed connection and AC electric power received at a second AC frequency at the further power feed connection, the second AC frequency being different from the first AC frequency. Accordingly, the power system can be connected to an external power source irrespective of the AC frequency which the onboard power system is configured for.

In an embodiment, the power system is further configured such that the external power feed connection is electrically connectable to the second rectifier and the further power feed connection is electrically connectable to the first rectifier of the drive system. An increased availability and operational flexibility of the power system may thus be achieved. Also, if a rectifier or a power source fails, the power system may still be operable by appropriately switching the respective electrical connections, so that fault protection of the power system can be improved.

In an embodiment, the power system is configured such that the first rectifier is selectively connectable to either the external power feed connection or the further power feed connection (and disconnected from the respective other power feed connection) and such that the second rectifier is selectively connectable to either the external power feed connection or the further power feed connection (and disconnected from the respective other power feed connection).

In an embodiment, the power system further comprises a first AC transformer, an output of which is connectable to the first rectifier and a second AC transformer, an output of which is connectable to the second rectifier. The external power feed connection is connectable (e.g. via a switch) to the input of the first AC transformer and the further power feed connection is connectable (e.g. via a switch) to the input of the second AC transformer. The AC transformers are thus connected between the respective power feed connection and the respective rectifier. The first and the second AC transformers may be configured to be operable at at least two different AC frequencies of AC electrical power received at the input of the respective transformer. By providing the transformers, the appropriate voltage can be supplied to the drive system. Further, by enabling operation of the transformers at different AC frequencies, flexibility of the power system is ensured. Electric power at different AC frequencies can thus be provided via the external power feed connection and via the internal power feed connection.

The power system may for example be configured to be operable at an AC frequency within the range of about 40 to about 120 Hz, preferable of about 45 to about 70 Hz. It may for example be configured to be operable at least at an AC frequency of about 50 Hz and of about 60 Hz of the AC electric power received on the external power feed connection.

In an embodiment, the drive system is a drilling drive system and is powering an electric motor of at least one of a mud pump, a cement pump, draw works or a top drive. It may be adapted to power these motors at variable frequency, so that they can be operated at variable speed.

The power system may be adapted to deliver an electric power of at least 0.5 MW, preferably at least 1.0 MW to the drive system. For example, the delivered electric power may lie within a range of about 0.5 to about 25 MW.

The power system may be configured such that an electric power within the range of about 0.5 to about 10 MW can be supplied from the external power feed connection to the drive system.

In an embodiment, the drive system comprises a first drive system including the first and second rectifiers and a second drive system for driving electric motors of the floating vessel, wherein the second drive system comprises a DC-bus and at least a third rectifier and a fourth rectifier which are configured to receive AC electric power and to provide DC electric power to the DC-bus. The external power feed connection is electrically connectable (e.g. via a switch) to the third rectifier of the second drive system and the further power feed connection is electrically connectable (e.g. via a switch) to the fourth rectifier of the second drive system such that in operation, electric power can be supplied to the DC-bus of the second drive system from the external power feed connection via the third rectifier and from the further power feed connection via the fourth rectifier. In the first mode of operation, the external power feed connection may be connector to the third rectifier but disconnected from the further rectifier, and the further power feed connection may be connected to the fourth rectifier but disconnected from the third rectifier. Accordingly, also the second drive system can be powered even if the external power source and the further power source are not synchronous and the external power source can be disconnected without any interruption in the power supply of the drives (e.g. in case of an emergency disconnect).

As mentioned above, electric connections can further be provided for connecting the third rectifier to the further power feed connection and for connecting the fourth rectifier to the external power feed connection. Accordingly, an improved resistivity against faults in the power system can be achieved, and operation may be continued even in case of a blackout of some part of the power system.

Similar to what was mentioned above, a corresponding AC transformer may be connected before each of the third and fourth rectifiers.

The AC-transformers may be three or four winding transformers. In some configurations, an AC transformer may have three secondary windings, providing three phase shifted AC power outputs for rectification. In other embodiments, an AC transformer may have three secondary windings which provide two phase shifted AC power outputs for rectification and a further auxiliary power output (which may for example be at a different voltage and/or phase). Transformers of one or the other configuration can be used together in the power system.

Each of the first, second, third and fourth rectifiers may comprise one or more rectifiers, e.g. two, three or more. As an example, the AC transformer may provide three phase shifted AC power outputs, and each of said rectifiers may comprise three rectifiers, one connected to each AC power output. This way, harmonic distortions may be decreased and a relatively smooth DC voltage may be obtained on the DC bus.

In an embodiment, the power system has at least a first part and a second part that are physically separate on the floating vessel. The further power source comprises a first generator set in the first part (A-side) (e.g. in a first engine room) and a second generator set in the second part (B-side) (e.g. in a second engine room). The first part comprises the first drive system and the second part comprises a second drive system including at least a third and a fourth rectifier. In each drive system, one rectifier is selectively connectable to either the external power feed connection or the first generator set without being connected to the second generator set, and one rectifier is selectively connectable to either the external power feed connection or the second generator set without being connected to the first generator set. Accordingly, redundancy can be provided in the power system and the reliability is improved. Since each drive if provided with electric energy both from the first part and the second part of the vessel (i.e. form the A-side and from the B-side of the power system), a fire or flooding on one part of the vessel will not lead to a blackout of a drive system. Rather, both drive systems can remain operational.

In an embodiment, the second drive system is a cantilever drilling drive system provided on a cantilever of the floating vessel, the second drive system being configured to drive at least a top drive of a drilling system of the floating vessel. Accordingly, it becomes possible to operate major drilling equipment with electric power supplied from the external power feeder connection.

A cantilever may be a movable part of the floating vessel which includes a drill tower and which is moved out from the deck of the vessel when the vessel is about to drill. In an example embodiment, the first drive system may be a hull drive system which powers electric motors of a mud pump and a cement pump, and the second drive system may be a cantilever drive system which may power the electric motors of draw works of the drill string and of a top drive.

In an embodiment, the floating vessel is a jack-up rig, wherein the power system is further configured to provide electric power to a jacking drive system having two or more variable frequency drives for driving electric motors of a jacking system of the jack-up rig, wherein the external power feed connection is electrically connectable to a first of the at least two variable frequency drives and wherein the further power feed connection is electrically connectable to a second of the at least two variable frequency drives of the jacking drive system. Accordingly, also a jacking operation may be power from electric power received via the external power feed connection.

In an embodiment, the DC-bus of the drive system may comprise a first bus section coupled to the first rectifier and a second bus section coupled to the second rectifier. In operation, the first bus section may be connected to the second bus section. The first bus section may for example be connected to the second bus section by means of a bus tie comprising one or more bus tie breakers. One section of the drive system may thus be isolated from the other section (by opening the bus tie breaker), e.g. to prevent fault propagation or the like. After a fault in one part of the drive system, the other part may thus continue to operate.

In an embodiment, the further power feed connection is an onboard power feed connection and the further power source is an onboard power generation system located onboard the floating vessel. The onboard power generation system may for example comprise a prime mover, such as a diesel engine or a gas turbine, and a generator connected thereto. This way, redundancy of the power supply can be achieved while only a single external connection is required.

In other embodiments, the further power feed connection may be a second external power feed connection and the further power source may be a second external power source external to the floating vessel. This way, redundancy of the power supply can be achieved.

In an embodiment, the power system further comprises an (first) external power feed switchgear having a power input which is connected to the external power feed connection and a power output which is connectable to the first rectifier, the external power feed switchgear having switches for switching at least the power output, wherein the power system comprises an electric connection from the onboard power generation system to the power output of the external power feed switchgear. The electric connection may be a switchgear-internal connection, i.e. a connection from the onboard power generating system to the switchgear, which is internally connected to the switchgear output.

The external power feed switchgear is generally located onboard the floating vessel, the term ‘external power feed’ is used since it may switch the external power feed connection.

If an AC transformer is provided, the electric connection from onboard power generation system to the power output of the external power feed switchgear is preferably before the transformer, so that either the electric power from the external power feed switchgear or from the onboard power generation system is supplied to the transformer (e.g. dependent on the switching state).

In an embodiment, the power system further comprises a second external power feed switchgear having a power input which is connectable to the first external power feed switchgear and/or to a second external power feed connection which is configured to receive AC electric power from a second external power source.

The second external power feed switchgear may for example be located in a different switchgear room, so as to achieve physical separation, increasing the operational safety against fire and the like. By providing a second external power feed switchgear which can be selectively connected to either the first external power feed switchgear and thus to the external power feed connection, or to a second external power feed connection, the power system may be operated with one or two external power feed connection, e.g. for providing redundancy in the external power supply.

In an embodiment, the power system further comprises an onboard power generation switchgear having a power input connected to the onboard power generation system and having a power output connectable to the second rectifier, wherein the onboard power generation switchgear has switches for switching the power input or the power output or both.

The power system may further comprise a second onboard power generation switchgear having a power input connected to the onboard power generation system, wherein the power input of the first onboard power generation switchgear is connected to a first set of generators and the power input of the second onboard power generation switchgear is connected to a second set of generators of the onboard power generation system. Accordingly, safety of the system against blackout can be improved. If one switchgear or one set of generators should fail, operation can continue with the other switchgear or the other set of generators.

In an embodiment, the first and second onboard power generation switchgears each comprise an AC bus, the AC buses of the first and second onboard power generation switchgears being interconnected by means of a bus tie comprising one or more bus tie breakers.

Preferably, the first and second sets of generators are provided in different engine rooms of the floating vessel. Continued supply with electric power can thus be ensured, e.g. if the external power feed connection is cut and on generator set is failing, e.g. due to fire in an engine room.

In an embodiment, the power system may be a redundant power system. A first part of the power system (A-side) may comprise the first external power feed switchgear and the second onboard power generation switchgear, whereas a second part of the power system (B-side) may comprise the second external power feed switchgear and the first onboard power generation switchgear. A-side and B-side of the power system may be provided in physically separate rooms on the floating vessel, e.g. in separate switchboard rooms.

The power system can be configured such that the first rectifier is supplied with AC electric power from the A-side and the second rectifier is supplied with electric power from the B-side of the power system. Accordingly, if a rectifier or one side of the power system fails, the drive system can still be supplied with electric power via the other side of the power system and the other rectifier. By means of the DC-bus, in particular the interconnected DC-bus sections, most if not all loads of the drive system can still be supplied with electric power.

The above mentioned second drive system may be configured and connected correspondingly, so that its at least two rectifiers can be supplied with electric power from the A-side or the B-side of the power system.

In an embodiment, the power system is configured to enable an autonomous supply of the drive system with electric power from the onboard power generation system of the floating vessel when the external power feed connection is not connected to an external power source, and to enable a simultaneous supply of the drive system with electric power from the onboard power generation system and from an external power source when the external power feed connection is connected to the external power source. A continued drilling operation may thus be achieved, even is the external power source is suddenly disconnected or stops the supply of electric power.

The external power feeder connection may be provided by a power cable, in particular an three phase power cable or three single phase power cables, and it may be termed ‘cable interconnect’. The external power source may for example be provided by a power generation system of a fixed offshore platform, or of another floating vessel, such as a floating offshore rig or production vessel, e.g. a semi-submersible offshore platform. As an example, the other fixed platform or vessel may produce a surplus of electric power, e.g. when a surplus of gas is available during production, and may export this surplus of electric power via the cable interconnect to the power system of the floating vessel.

A further embodiment according to the invention provides a method of operating a power system of a floating vessel, in particular of a drilling vessel, the power system comprising a drive system for driving electric motors of the floating vessel, wherein the drive system comprises a DC-bus and at least a first rectifier and a second rectifier configured to receive AC electric power and to provide DC electric power to the DC-bus. The method comprises the steps of connecting an external power feed connection to an external power source which is external to the floating vessel for receiving AC electric power from the external power source; connecting a further power feed connection to a further power source for receiving AC electric power from the further power source (e.g. by closing a corresponding switch); connecting the external power feed connection to the first rectifier of the drive system; connecting the further power feed connection to the second rectifier of the drive system; and operating the power system such that electric power is supplied to the DC-bus from the external power feed connection via the first rectifier and the from the further power feed connection via the second rectifier.

With such method, advantages similar to the ones outlined further above with respect to the power system may be achieved. The power system can be configured in accordance with any of the above outlined embodiments.

In an embodiment, the method may further comprise the steps of receiving AC electric power on the external power feed connection at a first AC frequency and receiving electric power on the further power feed connection at a second AC frequency different to the first AC frequency. Accordingly, the drive system may be fed by AC electric power at two AC frequencies, enabling a flexible use of the power system with respect to the import of electric power via the external power feeder connection.

The features of the embodiments of the invention mentioned above and those yet to be explained below can be combined with each other unless noted to the contrary. In particular, the power system may be configured as described with respect to embodiments of the method, whereas the method may be performed by means of a power system in any of the above outlined configurations.

Brief description of the drawings

The foregoing and other features and advantages of the invention will become further apparent from the following detailed description read in conjunction with the accompanying drawings. In the drawings, like reference numerals refer to like elements.

Figure 1 shows a schematic diagram of a power system of a floating vessel according to an embodiment of the invention.

Figure 2 shows a schematic diagram of a power system of a floating vessel according to an embodiment of the invention, wherein redundancy is provided in the power system.

Detailed description

In the following, embodiments of the invention will be described in detail with reference to the accompanying drawings. It is to be understood that the following description of the embodiments is given only for the purpose of illustration and is not to be taken in a limiting sense.

The drawings are to be regarded as being schematic representations only, and elements in the drawings are not necessarily to scale with each other. Rather, the representation of the various elements is chosen such that their function and general purpose become apparent to a person skilled in the art. It is also to be understood that the coupling of physical or functional units as shown in the drawings and described hereinafter does not necessarily need to be a direct connection or coupling, but may also be an indirect connection or coupling, i.e. a connection or a coupling with one or more additional intervening elements. The skilled person will further appreciate that the physical or functional units illustrated and described herein with respect to the different embodiments do not necessarily need to be implemented as physically separate units. One or more physical or functional blocks or units may be implemented in a common circuit, chip, circuit element or unit, while other physical or functional blocks or units may be implemented in separate circuits, chips, circuit elements or units.

The term ‘connectable’ as used herein may include providing an electric coupling which can but does not need to comprise one or more intervening elements (such as switches, fuses, transformers or the like). It can be a permanent electric coupling or a switchable electric coupling. A switch may be provided for selected electric connections, for example as illustrated in the figures.

Figure 1 is a schematic diagram of a power system 10 of a floating vessel 100. The components of the power system 10 are installed on the floating vessel 100. The floating vessel 100 may for example be a floating offshore platform, a jack-up rig or a ship, it may in particular be a drilling vessel, i.e. a drilling platform, a drilling rig or a drill ship.

Power system 10 comprises an external power feed connection 11 towards an external power source 12, which is external to the vessel 100. This external power source 12 may for example be provided by power generation equipment on a fixed offshore platform or of another floating vessel, which may for example generate excess power that can be used onboard the vessel 100. For this purpose, the external power feed connection 11 is adapted to receive AC electric power from the external power source 12. The external power feed connection may for example be provided by an electric power cable, in particular by a three phase electric power cable, or an alternative arrangement for transferring three phase AS electric power to the power system 10.

The power system 10 comprises a further power feed connection 15, which in the embodiment of figure 1 is a connection to a onboard power generation system 16. This system may for example comprise generators and prime movers, such as diesel engines of gas turbines, installed on the floating vessel 100. In other embodiments, the further power feed connection may be a connection to another external power source (not shown) which is external to the vessel 100.

The power system 100 further comprises a drive system 20 for driving electric motors 36 of the vessel 100. It is in particular a variable speed drive system which can provide AC electric power to the electric motors 36 at a variable AC frequency. For this purpose, the drive system 20 comprises at least a first rectifier 31 and a second rectifier 32 which, at their respective inputs, receive AC electric power. In operation, they rectify the received AC electric power and at their respective outputs provide DC electric power to a DC-bus 40 of the drive system 20.

The DC-bus 40 has two bus sections 41 and 42, which can be interconnected by means of the bus tie 43 by closing respective bus tie breakers 44. This way, in case of a fault of a component connected to one DC-bus section, the DC-bus section can be disconnected and operation can continue with the other DC-bus section. In normal operation, the bus tie breakers 44 are closed, thus providing a common DC-bus 40 into which both rectifiers 31, 32 feed DC electric power.

Two or more inverters 35 can be connected to the DC-bus 40 for providing AC electric power at variable AC frequency to electric motors 36. It should by clear that any number of inverters 35 may be connected to the DC-bus 40, and that the number of inverters does not need to match the number of rectifiers.

The drive system 20 is for example a drilling drive system. The electric motors 36 can comprise electric motors of a top drive, mud pumps, of cement pumps, of drawworks or the like. Accordingly, the drive system 20 needs to be supplied with electric power of considerable magnitude, e.g. within a range of about 0.5 to about 25 MW. It should be clear that the particular power requirement will depend on the configuration of the drive system 20 and the vessel 100.

As can be seen from the drawing, the external power feed connection 11 is connectable, via respective switches and via a first AC transformer 51, to the first rectifier 31. Further, the further power feed connection 15, hereinafter termed onboard power feed connection, is connectable to the second rectifier 32 via respective switches, the electric connection 12 and the AC transformer 52. Accordingly, the DC-bus 40 can be fed with electric power from both the external power feed connection 11 and the onboard power feed connection 15 by closing the respective switches, which may be implemented as circuit breakers (CBs).

Using such electric connections, it is possible to supply electric power at a first AC frequency via the first rectifier 31 and AC power at a second AC frequency via the second rectifier 32. Since the electric power is first rectified and then fed to a common DC bus, a power supply from the two power sources becomes possible without requiring synchronization. Accordingly, the external power feed connection 11 can be connected to a external power source 12 irrespective of the AC frequency at which the external power source 12 provides electric power. As an example, the onboard power generation system 16 may operate at an AC frequency of 60 HZ, while the external power source 12 may provide power at an AC frequency of 50 Hz, or vice versa. The power system can operate the drive system 20 simultaneously on the electric power from both power sources. Power balancing can thus occur on the common DC-bus 40.

Furthermore, the external power feed connection 11 is connectable to the second rectifier 32 via respective switches and the second AC transformer 52. Also, the further power feed connection 15 is connectable via respective switches, the electric connection 13 and the first AC transformer 51 to the first rectifier 31. Accordingly, an improved protection against blackout of the power system 10 can be provided, since for example if the external power source 12 is not connected and rectifier 32 or transformer 52 should fail, the DC-bus 40 can still receive electric power from the onboard power generation system 16 via the first rectifier 31.

In the described configuration, the power provided via the external power feed connection 11 can be fully used, while the power required from the onboard power generation system 16 can be reduced. This leads to significant fuel savings on the vessel 100. Also, due to a higher available power, drilling efficiency may be improved. Continuous drilling operation can be ensured even if the power supply by the external power source 12 is shed, e.g. due to a blackout or other problems on the respective other platform or vessel. In such case, the DC-bus 40 is still supplied with electric power via the onboard power generation system 16, which can as a response increase its power output. Redundancy in the power supply is thus achieved.

The transformers 51 and 52 are adapted to convert the AC power received from the external power source 12 and from the onboard power generation system 16 to an AC voltage suitable for operating the drive system 20. They may for example be adapted to convert from a medium voltage range (e.g. between 5000 V and 20000 V) to a low voltage range (e.g. between 200 V and 1000 V). Other voltage ranges are also conceivable.

The transformers 51 and 52 are adapted to be operable within a AC frequency range. Preferably, they are adapted to be at least operable at an AC frequency of 50 HY and at an AC frequency of 60 Hz. This way, flexibility regarding the AC frequency of the power supplied via the external power feed connection 11 or the further power feed connection 15 can be ensured.

Turning now to figure 2, a particular implementation of the power system 10 of figure 1 is schematically shown. Accordingly, all the explanations given above with respect to figure 1 are equally applicable to the power system 10 illustrated in figure 2.

In figure 2, the onboard power generation system 16 is shown as several generators (G), which can for example be provided in two generator sets (as illustrated), which can be located in different engine rooms. In the example of figure two, the switches illustrated in figure 1 are provided in switchboards. The power system is separated into a first part, termed A-side and into a second part, termed B-side. The switchboards of the A-side may be provided in a first switchboard room 81 and the switchboards of the B-side may be provided in a second switchboard room 82 which are physically separated. This way, continued operation of power system 10 can be ensured even if fire should break out in on of the room 81, 82.

On the A-side, a first external power feed switchboard 61 is provided, which may have an AC-bus 64 and an input of which is connected to or provides the external power feed connection 11. It further provides, at an output, an electric connection to the first rectifier 31.

On the B-side, a second external power feed switchboard 62 is provided, having an AC bus 63. A switchable interconnection 65 is provided between the first and second external power feed switchboards 61 and 62. Furthermore, the second external power feed switchboard 62 may comprise an input connected to or providing a second external power feed connection, so that power can received from a second external power source (not shown). Via the second external power feed switchboard 62, the external power feed connection 11 is also connectable to the second rectifier 32.

On the A-side, a first onboard power generation switchboard 71 is further provided, having an AC-bus 73. Similarly, a first onboard power generation switchboard 72 is provided on the B-side of the power system 10 having an AC-bus 73, and an interconnection 75 is provided to interconnect the AC-bus 73 and the AC-bus 74.

Note that A-side and B-side switchboard are configured essentially symmetrically with respect to the power system 10.

The drive system 20 comprises two parts: a first drive system 21 with the first and second rectifiers 31 and 32, and a second drive system 22 with the third and fourth rectifiers 33 and 34. Corresponding AC-transformers 51, 52, 53 and 54 are provided. Note that each rectifier 31, 32, 33 and 34 actually comprises three rectifiers coupled to three secondary winding of the respective AC-transformer. This way, phase shifted AC electric power can be provided at the three transformer outputs, leading to reduced harmonic distortions an smoother DC-voltage on the DC-bus 40.

Note that the configuration is such that each rectifier 31, 32, 33, 34 can be connected to each switchboard, so that protection against faults in the power system is improved. In normal operation, one rectifier of the first and second drive systems 21, 22 can be fed from the A-side of the power system and the other rectifier from the B-side of the power system. Thus, even if the A-side or B-side should fail, each drive system 21, 22 remains operable due to the common DC-bus of each drive system 21, 22.

A jacking system 90 is provided on the vessel, e.g. when the vessel is a jack-up rig. The jacking system 90 comprises a jacking drive system with variable frequency drives 91, 92, which operate electric motors of the drive system. As shown, electric connections are provided so that the variable frequency drives 91, 92 are also connectable to the external power feed connection 11 and the onboard power feed connection 15. Accordingly, they can also be operated with electric power received from the external power source 12 (not shown in figure 2).

In an exemplary configuration, both drive systems 21, 22 are drilling drive systems. Drive system 20 is powering electric motors of a mud pump and cement pump. Power distribution transformers 103, 104 are provided for powering auxiliary equipment, including for example an anchor winch drive, cranes, cooling pumps and the like. The second drive system 22 is provided on a cantilever 101 which is movable. The cantilever comprises the drill tower and can be moved out for a drilling operation. Cable drag chains 102 are provided to enable movement. The electric motors 36 powered by the second drive system 22 may for example comprise motors of a top drive and of the draw work of the vessels drilling system. The draw works is for example used to raise and lower the drill string.

The generators 15 providing the onboard power generation can be cycled, i.e. the generator currently in operation can be switched through. Accordingly, the generators of one side of the power system 10 can be taken out of operation for servicing and testing, while a drilling operation can continue, with power supply redundancy being provided by the external power feed and the other side of the power system.

As can be seen, the configuration is such that both drive systems 21, 22 can be powered simultaneously from the external power feed connection 11 and from the onboard power feed connections 15, while maintaining flexibility with respect to the supplied AC frequency. Also, the system requires hardly any additional weight and space and is thus cost efficient to implement. Also, the system provides redundancy in the power supply.

Note that the voltages and frequencies given in the drawing are only an example and may be changed or may be completely different.

While specific embodiments are disclosed herein, various changes and modifications can be made without departing from the scope of the invention. The present embodiments are to be considered in all respects as illustrative and non-restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

Claims

1. A power system for a floating vessel, in particular for a drilling vessel, comprising

- an external power feed connection (11) which is electrically connectable to an external power source (12) which is external to the floating vessel (100), the external power feed connection (11) being adapted to receive AC electric power from the external power source,
- a further power feed connection (15) adapted to receive AC electric power from a further power source (16), and
- a drive system (20) for driving electric motors (36) of the floating vessel, wherein the drive system (20) comprises a DC-bus (40) and at least a first rectifier (31) and a second rectifier (32) which are configured to receive AC electric power and to provide DC electric power to the DC-bus (40),

wherein the external power feed connection (11) is electrically connectable to the first rectifier (31) of the drive system and wherein the further power feed connection (15) is electrically connectable to the second rectifier (32) of the drive system such that in operation, electric power can be supplied to the DC-bus (40) from the external power feed connection (11) via the first rectifier (31) and the from the further power feed connection (15) via the second rectifier (32),
wherein the power system is configured to have at least a first mode of operation in which
- the external power feed connection (11) is connected to the first rectifier (31) to supply electric power to the first rectifier (31), the external power feed connection (11) being disconnected from the second rectifier (32), and
- the further power feed connection (15) is connected to the second rectifier (32) to supply electric power to the second rectifier (32), the further power feed connection (15) being disconnected from the first rectifier (31), and

- the first and the second rectifiers (31, 32) provide electric power to the DC bus (40).

2. The power system according to claim 1, wherein power system is further configured such that the external power feed connection (11) is electrically connectable to the second rectifier (32) and the further power feed connection (15) is electrically connectable to the first rectifier (31) of the drive system.

3. The power system according to claim 2, wherein power system (10) is configured to have a second mode of operation in which
- the external power feed connection (11) is connected to the second rectifier (32) to supply electric power to the second rectifier (32), the external power feed connection (11) being disconnected from the first rectifier (31), and
- the further power feed connection (15) is connected to the first rectifier (31) to supply electric power to the first rectifier (31), the further power feed connection (15) being disconnected from the second rectifier (32), and
- the first and the second rectifiers (31, 32) provide electric power to the DC bus (40).

4. The power system according to any of the preceding claims, further comprising first AC transformer (51) an output of which is connectable to the first rectifier (31) and a second AC transformer (52) an output of which is connectable to the second rectifier (32), wherein the external power feed connection (11) is connectable to the input of the first AC transformer (51) and the further power feed connection (15) is connectable to the input of the second AC transformer (52), wherein each of the first and second AC transformers (51, 52) is configured to be operable at at least two different AC frequencies of AC electrical power received at the input of the respective transformer.

5. The power system according to any of the preceding claims, wherein the drive system (20) is a drilling drive system and is powering an electric motor of at least one of a mud pump, a cement pump, draw works or a top drive.

6. The power system according to any of the preceding claims, wherein the drive system (20) comprises a first drive system (21) including the first and second rectifiers (31, 32) and a second drive system (22) for driving electric motors (36) of the floating vessel, wherein the second drive system (22) comprises a DC-bus (40) and at least a third rectifier (33) and a fourth rectifier (34) which are configured to receive AC electric power and to provide DC electric power to the DC-bus,
wherein the external power feed connection (11) is electrically connectable to the third rectifier (33) of the second drive system and the further power feed connection (15) is electrically connectable to the fourth rectifier (34) of the second drive system such that in operation, electric power can be supplied to the DC-bus of the second drive system (22) from the external power feed connection (11) via the third rectifier (33) and from the further power feed connection (15) via the fourth rectifier (34).

7. The power system according to any of the preceding claims, wherein the power system has at least a first part and a second part that are physically separate on the floating vessel, wherein the further power source (16) comprises a first generator set in the first part and a second generator set in the second part, and wherein the first part comprises the first drive system (21) and the second part comprises a second drive system (22) including at least a third and a fourth rectifier (33, 34),
wherein in each drive system (21, 22), one rectifier (31, 33) is selectively connectable to either the external power feed connection (11) or the first generator set without being connected to the second generator set, and one rectifier (32, 34) is selectively connectable to either the external power

feed connection (11) or the second generator set without being connected to the first generator set.

8. The power system according to claim 6 or 7, wherein the second drive system (22) is a cantilever drilling drive system provided on a cantilever of the floating vessel, the second drive system being configured to drive at least a top drive of a drilling system of the floating vessel.

9. The power system according to any of the preceding claims, wherein the floating vessel (100) is a jack-up rig, wherein the power system (10) is further configured to provide electric power to a jacking drive system (90) having two or more variable frequency drives (91, 92) for driving electrical motors of a jacking system of the jack-up rig, wherein the external power feed connection (11) is electrically connectable to a first of the at least two variable frequency drives and wherein the further power feed connection (15) is electrically connectable to a second of the at least two variable frequency drives of the jacking drive system.

10. The Power system according to any of the preceding claims, wherein the further power feed connection (15) is an onboard power feed connection and the further power source (16) is a power generation system located onboard the floating vessel.

11. The Power system according to claim 10, wherein the power system further comprises an external power feed switchgear (61) having a power input which is connected to the external power feed connection (11) and a power output which is connectable to the first rectifier (31), the external power feed switchgear (61) having switches for switching at least the power output, wherein the power system (10) comprises an electric connection from the onboard power generation system (16) to the power output of the external power feed switchgear (61).

12. The Power system according to claim 11, wherein the power system further comprises a second external power feed switchgear (62) having a power input which is connectable to the first external power feed switchgear (61) and/or to a second external power feed connection which is configured to receive AC electric power from a second external power source.

13. The Power system according to any of claims 10-12, further comprising a onboard power generation switchgear (71) having a power input connected to the onboard power generation system (16) and having a power output connectable to the second rectifier (32), wherein the onboard power generation switchgear (71) has switches for switching the power input or the power output or both.

14. The Power system according to claim 13, wherein the power system further comprises a second onboard power generation switchgear (72) having a power input connected to the onboard power generation system (16), wherein the power input of the first onboard power generation switchgear (71) is connected to a first set of generators and the power input of the second onboard power generation switchgear (72) is connected to a second set of generators of the onboard power generation system (16).

15. The Power system according to any of claims 10-14, wherein the power system is configured to enable an autonomous supply of the drive system (20) with electric power from the onboard power generation system (16) of the floating vessel (100) when the external power feed connection (11) is not connected to an external power source, and to enable a simultaneous supply of the drive system with electric power from the onboard power generation system (16) and from the external power source (12) when the external power feed connection (11) is connected to an external power source.

16. The Power system according to any of the preceding claims, wherein in the first mode of operation, the outputs

of the first and second rectifiers (31, 32) are electrically connected by the DC bus (40).

17. The Power system according to claim 16, wherein the power system is configured such that in the first mode of operation, when one of the first or the further power feed connection (11, 15) is disconnected, the DC bus (40) receives electric power from the other of the first or the further power feed connection (11, 15) thereby enabling a continued operation of the electric motors (36) connected to the DC bus (40).

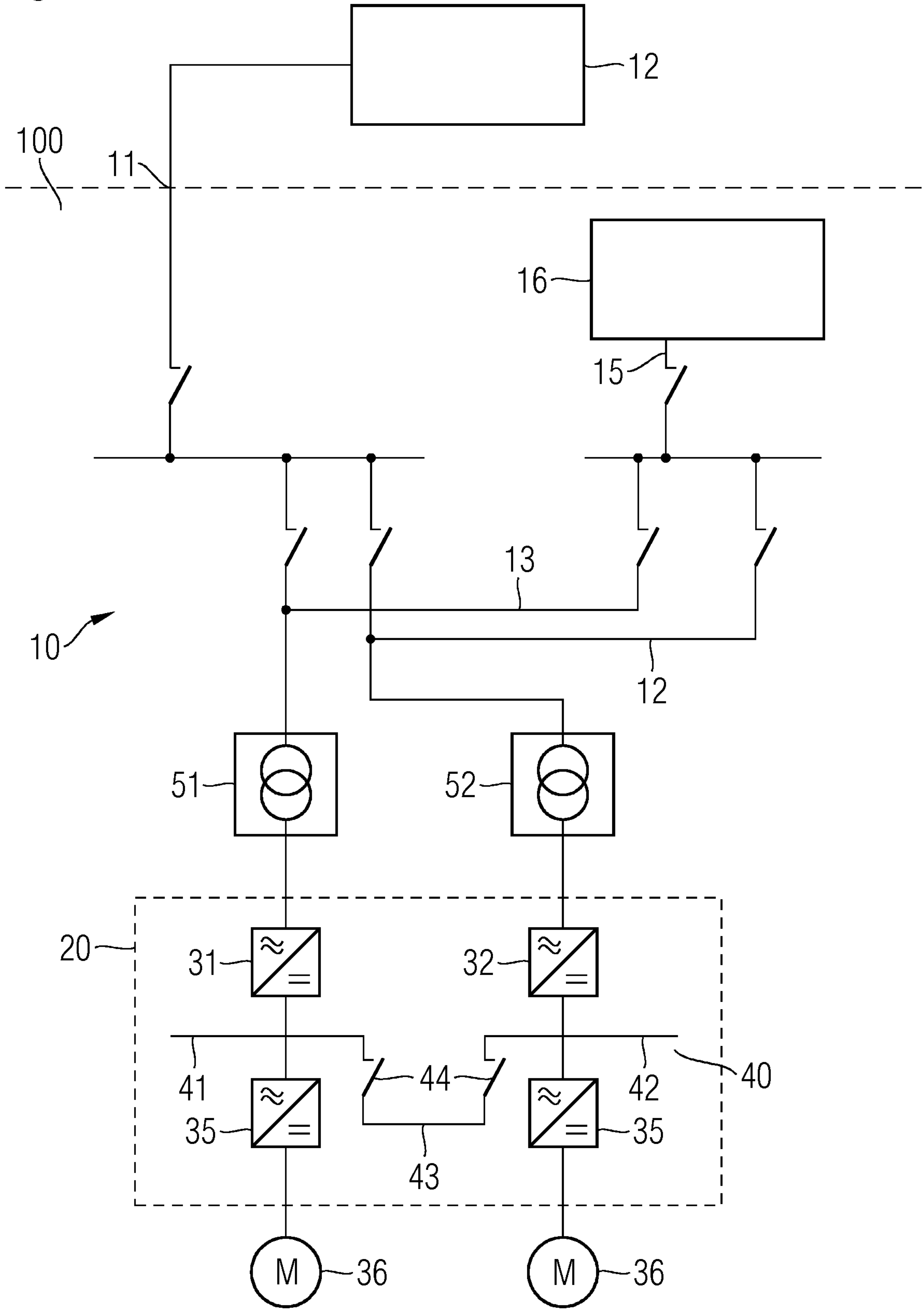
18. A method of operating a power system of a floating vessel, in particular of a drilling vessel, the power system comprising a drive system (20) for driving electric motors (36) of the floating vessel (100), wherein the drive system (20) comprises a DC-bus (40) and at least a first rectifier (31) and a second rectifier (32) configured to receive AC electric power and to provide DC electric power to the DC-bus, the method comprising the steps of:

- connecting an external power feed connection (11) to an external power source (12) which is external to the floating vessel (100) for receiving AC electric power from the external power source (12),
- connecting a further power feed connection (15) to a further power source (16) for receiving AC electric power from the further power source,
- connecting the external power feed connection (11) to the first rectifier (31) of the drive system (20), the first rectifier being disconnected from the further power feed connection (15),
- connecting the further power feed connection (15) to the second rectifier (32) of the drive system (20), the second rectifier being disconnected from the external power feed connection (11),
- operating the power system (10) such that electric power is supplied to the DC-bus (40) from the external power

feed connection (11) via the first rectifier (31) and the from the further power feed connection (15) via the second rectifier (32).

19. The method according to claim 18, further comprising the steps of receiving AC electric power on the external power feed connection (11) at a first AC frequency and receiving electric power on the further power feed connection (15) at a second AC frequency different to the first AC frequency.

FIG 1



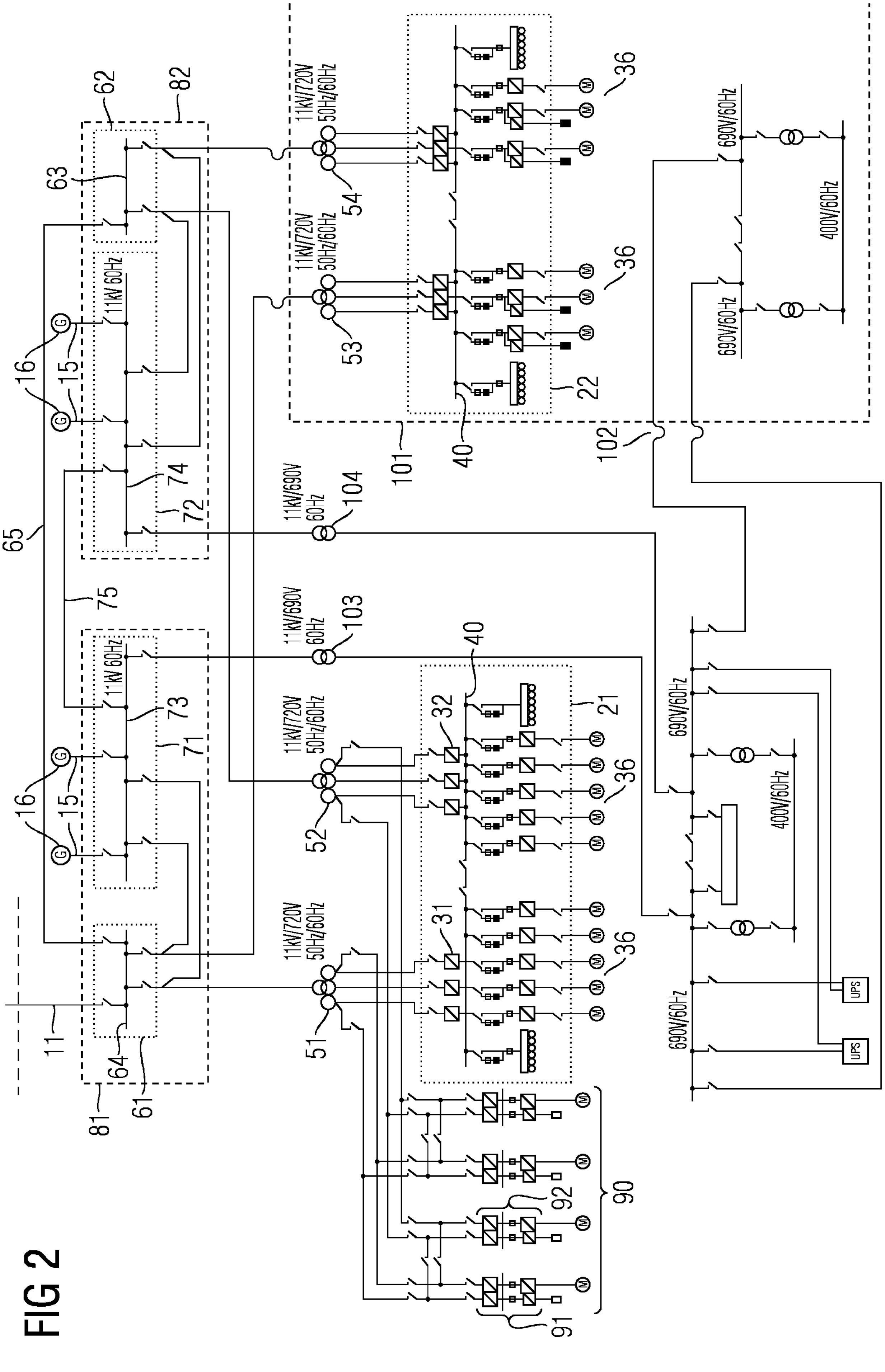

11kV 60Hz
11kV/720V 50Hz/60Hz
11kV/690V 60Hz
690V/60Hz
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FIG 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/057039

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63J3/04
ADD.

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)
B63J B63B

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 practicable, 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	WO 2009/067722 A1 (LEGACY AUTOMATION POWER & DESI [US]; REMBACH PAUL [US]; CASTLEMAN GREG) 28 May 2009 (2009-05-28) page 2, lines 23-26 page 4, line 15 - page 5, line 26 page 6, lines 15-18 page 7, lines 15-24 page 8, lines 15-22 page 9, lines 12-16 page 11, lines 8-10 page 14, lines 13-30 page 15, lines 1-5 figures 1-2 ----- -/--	1-19

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 May 2014	21/05/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Blazquez Lainez, R

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/057039

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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International application No
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